REPORT

OF THE

Thirteenth Meeting of the Australasian Association for the Advancement of Science

HELD AT SYDNEY, 1911

EDITED BY THE PERMANENT HONORARY SECRETARY, ASSISTED BY THE SECRETARIES OF SECTIONS.

PUBLISHED BY THE ASSOCIATION
: AT ITS PERMANENT OFFICE ::
5 ELIZABETH ST., SYDNEY, N.S.W.

Sydney:
W. E. SMITH Limited, Bridge Street
1912

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LIST OF ILLUSTRATIONS

OFFICERS OF THE SYDNEY MEETING

JANUARY, 1911

MEETING HELD AT THE UNIVERSITY, JANUARY 9TH TO 14TH, 1911.

Patron:

THE RIGHT HONOURABLE THE LORD CHELMSFORD, K.C.M.G.,
Governor of New South Wales.

Vice-Patron:

HIS EXCELLENCY SIR THOMAS GIBSON CARMICHAEL, K.C.M.G.,
Governor of Victoria.

President:

PROFESSOR ORME MASSON, D.Sc., F.R.S.,
Professor of Chemistry in the University of Melbourne.

Vice-Presidents:

PROFESSOR A. LIVERSIDGE, LL.D., F.R.S., Emeritus Professor of Chemistry in the University of Sydney. (President, Sydney Meeting, 1898.)

PROFESSOR T. W. E. DAVID, B.A., F.R.S., Professor of Geology in the University of Sydney. (President, Dunedin Meeting, 1904).

PROFESSOR W. H. BRAGG, M.A., F.R.S., Professor of Physics in the University of Leeds. (President, Brisbane Meeting, 1909).

RICHARD TEECE, F.I.A., F.F.A., F.S.S., General Manager and Actuary, Australian Mutual Provident Society, 87 Pitt Street, Sydney. (Elected Sydney Meeting, 1911.)

G. H. KNIBBS, C.M.G., F.R.A.S., Commonwealth Statistician, Melbourne. (Elected Sydney Meeting, 1911.)

Hon. Gen. Treasurer:

DAVID CARMENT, F.I.A., F.F.A., A.M.P. Society, 87 Pitt Street, Sydney.

Permanent Hon. Secretary:

J. H. MAIDEN,
Government Botanist and Director of the Botanic Gardens, Sydney.

Office of the Association:

ROYAL SOCIETY'S HOUSE, ELIZABETH STREET, SYDNEY.

Local Secretaries:

NEW SOUTH WALES—J. H. MAIDEN.

VICTORIA—T. S. HALL, M.A., D.Sc., Lecturer in Biology in the University of Melbourne.

SOUTH AUSTRALIA—WALTER HOWCHIN, F.G.S., Lecturer in Geology and Palæontology in the University of Adelaide.

WEST AUSTRALIA—A. GIBB MAITLAND, F.G.S., Government Geologist, Perth.

QUEENSLAND—JOHN SHIRLEY, B.Sc., Senior Inspector of Schools, "Colarmie," New Farm, Brisbane.

TASMANIA—ROBERT HALL, F.L.S., Curator of the Tasmanian Museum, Hobart.

NEW ZEALAND—C. COLERIDGE FARR, D.Sc., Professor of Physics in the Canterbury College, Christchurch (R. SPEIGHT, M.A., F.G.S., Canterbury College, acting during Prof. FARR's absence in England).

OFFICERS OF SECTIONS

Section A—Astronomy, Mathematics and Physics

President—PROFESSOR T. H. LABY, B.A., Professor of Physics in Victoria College, Wellington, N.Z.
Vice-President—GEO. D. HIRST, F.R.A.S., Sydney.
Secretaries—PROFESSOR E. M. MOORS, M.A., Lecturer in Mathematics in the University of Sydney; O. U. VONWILLER, B.Sc., Lecturer in Physics in the University of Sydney.

Section B—Chemistry, Metallurgy and Mineralogy

President—BERTRAM D. STEELE, D.Sc., Lecturer in Chemistry in the University of Melbourne (now Professor of Chemistry in the University of Queensland, Brisbane).
Vice-Presidents—W. M. HAMLET, F.I.C., Government Analyst, Sydney; T. S. LONEY, President of the Pharmaceutical Society of N.S.W.
Secretaries—PROFESSOR C. FAWSITT, D.Sc., Professor of Chemistry in the University of Sydney.; A. FORSTER, Secretary of the Pharmaceutical Society and of the Pharmacy Board of N.S.W., Richmond Terrace, Domain, Sydney (Secretary Sub-section for Pharmacy).

Section C—Geology

President—PROFESSOR P. MARSHALL, D.Sc., F.G.S., Professor of Geology in the University of Otago, Dunedin, N.Z.
Vice-Presidents—E. F. PITTMAN, A.R.S.M., Government Geologist and Under-Secretary for Mines, Sydney; PROFESSOR E. W. SKEATS, D.Sc., F.G.S., Professor of Geology in the University of Melbourne; Professor W. G. WOOLNOUGH, D.Sc., F.G.S., Lecturer in Geology in the University of Sydney.
Secretary—W. S. DUN, Palæontologist to the Geological Survey, and Lecturer in Palæontology in the University of Sydney.

Section D—Biology

President—F. M. BAILEY, F.L.S., Government Botanist, Brisbane.
Vice-Presidents—PROFESSOR J. T. WILSON, M.B., F.R.S., Professor of Anatomy in the University of Sydney; H. G. CHAPMAN, M.D., Demonstrator in Physiology in the University of Sydney; R. T. BAKER, F.L.S., Curator of the Technological Museum, Sydney.
Secretary—CHARLES HEDLEY, F.L.S., Assistant Curator of the Australian Museum, Sydney.

Section E—Geography and History

President—PROFESSOR G. C. HENDERSON, M.A., Professor of History in the University of Adelaide.
Vice-Presidents—ECCLESTON DU FAUR, President, National Art Gallery, Sydney; J. H. WATSON, late President of the Australian Historical Society, Sydney.
Secretary—H. W. S. CRUMMER, Department of Lands, Sydney.

Section F—Anthropology and Philology

President—EDWARD TREGEAR, Dept. of Labour, Wellington, N.Z.
Vice-Presidents—REV. B. DANKS, General Secretary of Methodist Missions, Sydney; F. J. GILLEN, F.A.S., Moonta, South Australia.
Secretary—REV. DR. GEORGE BROWN, Gordon, Sydney.

Section G1—Social and Statistical Science

President—E. W. H. FOWLES, M.A., LL.B., Barrister-at-Law, Telegraph Chambers, Brisbane.
Vice-Presidents—G. H. KNIBBS, F.R.A.S., Commonwealth Statistician, Melbourne; SIR WILLIAM MCMILLAN, K.C.M.G., Edgecliff; R. TEECE, F.I.A., General Manager and Actuary, A.M.P. Society, Sydney.
Secretary—A. DUCKWORTH, F.R.E.S., A.M.P. Society, 87 Pitt Street, Sydney.

Section G2—Agriculture

President—WILLIAM ANGUS, B.Sc., late Director of Agriculture, Adelaide.
Vice-Presidents—H. W. POTTS, F.L.S., F.C.S., Principal of the Hawkesbury Agricultural College, Richmond.; PROFESSOR WATT, M.A., B.Sc., Professor of Agriculture in the University of Sydney.
Secretary—F. B. GUTHRIE, F.I.C., Chemist to the Department of Agriculture, Chemical Laboratory, George Street, Sydney.

Section H—Engineering and Architecture

President—ELLWOOD MEAD, Chairman of the State Rivers and Water Supply Commission, Melbourne.
Vice-Presidents—HENRY DEANE, M.A., M.Inst.C.E., Consulting Engineer to the Commonwealth Government, Sydney; COLONEL W. L. VERNON, F.R.I.B.A., Government Architect, Sydney; J. SULMAN, F.R.I.B.A., Consulting Architect, Sydney; PROFESSOR W. H. WARREN, M.I.C.E., Professor of Engineering in the University of Sydney.
Secretary—A. J. GIBSON, Assoc. M. Inst. C.E., Assistant Lecturer and Demonstrator in Engineering Design in the University of Sydney (now Professor of Engineering, University of Queensland, Brisbane.).

Section I—Sanitary Science and Hygiene

President—W. PERRIN NORRIS, M.D., D.P.H., Commonwealth Director of Quarantine, Melbourne.
Vice-Presidents—W. G. ARMSTRONG, M.B., D.P.H., City Medical Officer, Town Hall, Sydney; REUTER E. ROTH, M.R.C.S., D.S.O., Sydney; E. S. STOKES, M.B., D.P.H., Medical Officer to the Water and Sewerage Board; FRANK TIDSWELL, M.B., D.P.H., Director of Bureau of Microbiology, Sydney.
Secretary—R. GREIG-SMITH, D.Sc., Macleay Bacteriologist, Linnean Society, Elizabeth Bay, Sydney.

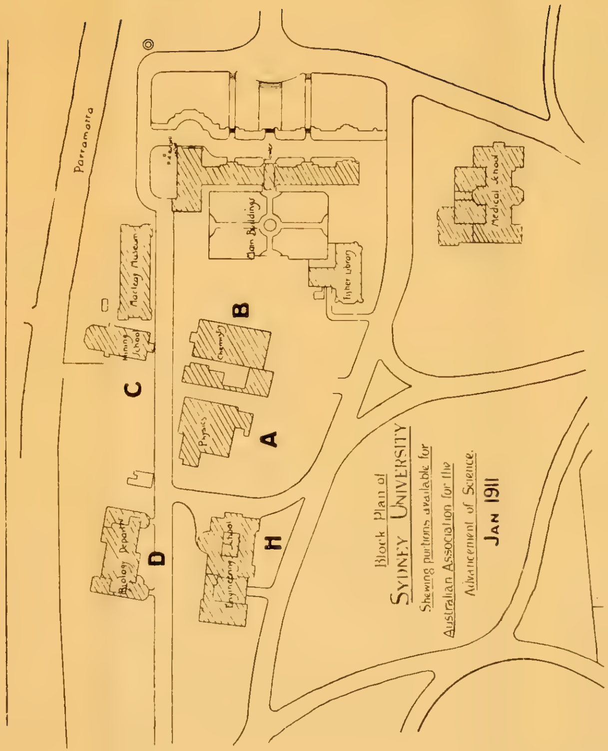
Section J—Mental Science and Education

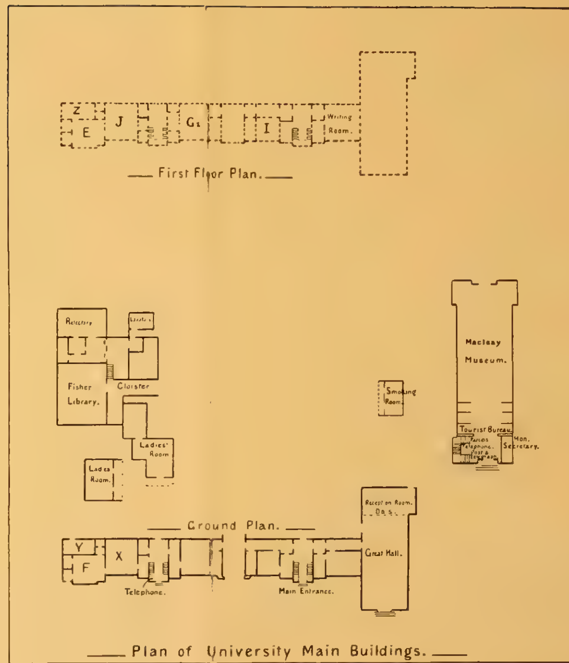
President—REV. E. H. SUGDEN, M.A., B.Sc., Master, Queen's College, Melbourne.
Vice-Presidents—PROFESSOR H. LAURIE, LL.D., Professor of Mental and Moral Philosophy in the University of Melbourne; PETER BOARD, M.A., Director of Education and Under-Secretary, Department of Public Instruction, Sydney.
Secretary—ARTHUR GILES, B.A., The Sydney Grammar School, Sydney.

LOCAL COUNCIL

SYDNEY MEETING. 1911

Anderson, Prof. F., M.A.
Anderson, H. C. L., M.A.
Armstrong, Dr. W. G.
Baker, R. T., F.L.S.
Bavin, T. R., M.A., LL.B.
Board, Peter, M.A.
Brown, Rev. Dr. George
Cambage, R. H., F.L.S.
Card, G. W., A.R.S.M.
Carment, David
Chapman, Dr. H. G.
Crummer, H. W. S.
Danks, Rev. B.
David, Prof., T. W. E., F.R.S.
Deane, Henry, M.A., M.Inst.C.E.
Duckworth, A., F.R.E.S.
Dun, W. S.
Etheridge, R.
Fawsitt, Prof. C., D.Sc.
Fletcher, J. J., M.A., B.Sc.
Forster, A.
Gibson, A. J., Prof., M.I.C.E.
Giles, Arthur, B.A.
Guthrie, F. B., F.I.C.
Hamlet, W. M., F.I.C.
Haswell, Prof., D.Sc., F.R.S.
Hedley, C., F.L.S.
Hirst, George D., F.R.A.S.
Jack, Dr. R. L.
Jensen, Dr. H. I.
Kent, H. C., M.A.
Lucas, A. H. S., M.A., B.Sc.
Loney, T. S.
MacLaurin, Sir Normand, The Honble., M.D.
McMillan, Sir William, K.C.M.G.
Madsen, Dr. T. P. V.
Maiden, J. H.
Moors, Prof. E. M., M.A.
Peden, Prof., M.A., LL.B.
Pittman, E. F., A.R.S.M.
Pollock, Prof. J. A., D.Sc.
Potts, H. W., F.L.S.
Roth, Dr. Reuter
Smith, Dr. R. Greig
Stokes, Dr. E. S.
Sulman, J., F.R.I.B.A.
Teece, R.
Thompson, Dr. Ashburton
Tidswell, Dr. Frank
Vernon, Col. W. L., F.R.I.B.A.
Vonwiller, O. U., B.Sc.
Warren, Prof., W. H., M.I.C.E.
Watson, Capt. J. H.
Watt, Prof., M.A., B.Sc.
Wilson, Prof. J. T., M.B., F.R.S.
Woolnough, Dr. W. G.





PLAN OF UNIVERSITY, SYDNEY MEETING, 1911.

PLAN OF THE BUILDINGS, SYDNEY MEETING

(SEE PLATE XLVIII)

This plan was prepared showing the utilisation of all the University rooms available for the purposes of the Congress. It is almost self-explanatory.

Y was the Press Room.

X was the General Council Room; it was also used as a spare Lantern Room.

Z was a Reserve Room.

The other letters are those of the Sections.

The Sections met in the following places :—

A Physics Laboratory.

B Chemical Laboratory.

C Mining School.

D Biology Department.

E First Floor, University main building.

F Ground Floor, University main building.

G1 First Floor, University main building.

G2 Mining School (smaller Lecture Room). The President's address was given in Room X.

H Engineering School.

I First Floor, University main building.

J First Floor, University main building.

LIST OF DELEGATES

NEW SOUTH WALES

Royal Society of N.S.W.—Dr. F. H. Quaife, Mr. Henry G. Smith, Mr. Henry Deane Walsh, M.Inst. C.E.

Linnean Society of N.S.W.—Mr. J. H. Campbell, Mr. W. W. Froggatt.

British Medical Association, N.S.W. Branch—Dr. J. A. Dick, Dr. W. H. Crago, Dr. A. J. Brady.

British Astronomical Association, N.S.W. Branch—Mr. James Nangle, F.R.A.S.

Institution of Surveyors of N.S.W.—Mr. R. H. Cambage, F.L.S., Mr. T. F. Furber, Mr. J. F. Campbell.

Society of Chemical Industry, Sydney Section—Mr. T. Steel, F.L.S.

Australian Flora Society, Sydney—Mr. E. Cheel.

N.S.W. Naturalists' Club, Sydney—Mr. W. B. Gurney, F.E.S.

Pharmaceutical Society of N.S.W.—Mr. Charles James Carroll, Mr. Thomas Slade Loney, Mr. Andrew Wadsworth.

Sydney University Science Society—Mr. E. Griffiths, B.Sc.

Teachers' Guild of N.S.W.—Rev. C. J. Prescott, M.A.

Australian Historical Society—Rev. W. H. H. Yarrington, M.A., LL.B.

Aquarium Society of New South Wales—Mr. David G. Stead.

QUEENSLAND

Field Naturalists' Club, Brisbane—Mr. S. B. J. Skertchly.

Royal Society of Queensland—Mr. F. M. Bailey, Mr. W. R. Parker.

Royal Geographical Society of Australasia, Queensland Branch—Miss Alice J. Alison-Greave, Mr. George Vowles.

Opticians' Society of Queensland—Major James Sankey.

VICTORIA

Field Naturalists' Club of Victoria—Mr. R. W. Armitage, Mr. J. T. McLennan.

Royal Geographical Society of Australasia, Victorian Branch—Mr. E. A. Petherick, F.R.G.S.

Royal Society of Victoria—Mr. G. Sweet, F.G.S.

Society of Chemical Industry, Victorian Section—Mr. D. Avery, M.Sc.

University of Melbourne—Prof. Orme Masson, D.Sc., F.R.S.

Geelong Field Naturalists' Club—Mr. C. Daley.

TASMANIA

Field Naturalists' Club of Tasmania—Mr. L. Rodway.

Royal Society of Tasmania—Mr. W. H. Twelvetrees, F.G.S.

SOUTH AUSTRALIA

Royal Society of South Australia—Dr. R. Pulleine.

South Australian Institute of Surveyors—Mr. A. B. Black.

WESTERN AUSTRALIA

Western Australian Natural History and Science Society—Mr. Thomas N. Lee.

NEW ZEALAND

Otago Institute—Prof. P. Marshall, D.Sc., F.G.S. ; Prof. W. B. Benham D.Sc., F.R.S.

Philosophical Institute of Canterbury—Mr. A. M. Wright, F.C.S.

Wellington Philosophical Society—Mr. A. Hamilton.

Auckland Institute—Dr. R. Briffault.

GENERAL PROGRAMME
AS CARRIED OUT

MONDAY, JANUARY 9TH.

10.30 a.m.—Sectional Committees met (Rule 23).
11 a.m.—First meeting of General Council (Rule 7).

BUSINESS :

To receive the balance-sheet.

To appoint a Recommendation Committee (Rule 36)

To consider questions referred by the Sydney Committee, viz., suggested alterations in rules.

Mueller Memorial Medal.

Other business.

2-3.30 p.m.—Presidential Addresses in Sections A, C, G2, and J.
3.30 p.m.—President's Reception at the University. This took the form of a garden party.
8.30 p.m.—President's Address at the University.

TUESDAY, JANUARY 10TH.

10 a.m.—Sectional Committees met.
10.30 a.m. to 1 p.m.—Presidential Address and Papers in Sections.
2 p.m. to 4 p.m.—Presidential Addresses and Papers in Sections.
4-6 p.m.—Garden Party at the Women's College, the University.
8.30 p.m.—Popular Lecture in the Great Hall of the University, by Professor G. C. Henderson, M.A., of Adelaide. Subject: "The Mutation Theory of Evolution in History."

WEDNESDAY, JANUARY 11TH.

10 a.m.—Sectional Committees met.
10.30 a.m. to 1 p.m.—Papers in Sections.
12.45 p.m.—Sub-committee on Rules met.
3.30 p.m.—Garden Party given by His Excellency the Governor, Lord Chelmsford, and Lady Chelmsford, at Government House, "Cranbrook," Rose Bay.
Dover Road or Watson's Bay trams. Extra trams were arranged for through the kindness of the Tramway authorities.
Evening unallotted for official functions.

THURSDAY, JANUARY 12TH.

10 a.m.—Sectional Committees met.

10.30 a.m. to 1 p.m.—Sections for Reading of Papers, etc.

2 p.m. to 4 p.m.—Sections met for Reading Papers, etc., or Afternoon Excursions.

3.30 p.m.—First Meeting of the Recommendation Committee.

4 p.m.—Second Meeting of General Council at the University.

BUSINESS :

To appoint Officers for the Melbourne Meeting.

To decide the place for the Meeting next following.

To appoint a Publication Committee (Rule 38). To receive Reports of Research Committees. And other business.

8.30 p.m.—Popular Lecture in the Great Hall of the University by Prof. P. Marshall, D.Sc., Dunedin. Subject: "Glaciers of the Southern Alps."

FRIDAY, JANUARY 13TH.

10 a.m.—Sectional Committees met.

10.30 a.m. to 1 p.m.—Sections met for Reading of Papers, etc. Morning Excursions in some Sections.

2 p.m. to 4 p.m.—Afternoon Excursions.

3.30 p.m.—A short Lecturette on "Boomerangs, and how to make and throw them," with practical demonstration near the Engineering School, by Dr. Harvey Sutton, Education Department, Victoria.

8.30 p.m.—Combined Conversazione given by the Councils of the Royal Society of New South Wales and of the Association at the University.

The Mueller Memorial Medal, "for Researches in Natural Science."—This Medal was awarded by the Association to Mr. Robert Etheridge, Curator of the Australian Museum, and it was presented by the President of the Australasian Association for the Advancement of Science (Prof. Orme Masson) during the evening.

SATURDAY, JANUARY 14TH.

10 a.m.—Sectional Committees met.
Second Meeting of the Recommendation Committee.

10.30 a.m.—Third Meeting of General Council at the University.

BUSINESS :

To receive Report of Recommendation Committee.
Votes of thanks.
Other business.
Excursions. See special pamphlet.

HARBOUR EXCURSION.

The Sydney Ferries Limited s.s. "Kookaburra" was hired for the purpose of a Saturday afternoon Excursion for all Members and Associates, who showed tickets or badges. No separate invitations were issued. The "Kookaburra" left Fort Macquarie (near Man-o'-War Steps) at 2.30 p.m. and returned to Sydney at 6 p.m.

EXCURSION TO WOLGAN VALLEY.

An Excursion to Newnes and the Wolgan Valley was organised by Mr. Gerald H. Halligan, of the Public Works Department, and Mr. Henry Deane, of the Commonwealth Oil Corporation, for the purpose of inspecting the railway property and plant of that Corporation.

By the courtesy of the Chief Commissioner for Railways and the Commonwealth Oil Corporation a Pullman car was provided for Association visitors.

Tuesday, January 17th.

4.8 p m —Train left Sydney.

7 p.m.—Arrived at Mount Victoria ; dinner at station.

8.7 p.m.—Party conveyed in the Pullman car to Newnes Junction, where it remained in a siding all night.

Wednesday, January 18th.

7 a.m.—The Commonwealth Oil Corporation took the train to Newnes, arriving at 10 a.m.

10 a.m. to 2 p.m.—Opportunity was afforded to view the Retorts and Refinery in process of erection, the Shay locomotive, etc., and to have lunch.

2 p.m.—Train left on return journey to meet the Western train at Newnes Junction. Passengers arrived in Sydney about 9.30 p.m.

The number of passengers was limited to twenty.

PROCEEDINGS OF THE SECTIONS

SECTION A.

ASTRONOMY, MATHEMATICS AND PHYSICS.

Section Committee (other than office-bearers):—Professors Carslaw, Hosking and Pollock, Messrs. C. E. Adams, P. Barrachi, G. H. Knibbs, R. H. Roe, K. ff. Swanw ck.

WEDNESDAY, 11TH JANUARY.

Papers read: –

"The Harmonic Analysis of Tidal Observations." C. E. Adams, M.Sc.

"Tidal Predictions." C. E. Adams.

"The Time Control of the Wellington Tide Gauge." C. E. Adams.

"An Inductive Method of Deriving Certain Mathematical Formulæ." H. Tomkys.

"A Direct Method of Establishing the Converse of a Proposition." H. Tomkys.

"Standard Astronomy: its Present Position and Future Prospects." W. E. Cooke.

"The Geographical Position, Character and Custom of Acute Cyclones as an Indication of Coming Weather." H. A. Hunt.

"The Trilinear Geometry of the Complete Quadrilateral." E. C. Hogg.

A special excursion to St. Ignatius' College, Riverview, took place on Friday, 13th January (Sections A and C).

Members travelled by the 2 p.m. Lane Cove River steamer, leaving No. 7 Jetty, Circular Quay.

Mr. Lawrence Hargrave kindly invited any members interested in aviation to inspect his workshop at 1 Wunulla Road, Woollahra Point, Rose Bay, any afternoon between 3 and 5 o'clock.

Thursday, 12th January.

Papers read :—

"The Scattering of Cathode Rays." Dr. J. P. V. Madsen.

"Note on the Theory of the Electrodeless Discharge." Professor Pollock.

"The Nature of the Light Effect in Selenium." O. U. Vonwiller.

"Standards of Electromotive Force." R. C. Simpson.

"On a System of Related Triangles." E. G. Hogg.

"Note on the Scattering of Sound Waves by a Solid Cone." Professor Carslaw.

"Brief Note on the New Mainka Seismometer at St. Ignatius' College, Riverview." Rev. E. F. Pigot, S.J., B.A., M.B.

Discussion of Dr. Cooksey's paper on "Comets and their Tails."
Meeting of Solar Eclipse and Solar Research Committees.

Friday, 13th January.

"Action of the Latex of *Euphorbia peplus* on the Photographic Plate." Dr. H. G. Chapman and Dr. J. M. Petrie.

"Notes on Ionisation by Impact." Prof. Kerr Grant.

"On a Simple Laboratory Method of Measuring the Ratio of the Principal Elasticities of a Gas." Dr. E. F. J. Love and G. Smeal.

Afternoon excursion to St. Ignatius' College, Riverview.

Section B.

CHEMISTRY, METALLURGY AND MINERALOGY.

Committee Section (other than office-bearers) :—G. J. Burrows, B.Sc., E. Brereton, Dr. H. G. Chapman, Miss L. Green, Dr. W. H. Green, E. C. Grey, B.Sc., E. Griffiths, B.Sc., Dr. G. Harker, J. B. Henderson, Professor Orme Masson, J. C. H. Mingaye, G. J. Saunders, J. A. Schofield, W. J. Clunies Ross, B.Sc., H. G. Smith, Thomas Steel, Miss Clara Taylor, G. Wright, A. M. Wright.

10th January.

Presidential Address : "Inorganic Solvents," by Prof. B. D. Steele.

Meeting of Section along with Section H (Engineering), in the Department of Chemistry.

Papers :—

"The Corrosion of Iron and Steel." Professor Fawsitt.

"Notes on the Corrosion of Artesian Bore Casings." S. J. Burrows and Professor Fawsitt.

"The Action of Water on Persulphuric Acid and its Salts," by Miss L. Green and Professor Orme Masson.

"The Decomposition of Diethyline Disulphide and Methylsulphine Hydroxide in Aqueous Solution," by Miss L. Green and Miss B. Sutherland (communicated by Prof. Orme Masson).

"The Use of Calcium Carbide in Determining Moisture," by Mr. Irvine Masson (communicated by Prof. Orme Masson).

12TH JANUARY.

"The Vapour Pressure Curves of Binary Mixture of some Liquefied Gases." L. S. Bagster and Prof. Steele.

"The Use of the Microbalance." G. Ampt and Prof. Steele.

"The Ketones of the Higher Fatty Acids." Miss Clara N. Taylor and Prof. Easterfield.

"The Separation of Fats, with an Improved Method of Determining Fatty Acids and Cholesterol from Animal Tissues." E. C. Grey.

"The Essential Oil of the Leaves of the Native Sassafras of Victoria." Miss M. Scott.

"Chemistry in its Relation to the Frozen Meat Industry." A. M. Wright.

13TH JANUARY.

"On the Composition of Bread made in Sydney." Dr. H. G. Chapman.

"On some Remarkable Oils from the Australian Myrtaceæ." H. G. Smith.

"Red Rain Dust." Thomas Steel.

"Note on the Freezing Point of Milk." J. B. Henderson.

SUB-SECTION.

PHARMACY.

President : A. Wadsworth, President Pharmaceutical Society of N.S.W.

Vice-President : T. S. Loney, President of the Pharmacy Board of N.S.W.

11TH JANUARY.

Cowley, R. C. (Brisbane):
(*a*) "Liquor Bismuthi."
(*b*) "Some Organic Compounds of Iron with Alkalis."

Mackay, George J. (Brisbane):
(*a*) "The Proteolytic Value of certain Pepsine Preparations."
(*b*) "Notes on certain Metallic Oleates."

Power, Dr. Fredk. (London): "Constituents of some Cucurbitaceous Plants."

Wearne, W. T. (Sydney): "Antiseptics."

12TH JANUARY.

Australian Pharmaceutical Formulary. Reciprocity with Great Britain and New Zealand.
"Pure Food Legislation."
"The Ideal Pharmaceutical School." T. E. Turner.

13TH JANUARY.

"Formation of a Pharmaceutical Society of Australia."
"Efforts of Recent and Intended Legislation on the Business of Pharmacists."

SECTION C.

GEOLOGY.

Presidential Address: "The Western Margin of the Pacific Basin."

10TH JANUARY.

Committee met at 10 a.m.
Sectional Committees met at 10.30 a.m.
Papers read, 10.30 a.m.—
"Preliminary Notes of the Geology and Petrology of the Nundle District." W. N. Benson.
"Notes on Recent Additions to the Geology of the Tertiaries of Southern Australia." G. B. Pritchard.
"The Geology of Yass." A. T. Shearsby.
"Notes on the Geology of the Jenolan Caves Area." C. A. Sussmilch.

11TH JANUARY.

"The Occurrence of Nepheline in Victoria." Prof. E. W. Skeats.
"Notes on the Alkaline Eruptive Rocks of West Moreton, Queensland." R. A. Wearne and W. G. Woolnough.
"The Alkaline Rocks of Society and Cook Islands." Prof. P. Marshall.
"Preliminary Note on the Alkali Rocks of Dundas, Victoria." H. S. Summers.

At 11.30 a.m., in the Geology Department, Dr. Mawson delivered a lecture on Antarctica.

12TH JANUARY.

Sectional Committee met at 9.30 a.m.

Section met at 9.30 in the Geology Department.

Papers read :—

(1) "Relations of the Ore-bodies to Igneous Rocks of the Heemskirk—Comstock—Zeehan Area."

(2) "The Heemskirk Massif, its structure and relationships."

(3) "The Origin of certain Contact Rocks."
All by L. K. Ward.

"On the Transport of Mud by a River in Flood." T. Steel.

"Coral Reefs of the Society and Cook Islands." Prof. Marshall.

A visit was paid to the Mining Museum, George Street North, at 2.30 p.m.

13TH JANUARY.

Papers :—

"Precambrian Areas in the North-Eastern portions of South Australia and the Barrier, New South Wales." D. Mawson.

"Notes on some Physiographic Problems." E. C. Andrews.

"An Exhibit of Graphite-bearing Ore from Queensland." C. Ball.

"A Catalogue of the Minerals of New South Wales, with Bibliography." By Dr. C. Anderson.

"Note on the Limitations of De Chaulnes' Method of Determining Refractive Index." By L. A. Cotton.

(*a*) "Note on the Occurrence of *Oxyrhinca* in the Cretaceous of N.S. Wales." By W. S. Dun.

(*b*) "Notes on the Fauna of the Gympie Beds of Gympie, Queensland." By W. S. Dun.

"Some Examples of River Development in the Coastal Area of New South Wales." By Dr. W. G. Woolnough.

The Section met in the Geology Department, Demonstration Room.

An exhibit of Alkaline Rocks, prepared by Dr. Jensen, was on view in the Macleay Museum.

Sections A and C.—Special Excursion to St. Ignatius' College, Riverview.

SECTION D.

BIOLOGY.

Section Committee (in addition to office-bearers).—Prof. W. B. Benham, D.Sc., F.R.S., Prof. Haswell, D.Sc., F.R.S., and Prof. H. B. Kirk, M.A., Drs. Chapman and G. Sweet and Mr. John Shirley, B.Sc.

January 11th.

Zoological Papers, 10.30 a.m. to 1 p.m.

(*a*) "Notes on the Results of a Zoological Expedition to the sub-Antarctic Islands of New Zealand." (*b*) "The Affinities of the Invertebrate Fauna of the Kermadecs." Prof. W. B. Benham.

"Contributions to the Study of Precipitins." Dr. H. G. Chapman.

"Notes on the Occurrence of a Pathological Condition in a Nematode." Dr. J. B. Cleland and T. Harvey Johnson.

"Some Effects of the Gases Dissolved in Artesian Waters on Trout, their Eggs and Fry." Prof. C. Coleridge Farr.

"On the Progress of the Disappearance of some of the Rarer Birds of New Zealand." A. Hamilton.

"A Contribution to Our Knowledge of Filaria (Or hocerca) Gibsoni, Cleland and Johnston." Prof. J. A. Gilruth and Dr. Georgina Sweet.

January 12th.

Botanical Papers, 10.30 a.m. to 1 p.m.

"The Cinnamonums of Australia." R. T. Baker.

"Some Examples of Precocious Blooming in Heteroblastic Species of New Zealand Plants." Dr. L. Cockayne.

"On the Xerophytic Character of the Hawkesbury Sandstone Flora." A. G. Hamilton.

"Records of Australian Botanists—First Supplement." J. H. Maiden.

Botanical Papers, 2 p.m. to 4 p.m.

"Growth, Development and Life-History in the Desmidiaceæ." G. I. Playfair.

"A Revision of the Tasmanian Flora." L. Rodway.

"The Botany of the Basaltic Tableland," Queensland illustrated by specimens and twenty-four original lantern slides. J. Shirley.

(*a*) "On Australian Grasses, Saltbushes, Pasture Herbs, Shrubs and Trees, and their Importance to the Pastoral Industry." (*b*) "Notes on Australian Myoporacæ." F. Turner.

"Australian and South Sea Island Stictaceæ." E. Cheel.

January 13th.

Zoological Papers, 10.30 a.m. to 1 p.m.

"Notes of a Naturalist on the Capricorn Islands" (with lantern illustrations). L. Harrison.

(*a*) "On the Re-Examination of Krefft's Types of Entozoa." (*b*) "On a New Genus of Cestoda from Marsupials." (*c*) "Description of New Species of Avian and Reptilian Cestoda." T. Harvey Johnston.

(*a*) "Notes on a Larval Echiborhynch infesting certain birds." (*b*) The Endoparasites of Man in Australia." T. Harvey Johnston and Dr. J. Cleland.

"On the Need of More Uniformity in the Vernacular Names of Australian Edible Fishes." D. G. Stead.

"The Macleayan Types of Australian Fishes." E. R. Waite.

"The Probable Influence on Radiology on Organic Evolution." Dr. F. Watson.

Section E.

GEOGRAPHY AND HISTORY.

President : Prof. G. C. Henderson, M.A., Professor of History in the University of Adelaide.

January 10th.

"Colonial Historical Research." Presidential Address.

"Early Trade between Sydney and the South Sea Islands." Louis Becke.

"Discovery of Pitcairn Island, Mutiny of the 'Bounty,' and Life of the Mutineers on the Island of Pitcairn." A. C. MacDonald.

"Exploration in New Guinea." Donald Mackay.

January 11th.

Geological Theatre.—Dr. Mawson, of Adelaide, lectured on "Antarctica," with special reference to his Expedition. (See also Section C, as this lecture was given in conjunction with that Section.)

January 12th.

Geological Theatre.—"Governor Phillip—a Fragment of Australian History." J. McMahon.

Geological Theatre.—Lantern Lecture by His Honor Judge Docker—"The North Coast of N.S.W." (illustrated), showing the scenery of the Tweed, Richmond, Clarence, Bellinger, Macleay, Hastings and Manning Rivers.

January 13th.

"Early Discovery of Australia." George de Tourcey Collingridge.

Section F.

ANTHROPOLOGY AND PHILOLOGY.

10th January.

Sectional Committee met at 10.30 a.m.

"The Conceptional Theory of the Origin of Totemism." Rev. George Brown, D.D.

"The Customs of Australian Aborigines." R. H. Mathews.

"Notes on some Customs and Beliefs of the Natives of Choiseul Islands in the Solomon Group." Rev. S. R. Rooney.

11th January.

"Papuan Beliefs and Folk Lore." Rev. Dr. Bromilow.

"On the Necessity for a Uniform System of Spelling Australian Place Names." Rev. Dr. Brown.

12th January.

"The Development of the Artistic Sense in the Australian Aborigines." C. Daley.

"An Ethnologist in German New Guinea." Dr. Lewis.

"Decorative Art of the New Zealand Maoris," illustrated by lantern views.

13th January.

"The Future of the Australian Aborigines," followed by a discussion. Ven. Archdeacon Lefroy.

"Decorative Art of the New Zealand Maoris, illustrated by lantern views, by A. Hamilton, Director of the Dominion Museum, Wellington, N.Z. In the Geological Theatre.

Section G1.

SOCIAL AND STATISTICAL SCIENCE.

10th January.

Presidential Address: "Unemployment." E. W. H. Fowles, M.A., LL.B.

Papers :—

"Statistical Sidelights on Australian Morality." J. Stonham.

11th January.

"Some Observations on the Federal System of Government." T. R. Bavin.

"The Compulsory Principles in the Settlement of Industrial Disputes." H. Y. Braddon.

12th January.

"The National Physique." Dr. T. S. Purdy.

"Notes on the Increased Cost of Living." A. Duckworth.

13th January.

"Jottings on the Past, Present, and Future of Money." J. Cole Edwards.

"The Importance of Nationality." Dr. Harvey Sutton.

14th January.

"The Commonwealth Government Note Issue Account." Matthew Macfie.

Section G2.

AGRICULTURE.

11th January.

"Tasmanian Agriculture, with Special Reference to the Soils of the Country and their Treatment." H. J. Colbourn.

"Soils in Relation to Geology and Climate." Dr. Jensen.

"Some Aspects of the Nitrogen Question." Prof. Watt.

"New Factors connected with the Fertility of Soils." Dr. Greig Smith.

"On the Factors concerned in the Conversion of Organic Matter into Plant Food." Dr. Tidswell.

12th January.

"Braxy Diseases of Sheep in Australia." Prof. Gilruth.

"Contagious Bovine Mammitis Produced by the *Bacillus lactis ærogenes*." Prof. Gilruth and N. MacDonald.

"The Repression of Tuberculosis in Dairy Herds." Prof. Stewart.

"The Influence of Food upon Fertility in Stock." Darnell Smith.

"A New Method of the Mechanical Analysis of Soils." W. H. Green and G. A. Ampt.

Discussion of paper by Dr. Greig-Smith: "On New Factors connected with Soil Fertility."

"On the Behaviour of Certain Australian Varieties of Wheat when Grown in Surrey (England)." A. E. Humphries, Coxe's Lock Mill, Weybridge, England.

13th January.

"On the Proportion of Ferrous Sulphate used against the the White Rot of Grape Vines." M. Blunno.

"William Farrer in Connection with Recent Development in the Improvements of Wheat." W. S. Campbell.

"The Diseases of the Coco-nut and their Remedies." W. W. Froggatt.

"Notes on the Effect of Liming on the Availability of the Soil Constituents." F. B. Guthrie and L. Cohen.

"Macaroni Wheats; their Milling Qualities and Future Possibilities." G. W. Norris.

"An Inquiry into the Causes of Cream Taints and Decompositions." M. A. O'Callaghan.

"The Australian Aspect of Agricultural Education." H. W. Potts.

"Milling Experiments." A. E. V. Richardson.

"On the Field Results of Farrer's Work." G. L. Sutton.

Excursion.—A visit to the Hawkesbury Agricultural College was arranged.

Section H.

ENGINEERING AND ARCHITECTURE.

January 10th.

Presidential Address: "Conservation of Water in Australia." E lwood Mead.

Lecture: "Irrigation in India." W. H. Warren, M.Inst. C.E. University of Sydney.

Papers: (*a*) "Some Notes on Experiments with Built-up Steel Columns." (*b*) "Some Experiments on the Sustenance Afforded by the Atmosphere and by Water to Discs, Aeroplanes, Hydroplanes and Gyroplanes." G. Higgins.

Inspection of P. N. Russell School of Engineering.

A joint meeting, Section B (Chemistry) and Section H (Engineering), was held in the Chemistry Department to discuss Prof. Fawsitt's paper on "The Corrcsion of Iron and Steel."

January 12th.

Adjourned discussion on Prof. Fawsitt's paper in the Chemistry Department.

In the Engineering School—

"Modern Lighthouse Illumination." J. Shirra, Chief Engineer Surveyor, Department of Navigation, Sydney.

Demonstration of boomerang throwing by Dr. Sutton. This illustrated the paper given by Mr. Higgins.

An excursion was held on Thursday afternoon, January 12th, to view the various works carried out by the Sydney Harbour Trust in different parts of the harbour; a visit was also paid to the State Government Dockyard at Cockatoo Island.

By the courtesy of the Harbour Trust Commissioners, a launch was placed at the disposal of members of the Association, leaving the Harbour Trust Wharf, Circular Quay (opposite the offices of the Harbour Trust), at 2.15 p.m.

Members of other Sections who intended to make this excursion were asked to communicate with the Secretary, Section H, as the available accommodation was limited.

January 13th.

Sectional Committee met.

The following Papers were read:—

"The Hardness of N.S.W. Timbers and Resistance to Indentation as shown by the Brinell Ball and Cone Pressure Tests; also by the Cross Compression Test." Prof. W. H. Warren and G. F. Cowdery.

"The Resistance of N.S.W. Timbers to Abrasion, and the Wear in Floors and Street Pavements, as shown by the Sand Blast Apparatus." Prof. W. H. Warren and McD. J. Royle.

"The Holding Power of Nails and Dog Spikes in N.S.W. Timbers." Prof. W. H. Warren and H. A. Roberts.

"Reinforced Concrete in Building Construction." J. Nangle.

"On Waterways." J. Vicars.

Through the kindness of Mr. Lucy, Chief Mechanical Engineer, an inspection of the railway workshops at Eveleigh was made on Friday afternoon. Members desiring to attend were requested to meet at the offices of the Chief Mechanical Engineer, Eveleigh, at 2.30 p.m., and take Alexandria tram to Abercrombie-street.

Section I.

SANITARY SCIENCE AND HYGIENE.

January 11th.

"School Anthropometrics: the Importance of Australian Anthropometric Measurements conforming to the Schedule of the British Anthropometric Committee, 1908." Dr. Mary Booth.

"A Consideration of the Role of *Bac. typhosus* (Eberth-Gaffky) on the Ætiology of Typhoid Fever." Dr. Burton Bradley and Dr. J. Burton Cleland.

"The Biochemical Method of Bacteriological Analysis." Dr. Burton Bradley.

"On the Origin of Sulphuretted Hydrogen and Sulphide of Iron in Brackish Lagoons." Dr. H. G. Chapman.

"The Extermination of Mosquitoes, Flies, Fleas, Pediculi and other Insect-carriers of Disease." Dr. T. S. Purdy.

"Some Notes on School Construction." Dr. Reuter E. Roth.

"A Rapid Method of Determining the Probability of Decomposition occurring in Sewage Effluent." Dr. E. Stokes.

January 12th.

Discussion.—"The Dissemination of Tuberculosis," opened by Sir Philip Sydney Jones, M.D. The following ladies and gentlemen took part:—Dr. W. G. Armstrong, Dr. P. W. R. Boelke, Dr. Jane Greig, Dr. Cumpston, Dr. Ashburton Thompson, Dr. Zlotkowski.

Exhibits.—Apparatus, etc., by the Bureau of Microbiology.

Section J.

MENTAL SCIENCE AND EDUCATION.

January 10th.

Presidential Address—"The Place of Music in Education."

"Sociology in Australia—a Plea for its Teaching." Professor F. Anderson.

"The Sociological Concept of Education." C. H. Northcott.

"Notes Concerning the Education and Training of Children under the Control of Special Schools in New Zealand." R. H. Pope.

"Retardation in the Elementary Schools." Professor A. Mackie.

January 11th.

"On the Influence of the Universities on the Curricula of the Schools." Professor H. S. Carslaw.

January 12th.

The discussion on Professor Carslaw's Paper took place at 10 o'clock (half an hour earlier than usual). The discussion was followed by the following papers :—

"The Curriculum of the Elementary School." E. A. Riley, M.A., Inspector of Schools in N.S.W.

"The Present Position of Problems of Psychology." Bernard Muscio.

"The History of Education as a Subject in Teachers' Colleges." Dr. Percival Cole.

"The Work of the International Phonetic Association." Miss Symonds.

January 13th.

"Notes Concerning the Education and Training of Children under the control of Special Schools in New Zealand." R. H. Cope, M.A., Department of Education, Wellington, N.Z.

"The Evolution of Girls' Education," Miss E. A. Marchant, Otago Girls' High School, Dunedin.

"The Place of the Philosophical Sciences in Education." Dr. E. N. Merrington, Brisbane.

PROCEEDINGS OF THE GENERAL COUNCIL.

FIRST MEETING.

January 9th, 1911.

The first meeting of the General Council of the Australasian Association for the Advancement of Science was held at the Sydney University on Monday, January 9th, 1911, at 11 a.m. Professor Orme Masson presided, and there was a large attendance.

The minutes of the Brisbane meetings of the Council in 1909 were taken as read and confirmed.

Alterations and Additions to Rules.

The Permanent Honorary Secretary (Mr. J. H. Maiden) read the proposed alteration to Rule 10—Reception Committee—"That the word 'may' be substituted for 'shall' in the sentence 'shall form a Reception Committee.'"

On the motion of Dr. Woolnough, seconded by Mr. Knibbs, the suggested alteration was approved.

Professor Pollock said that at the local Council meetings considerable discussion had taken place in connection with the rules, and it was felt that they were in need of amendment. He proposed that the following form a sub-committee to consider the matter and report on the question to a subsequent meeting:—Mr. Knibbs, Mr. Shirley, Dr. Hall, Mr. Guthrie and the Permanent Honorary Secretary.

Dr. Woolnough seconded the motion. He said it was thought by the Local Council that instead of dealing with the alterations at Council meetings *seriatim*, a small sub-committee should be appointed, and report to a further meeting of the General Council.

The Permanent Honorary Secretary: Before the Council comes to a decision on the subject, I would like to point out that at the Brisbane meeting a rule was proposed, and if there is no objection to it to-day it will have the force of law. The new rule is: "That each Local Council shall be summoned by the Local Secretary to meet at least once annually, either in the month of July or September, to transact any business that may be brought before it." (Read the rule.) There was also an amendment carried to Rule 9 as follows (reading from "The President"). It is quite within the power of the General Council to approve of those alterations straight away, but I would throw it out as a suggestion that as you have appointed a sub-committee to go into the matter of the rules it might be desirable to remit the proposed alterations to the sub-committee. The sub-committee has been instructed to report before the end of this session so that the wish of the Brisbane Council will be still borne in mind.

Mr. Shirley : I should like to point out that if we let those rules stand till the sub-committee meets we shall put this matter off for two years. I would suggest that the Council should either accept or reject those, and then the sub-committee will have power to deal with them, and revise them if they think fit.

The Permanent Honorary Secretary : I do not think there is any objection to Mr. Shirley's suggestion. It would not be legal to allow the sub-committee to alter them.

The original motion was altered to read as follows :—"That this committee consisting of Mr. Knibbs, Mr. Shirley, Dr. Hall, Mr. Guthrie and the Permanent Honorary Secretary be appointed for the purpose of reporting at a subsequent meeting of this Council during the present session on the question of the alteration of the rules," and was agreed to.

Professor Pollock moved that the following alteration to Rule 9. "The President, not more than five Vice-presidents, the General Treasurer and the Permanent General Secretary, shall be appointed by the Council." be postponed to be considered by the sub-committee.

Dr. Hall seconded the motion.

Mr. Knibbs moved that the alteration be confirmed before being passed on to the sub-committee as a recommendation to them.

Mr. Shirley seconded the amendment.

The amendment, on being put to the meeting, was lost, and the motion as originally moved, carried.

The Permanent Honorary Secretary read an extract from circular No. 4, p. 4, Sydney meeting, from pp. 18 to 20, vol. XII., of the Brisbane meeting.

He said it appeared to him that to get a discussion on such subjects as those mentioned, all that was necessary was to get the discussers together, appoint a chairman, and proceed. He did not think that the way in which the discussion should be carried out, or the details, were matters for the General Council. (Hear, hear.) He wanted the Council to give him instructions as to what its wishes were. It had already been decided at the Adelaide meeting, and confirmed at the Brisbane meeting, in accordance with the rules, that two subjects were to be discussed. If there had been no other resolution, he would have taken steps to have communicated with the Secretaries of Sections and other officers, and would have secured a discussion on the few subjects by men who would have had two years' notice to consider their remarks. The effect of Mr. Lucas's proposal had been that he had not been able to warn them two years ahead. Therefore he wanted directions as to what he was to do, in view of Mr. Lucas's motion that the matter be postponed until the precise method in which general subjects were to be selected and considered were determined.

Dr. WOOLNOUGH moved: "That each Section decide for itself " what discussion shall take place at its next general meeting, in order to make the subjects sectional and not general."

Mr. KNIBBS seconded the motion, and suggested that it should be put in the following form: "That the Council, while approving in general with the proposal that subjects for discussion should, where possible, be selected two years in advance, prefers to leave the matter entirely to sectional management."

Dr. WOOLNOUGH adopted the suggestion, and amended his motion accordingly.

The PERMANENT HONORARY SECRETARY said it seemed to him that the proposal was superfluous, and it might be awkward in future if the General Council found it necessary to give detailed instructions of that character to the section.

Mr. TEECE: The resolution confirmed at the Adelaide meeting is now law. As I construe it, this motion is needless. I presided at the Local Council when the matter was discussed. The whole thing turns on the discussion of Mr. Lucas's amendment, where it refers to these resolutions regarding the early choice of subjects. I do not think we should allow ourselves to be overpowered by technicalities of this character. Mr. Lucas has already explained that he had no intention by his amendment to override the resolutions, and it seems to me our obvious course to pursue is to allow the resolution to pass. They have already the force of law, having been adopted at Adelaide and Brisbane meetings. Mr. Lucas's amendment seems to me not to interfere at all with them, but merely as to the manner in which the motion should be discussed.

Dr. BROWN: Has not the sectional committee power to choose any subject it likes?

The PERMANENT HONORARY SECRETARY: Yes, but the object of my original motion at Adelaide was to choose subjects for discussion, and the decisions would come with the authority of the whole Association. The whole Association could decree that a certain discussion shall take place at a particular meeting, but leave the details of arrangement for such Association discussions to each meeting.

Dr. BROWN said he saw a great many difficulties ahead. It might be possible that the Association would hold a meeting and have no subjects for public discussion. It appeared to him that the principle of Mr. Maiden's first resolution, passed at Adelaide and confirmed at Brisbane was a good one. There were many members of sections who would like to take part in discussions which they could not do unless there was a special time put aside for them. There were certain national subjects appropriate for discussion by members of the different sections. The Council had simply to settle whether they were to have public discussions on certain subjects or not.

Professor SKEATS said it appeared to him that the subject (the effect of the destruction of forests on the flow of streams in Australia) which Mr. Maiden proposed for discussion was a subject which was not sectional, but one which concerned two or more sections of the Association. What was intended was that two years ahead there should be chosen one or more subjects of general or national interest which could be debated and discussed at the following meeting.

The PERMANENT HONORARY SECRETARY: Hear, Hear.

Professor SKEATS: We want some wording to carry that general proposal into effect. This is not a sectional matter, but means that from time to time we shall have subjects involving two or more sections which might be publicly discussed, and time be allowed for them at the meetings two years hence.

The PRESIDENT: I think the discussion has been valuable, because it has brought home to us what is wanted. I would suggest that possibly it would be well to appoint a small Committee to report to this Council before the conclusion of the present session as to the best means to giving effect to the wishes of members in this matter. (Hear, hear.)

Mr. FOWLES moved: "That in order to carry out the instructions involved in the motion carried at the Brisbane meeting, a sub-committee, consisting of the Presidents and the Secretaries of Sections, be appointed to decide upon the precise method in which general subjects are to be selected and considered."

Mr. SELWAY seconded the motion, which was agreed to.

RECOMMENDATION COMMITTEE.

Professor POLLOCK moved: "That the Recommendation Committee consist of the Presidents of Sections, with the usual *ex officio* members, with power to add to their number."

Mr. KNIBBS seconded the motion, which was agreed to.

MESSAGES OF GREETING.

The PERMANENT HONORARY SECRETARY moved—"That messages of greeting be sent to the absent President, Professor Bragg, and to the absent founder of the Association, Professor Liversidge."

Mr. DUCKWORTH seconded the motion.

The PRESIDENT said he met Professor Bragg and Professor Liversidge in London recently, and they both spoke with great cordiality about the meeting. He had pleasure in announcing that he was the bearer of the message from Professor Liversidge wishing the Council all prosperity. (Applause.)

The motion was carried with acclamation.

Mueller Memorial Medal.

The President : The Mueller Memorial Medal Committee has recommended that the medal be awarded to Robert Etheridge (Curator of the Australian Museum, Sydney), for his researches in Palæontology and Ethnology. (Applause.) This was the unanimous finding of the Committee, and I will call on the Secretary to mention the subject.

The Permanent Honorary Secretary : I need say nothing about Mr. Etheridge's researches, either in New South Wales or to our friends from the other States, who are co-workers with Mr. Etheridge. (Hear, hear.) Mr. Etheridge is no longer a young man, and he has been a distinguished worker in palæontology, ethnology and anthropology over a period of years commencing before many of the gentlemen whom I see here were born. He is also known for his bibliographical work. He is one of the most accurate men with whom I have ever been brought into contact. Personally I have very much to be grateful to Mr. Etheridge for, as I have been helped by his accurate methods. He is a living example of the value of the advice attributed to Archbishop Whewell of " Verify your references." (Hear, hear.)

Dr. Hall (Victoria) supported the recommendation of the Committee. Mr. Etheridge had not only worked in Victoria and New South Wales, but in Queensland, South Australia and Tasmania. The whole continent was indebted to Mr. Etheridge. As regards his bibliographical work, his works on that subject had always been on his (Dr. Hall's) table for constant reference.

The recommendation of the committee was carried by acclamation.

Report and Balance-sheet.

Mr. Carment, Honorary General Treasurer, read the report and balance-sheet, and moved their adoption.

Mr. Teece seconded the motion. The auditors had discovered that the whole of the funds of the Association appeared to be under the heading " Research Fund." How that absorption came about he did not know, but it appeared that in the beginning the fund was known as a Perpetual Fund, and the subscriptions from life members and the interest thereon was set aside as a Research Fund, but as time went on the whole thing was looked upon as a Research Fund. The fact that it appeared in the report in such a way might lead members to believe that the Association had no funds. As a matter of fact, only a small portion of that fund of £3,000 was Research Fund, and the balance remained to be used by the Association as is thought fit.

The motion for the adoption of the balance-sheet was carried unanimously.

Report on Teaching Geometry in Schools.

Mr. Roe asked what had been done in connection with a resolution adopted by the Association with regard to the uniform teaching of geometry in schools, moved by him personally. He understood that Professor Bragg, while in England, was to interview the authorities at Cambridge University, and he would like to know if Professor Bragg had been successful.

The Permanent Honorary Secretary said that two years ago he wrote to Professor Bragg, and also to Mr. Duffield, forwarding a copy of Mr. Roe's resolution. He had not heard anything further about the matter, except that he understood that Professor Bragg had spoken to Mr. Roe and had written to him on the matter.

Mr. Roe: I heard from Professor Bragg some twelve months ago, when he told me he was moving, and that the matter was meeting with favour outside Cambridge University, but not in Cambridge University.

The Permanent Honorary Secretary: I have no further information.

Mr. Roe: Then I will know what action to take.

The meeting terminated.

SECOND MEETING.

The second meeting of the General Council of the Australasian Association for the Advancement of Science was held at the Sydney University on Thursday, January 12th, 1911, at 4 p.m. Professor Orme Masson presided, and there was a large attendance.

Appointment of Officers for Melbourne Meeting.

The President: The first business is to appoint officers for the Melbourne meeting in 1913. According to the usual procedure, the Victorian members of the Council have consulted together, and they are prepared to unanimously support a motion, which I now call upon Professor Skeats to bring before you.

Professor Skeats: In connection with the nomination of the President for the Melbourne meeting, the Victorian members, at their meeting recently held, have in mind not only the fact that they were to nominate the President for the Melbourne meeting of 1913, but that in the following year, 1914, when the British Association will meet in Australia, the gentleman nominated for presidency in 1913 will still be the President of the Australasian Association. In view of that fact we have unanimously decided to nominate as President of the Melbourne meeting in 1913, Professor David—(applause)—I do not think it needs any further words of mine to recommend in any way the claims of Professor David to such a position. (Hear, hear.) There was one matter that occurred to us in the meeting—that was that hitherto in the Association it has not been the custom to re-appoint a gentleman who has already been President of this Association. Professor David has been President of this Association, but we felt that in view of the very special circumstances attending this nomination that the gentleman nominated will be President during the visit of the British Association, we thought it would be well, at any rate for this next nomination, to nominate Professor David.

Professor STEELE : I have much pleasure in seconding the motion. There is nothing I can say in addition to what Professor Skeats has said. I would merely emphasise the fact that we felt strongly that this tradition that a past President should not be nominated for future presidency should be waived when we had an opportunity of having as our President, during the visit of the British Association, a man of such distinguished attainments as Professor David. (Applause).

The PRESIDENT : This is the nomination of certain Victorian members who have met together and consulted. Of course, it is open to this Council to accept or reject that nomination, and therefore I must ask for any other motion any member may desire to make.

Mr. J. SHIRLEY : I think everyone here is fully satisfied with the nomination, but the point that comes to my mind is that there must be a President-elect at the time. The President-elect will have to be nominated at the Melbourne meeting before the visit of the British Association, and there will be a President and President-elect in existence. There may be some claim on the part of the President-elect. (Voices : " No.") I think you misunderstand me. He will have some standing at the time. (Voice : " No official standing.") Professor Masson will be President until he has a successor, but you are going to depose him from any honour that might follow from the visit of the British Association.

A Member : We have always a President-elect and a President. If the Local Committee meet, it will meet under the presidency of the present President. Professor Orme Masson is our President until the next meeting in Melbourne. The meeting in Melbourne to deal with the presidency will meet under the presidency of Professor Masson, not the President-elect.

The PRESIDENT : I think, as a matter of law, that is correct. The President-elect enjoys all the pleasures of anticipation—(laughter)—but he is not fairly entitled to anything else. In the present instance when I was President-elect I did come in for a certain amount of duty (but that was simply because Professor Bragg, the President, had left Australasia) in connection with the invitation of the British Association. I think it was only because I was President-elect, and there was no President, that I was put in such a prominent position, but that was quite unusual. In the absence of any motion to the contrary I declare Professor David elected as President of the next Melbourne meeting of this Association—(applause)—and I feel that no words of mine are necessary to make it more thoroughly understood than it is at this moment that that is a most eminently satisfactory selection. (Hear, hear.)

The appointment of other officers for the Melbourne meeting was postponed.

Place of Meeting Next Following.

The President : The next business is to decide upon the place for the meeting next following the Melbourne meeting. There has been a certain rotation which I will ask the Secretary to read to you.

The Permanent Honorary Secretary : There are two rotations. The first is Sydney, Melbourne, Christchurch, Hobart, Adelaide, Brisbane ; the second is Sydney, Melbourne, Hobart, Dunedin, Adelaide, Brisbane and Sydney. So that after Melbourne originally Christchurch came, and on the second time of going round Hobart came.

The President : I think there are two things that go to determine the matter. One is past habit, the other is the goodwill of the representatives of the places in which we might like to meet. We cannot say we will meet in Hobart unless the Hobart representatives are prepared to say they will be glad to see us there. This is usually a matter for formal invitation. I think we would be more happy if we had some definite motion from the representatives of one of the States asking the Association to select their capital. (Hear, hear.)

Professor H. B. Kirk : The Wellington members of the Association will be heartily glad to receive the members of the Association there, and although I do not wish to force precedence of Hobart, if the Hobart representatives wish it, I move that the next meeting be held at Wellington, New Zealand.

Colonel Legge (Tasmania) : I am not the official delegate from Tasmania, but I can assure the Council the whole of the public in Tasmania had thought that after the meeting in Melbourne we should have the honour of meeting in Hobart. It is only my duty now to let this Council know, speaking of my State, that it is a favourite State for nearly all who will be there. I do not wish to say anything against New Zealand ; that is a most magnificent country as regards scenery.

Professor Kirk : I am quite prepared to withdraw in favour of Hobart, or have my motion postponed. Although Wellington will be exceedingly glad to receive the Association, we do not wish to push ourselves in front of Hobart.

Professor Laby : To put the matter in order, I second Professor Kirk's motion.

Professor KIRK : I am prepared to withdraw the motion should the Hobart representatives desire it.

Dr. T. S. HALL : I may point out that exactly the same difficulty occurred at Brisbane before the meeting in Melbourne, owing to some carelessness on the part of the official in Melbourne who ought to have looked after it, and it was not until after Brisbane had been reached that it was found that the invitation should have been sent. It was only through one of the Melbourne men taking on himself the duty of inviting the Congress to Melbourne that enabled the difficulty to be got over. I may say that we all fully expected that the Association would go to Hobart next. (Hear, hear.)

The PRESIDENT : If we take it that both invitations are before us it will be necessary for the Council to decide which invitation shall be accepted for that particular year.

Mr. WRIGHT : Before I left Christchurch, the Canterbury Philosophical Institute had the idea that you were going to New Zealand, and as far as the Canterbury Institute is concerned they are prepared to help the Association at the next meeting. I know they more than half expected you were going to New Zealand next time.

The PRESIDENT : Do I understand you are speaking for New Zealand or Christchurch ?

Mr. WRIGHT : I am speaking for New Zealand generally. I support the motion as far as Wellington is concerned.

Colonel LEGGE : To bring the matter in a businesslike form I move—That the meeting of the Association next following the Melbourne meeting be held in Hobart. (Applause.)

Professor SKEATS seconded the motion.

Porfessor KIRK : I desire to withdraw the invitation to Wellington, and would like to state that those who represent Wellington at the next meeting will certainly again bring forward the motion, and it will not lack heartiness. (Applause.)

The PRESIDENT : The applause that has greeted those remarks shows that the Council will be glad to have that invitation renewed at a later date. (Hear, hear.) There is only one motion before us—that the meeting be held at Hobart—and I have pleasure in declaring it carried. (Applause.)

REPORT OF RULES SUB-COMMITTEE :

ALTERATIONS AND ADDITIONS TO RULES (See pages xlvii to lxxii).

The PERMANENT HONORARY SECRETARY : At the last meeting a sub-committee was appointed to consider the rules. It met, and now submits the following recommendation. In Rule 4 it is proposed to add "Matriculated students attending the University in the State in which the meeting is being held may become Associates on payment of 10s." That practice has been carried out for the last few years, although it did not have the force of law. I move the adoption of the alteration on behalf of the sub-committee.

Professor H. W. KIRK: I move as an amendment that the words be "Matriculated students." There are students of other Universities that would like to be present at the meeting.

The PRESIDENT: Do you mean to say of any Australasian University?

Professor KIRK: Yes.

The PERMANENT HONORARY SECRETARY: The Committee thought an objection to that was our asking for a concession in fares when they only pay 10s.

Professor WILSON: I have pleasure in seconding the amendment that it apply to students of Australasian Universities.

The PRESIDENT: I presume you desire it to refer to Matriculated students?

Professor WILSON: Many students of Universities are not matriculated, for instance, students working at chemistry or biology. They are interested in those particular branches of learning, and it seems hard through the accident of their not being matriculated to deny them the privilege of becoming associated with University work. Although the reductions in their fares in each State are contingent on their being matriculated, that is no reason why we should restrict our affairs in that way. In fact it is the unmatriculated students who require more concessions than matriculated students. I would suggest that the wording be "Students in attendance at lectures at any of the Australasian Universities."

Mr. J. B. HENDERSON supported the suggested amendments, and the new rule as amended was agreed to.

The PERMANENT HONORARY SECRETARY: The next recommendation of the sub-committee is that Rule 6 be re-cast altogether so that it will read as follows:—"There shall be a Council consisting of the following: (1) President and former Presidents, Vice-Presidents, Treasurers and Secretaries of the Association, and present and former Presidents, Secretaries of Sections, and local Secretaries. (2) Members of the Association delegated to the Council by scientific societies. (3) Secretaries of Research Committees appointed by the Council."

"Scientific societies shall be invited by the local committees of the State in which the ensuing meeting is to be held to delegate members to the General Council; the number of such delegates is not to exceed one to every 100 members of the delegating societies; such delegates shall be members of the General Council only for the session to which they are delegated."

I propose that the rule that I have just read be substituted for Rule 6 as printed.

Professor SKEATS seconded the motion.

A Member: I should like to ask whether there is any limit to the number of delegates from each society.

The PERMANENT HONORARY SECRETARY: In practice in New South Wales we have confined the number to a maximum of three. That is an unwritten law, and I do not know if the other States have followed that practice.

The PRESIDENT: If that is so, should not the rule be altered accordingly?

A Member: Supposing a society has a membership of under 100, say 99?

The PERMANENT HONORARY SECRETARY: It will be entitled to one representative. I am prepared to alter the reading of the rule to make the maximum representation three. (Hear, hear.)

New rule with suggested alteration agreed to.

The PERMANENT HONORARY SECRETARY: The next recommendation is with regard to the alteration of Rule 9 from what it reads at present. The proposed new rule is as follows:—

"The officers shall consist of the President, five vice-presidents, a general treasurer and local secretaries and treasurers, who shall be appointed at each session, and a permanent honorary secretary. All appointments shall be made by the Council, and all officers elected for one session shall hold office till the commencement of the next session."

(Some discussion ensued as to the wording of the new rule, and Mr. Fowles moved that the drafting of the clause referring to the Permanent Honorary Secretary be left to the President and Secretary for re-submission to the Council at Saturday's meeting.)

Mr. DUCKWORTH seconded Mr. Fowles' motion, which was agreed to.

The PERMANENT HONORARY SECRETARY: The sub-committee suggests that in Rule 18 the words "Before each meeting of the Association" be substituted in lieu of the word "annually." I move that the suggestion be agreed to.

Mr. KNIBBS seconded the motion.

Agreed to.

The PERMANENT HONORARY SECRETARY: As an addition to Rule 19 it is proposed that before the rule as printed the following words should appear.

"Grants of money for the furtherance of specific objects of scientific research may be made by the General Council on the recommendation of the Recommendation Committee." As a matter of fact it is otherwise provided for, but it is put there as a matter of convenience. I move that the addition be agreed to.

Mr. SHIRLEY seconded the motion.

Agreed to.

The Permanent Honorary Secretary asked permission to re-number some of the sections in Rule 22 ." G 2 Agriculture " was deleted from the list of sections and reinserted as " K—Agriculture " at the end.

The Permanent Honorary Secretary: The Committee recommends that Rule 36 shall be preceded by the following words: " It shall be in the power of the Council to appoint research committees on the recommendation of the Recommendation Committee." The alteration makes the operation clearer. I move that the recommendation be adopted.

Professor Pollock seconded the motion.

Agreed to.

The Permanent Honorary Secretary moved as a consequential amendment that Rule 37 be struck out.

The motion was agreed to.

Publication Committee.

The Permanent Honorary Secretary moved: " That the Publication Committee shall consist of the secretaries of sections and the General Treasurer and Permanent Honorary Secretary."

Motion agreed to.

Arrangements re Date of Meeting.

Professor Kirk: I propose that it be a recommendation to the Local Council of Victoria that the date of the next meeting should, if possible, be chosen in such a way as to economise the time of members coming from a distance. I do not wish to be always quoting New Zealand, but that is the one place that I can quote in point on this occasion. The New Zealand members must come direct by boat, and to arrive in time on this occasion we had to come to Sydney six days before the meeting. In addition to that we must spend four days coming and four days going back. Most of us have no more time to stay, and we felt we should like to join in the excursions that are to take place next week. Some effort should be made to avoid this if possible.

The Permanent Honorary Secretary: I suggest that that may be got over by the New Zealand members writing to the Victorian Local Council as the time approaches to fix a suitable date.

Professor Kirk: The objection to that would be that New Zealand is not the only place from which delegates come, and New Zealand might ask for dates that would not suit Queensland, and so on. The Victorian Committee would be in a position of deciding what would suit.

The President: I suggest that having called attention to this matter, and it being recorded on the minutes that you have done so, your object will be quite achieved, because I am quite sure the Victorian Local Council will do all they can to meet your views.

Professor KIRK: I am quite satisfied with that and withdraw the motion.

VETERINARY SCIENCE.

The PERMANENT HONORARY SECRETARY: The Committee on Section G2—Agriculture—report that Professor J. D. Stewart, who is Professor of Veterinary Science in this University, desires that veterinary science be raised to the rank of a section of this Association.

After discussion, in which it was pointed out that the subject of agriculture itself has only just been raised to the rank of a section, it was decided to recommend that the subject of veterinary science be a sub-section of the agriculture section.

SURVEY WORK—NEW ZEALAND.

Mr. HEDLEY: I move—

> "That in the opinion of the Australasian Association the investigation of the continental shelf around New Zealand and the islands of the South of New Zealand is a work of pressing necessity, both for scientific and for economic reasons; and the Association, while recognising the value of the work already done in this direction, would urge upon the New Zealand Government the desirability of taking advantage of the facilities offered by the stay of the Antarctic exploring ship Terra Nova in New Zealand, to complete the survey of the surrounding seas by soundings and dredgings as far as possible."

In support of this motion I would remind the Council that when Lieutenant Shackelton went south he altered the procedure, inasmuch as it had been the custom for explorers in the Antarctic to allow their ships to stay in those regions. Lieutenant Shackleton sent his ship back to New Zealand, and that procedure will be adopted in future. In sending the ship back to New Zealand he arranged that she should be used in connection with scientific work in his absence, such as sounding, dredging, studying contour and ocean currents, and so on. I had hoped, as all students of oceanography did, that the ship would have done nearly as much work around the coast of New Zealand as the Shackelton party in the Antarctic, instead of lying idle in Lyttelton Harbour. The disappointment remained, and it appears the programme is likely to be repeated. Another ship is going back to New Zealand, and I wish to strengthen the hands of our New Zealand *confrères* by moving this motion, so that the New Zealand Government will move in that direction; and I trust to have a unanimous and cordial vote on this matter. (Applause.)

Mr. STEAD seconded the motion.

Professor POLLOCK: I do not understand how the suggestion is to be made to the agent of the Terra Nova, which is a privately-owned ship.

Professor KIRK: Captain Scott is very anxious to have this work done, and has asked the New Zealand Government for a grant. They have a staff on board ready to do the work. From the point of view of the promoters of the expedition that staff would be absolutely useless if it were not used in making these surveys.

Professor POLLOCK: That fully answers my question.

The motion was carried unanimously. (See p. lvii.)

FORESTS PROTECTION.

Colonel LEGGE: The motion that I will move deals with a matter that was informally mentioned at last meeting. I spoke to the Permanent Honorary Secretary, and he recommended that I should bring forward some such motion to-day. It is in reference to the conservation of water supply. I move—

> "That in view of the vital importance of the conservation of water in Australia by the protection of forests and timber around the sources of its rivers and streams, and which was to have been considered at the present Congress, but was deferred until next meeting in Melbourne, by resolution carried last Monday, it is advisable that a special committee be now appointed to deal with the question in the meantime, and also bring it to the notice of the several Governments of the Commonwealth, in order to prepare the way for a more successful result when dealing with the matter at the Melbourne meeting."

The evil is going on every year throughout Australasia. I know especially in Tasmania the evil that is being done by the clearing of timber around the sources of streams. I am sure it is going on here as well as in Tasmania. The American Forestry Department has taken the matter vigorously in hand and is carrying out experiments, having observations made of the flow of streams where the sources are cleared, and where they are not cleared, and where they are in primeval forest. I think we should follow their example in the Commonwealth. It is very hard to get the Government to move in this forestry matter. By having a special committee going into the matter and urging the Government to deal with the matter thoroughly in their Lands Department in each State some good might be done before it is considered at the next meeting. My feeling is that we should not lose two years' time.

Mr. LUCAS seconded the motion.

The motion was carried unanimously.

Colonel LEGGE: I would ask that this special committee be appointed on Saturday.

Nomination of Committee left to Colonel Legge to bring forward at next meeting on Saturday, 14th January, 1911.

Biological and Hydrographical Study of N.Z. Coast.

The Permanent Honorary Secretary: The Recommendation Committee recommends the adoption of the report of the Committee for the biological and hydrographical study of the New Zealand coast, and recommends that that Committee be reappointed.

Recommendation adopted.

Deep-Sea Dredging—Australian Coast.

The Permanent Honorary Secretary moved—"That the Committee on deep-sea dredging on the coast of Australia be discharged, Mr. Hedley having reported that the work is being undertaken by the official dredger, 'The Endeavour.'"

Mr. Hedley: I would like to state that I am not ungrateful for the assistance given by this Association, but I do not want to spend the money of this Association while the same object can be attained by the expenditure of Government funds.

Motion agreed to.

Periodical Literature.

Professor Wilson moved—"That a Committee be appointed to consider what steps should be taken with a view to the compilation of complete lists of serial and periodical literature both in public and private possession in each of the centres of Australasia." He said: In a remote part of the world, remote from the centres of periodical literature, we are often, with our inadequate resources, face to face with difficulties which will take us three months or more to look up or have looked up, some reference which is necessary to the proper appreciation of the work in hand. I think most scientific workers have had that experience, and will always have it, the more thorough their work is. The Australasian Association is the only institution which is co-extensive with Australasia, and which alone, therefore, can undertake the compilation of such a list or catalogue, which would be of immense service as a hand-book.

Dr. Hall suggested that the words "Scientific and technical" be inserted. He asked, "Are we to include only the natural sciences, or is it to include the whole work of this Association?" I think the matter ought to be more definite.

The Permanent Honorary Secretary: I hardly think the compilation of a work of this sort, if it is passed by the Council, which I hope it will be, could be carried out by the officers of the Association. Professor Wilson's is a very valuable suggestion, and it would be worked out on the card catalogue system. I would suggest it would be perfectly safe to leave the matter to the Committee of the Association proposed to be appointed.

Professor WILSON: I admit that the proposition is very vague, but the idea occurred to me only recently, and not in time to formulate a definite scheme. Perhaps it would be well to hasten slowly and allow the scheme to be thrashed out.

Professor POLLOCK seconded the motion, which was carried.

The PERMANENT HONORARY SECRETARY then, on behalf of the Recommendations Committee, moved seriatim, that certain resolutions be approved. (See pp. lv.-lx. for the list.)

Professor POLLOCK seconded the motion, which was agreed to. The meeting terminated.

THIRD MEETING.

The third meeting of the General Council of the Australasian Association for the Advancement of Science was held at the Sydney University on Saturday, January 14th, 1911, at 11 a.m. Professor ORME MASSON presided, and there was a large attendance.

APPOINTMENT OF OFFICERS.

The PRESIDENT: With regard to the appointment of the officers of the Association, in the first place the wording of the proposed rule was not quite satisfactory, and it was referred to the Permanent Honorary Secretary and myself to re-draft it. It was suggested afterwards that there should be some special enactment concerning the appointment of the Permanent Honorary Secretary to enable us to remove such an Officer. The proposed rule is as follows :—

> Officers shall include a President, five Vice-Presidents, a General Treasurer and Local Secretaries and Treasurers, who shall be appointed by the General Council at each meeting of the Association, and shall take office at the next following meeting, and there shall also be a Permanent Honorary Secretary who shall hold office until his appointment is terminated by death or resignation or by reason of a resolution of the General Council, the mover of such resolution to give not less than three months' notice in writing.

I thought it necessary to prevent it being possible, by a catch vote at a meeting, to get rid of a valuable officer—(hear, hear)—and that three months' notice in writing should be given. That will still leave it possible to appoint a new Permanent Honorary Secretary at one meeting, without delaying the matter till the next. The proposed new rule will take effect at once if carried.

The proposed new rule was agreed to on the voices.

Mr. Teece : There is nothing to prevent the Permanent Honorary Secretary employing clerical assistance to assist him in the discharge of his duties. It is altogether absurd to expect Mr. Maiden or any other gentleman to perform all the work in connection with this meeting. (Hear, hear.) He cannot do it.

The President : I am very glad that you have brought that matter forward, because the labours of the Permanent Honorary Secretary are very heavy. (Hear, hear.) I think he should be relieved of the most arduous portion of his work.

The Permanent Honorary Secretary : I have cut down expenditure for clerical assistance to the very bone, but I may point out that the work of the Association is showing a very healthy increase year by year, and I cannot promise to cope with it indefinitely. With regard to Rule 9 in connection with the five vice-presidents to be appointed, the rule says that they shall be appointed from past Presidents. I would point out that only four of those are at present alive—Professor Liversidge, Professor Bragg, Professor Masson and Professor David. The last-named gentleman is ineligible in the present case, because he is our present President-elect. Therefore, there remain Professors Liversidge, Bragg and Masson, and I would suggest that you do an illegal act, as they did in Brisbane, that is to have two gentlemen who have not been President elected Vice Presidents.

The President : This is another matter that was deferred from Thursday. We have to appoint five Vice-Presidents under the rule, and under the rule they must be past Presidents. It seems better to appoint five and add the names of two gentlemen as suggested by the Permanent Honorary Secretary, who are not past Presidents. The names that have been suggested are Mr. Teece and Mr. Knibbs. (Applause). The Permanent Honorary Secretary desires me to point out that those names were selected not only on account of the merits of their owners, but because these gentlemen are representative of Australia rather than of one State. (Hear, hear.)

The election of Messrs. Teece and Knibbs was agreed to on the voices.

Mr. Teece and Mr. Knibbs returned thanks in suitable terms for their election.

The President : With regard to the other officers to be appointed, it has been suggested that the Local Secretaries should be Dr. T. S. Hall, Victoria ; Mr. J. H. Maiden, New South Wales ; Mr. Howchin, South Australia ; Mr. A. Gibb Maitland, West Australia ; Mr. John Shirley, Queensland ; Mr. Robert Hall, Tasmania, and Dr. C. Coleridge Farr, New Zealand.

Mr. SHIRLEY : I should like to remind the Council that although we have amended the rules, they do not come into force until the Melbourne meeting. I wish to add to that motion that Dr. T. S. Hall be General Secretary for the Melbourne meeting.

The motion as to the appointment of Local Secretaries as named, with the addition suggested by Mr. Shirley, was carried on the voices.

Mr. LUCAS moved that the present Auditors of the Association (Messrs. R. Teece and R. A. Dallen) be reappointed.

Mr. A. HAMILTON seconded the motion, which was agreed to.

RESEARCH COMMITTEES.

The PERMANENT HONORARY SECRETARY moved the adoption of the reports of the Research Committees, which had been submitted to the Recommendation Committee. They were as follows : The Solar Eclipse Committee, appointed to observe the eclipse in Hobart in May, 1910, the Glacial Phenomena Committee, of which there are reports from South Australia, Western Australia and New Zealand ; a report on the structural features of New Zealand, submitted by Mr. Speight, the Local Secretary of New Zealand, and the report of the Alkaline Rocks Research Committee, submitted by Dr. Jensen, the Honorary Secretary of that Committee.

Mr. FOWLES seconded the motion, which was agreed to.

EARLY PRINTING OF PAPERS.

A discussion then took place on the general subject of the early printing of papers read before the Association.

Mr. TEECE : A way out of the difficulty would be to have these papers printed before the meeting takes place. They could then be in the hands of members before the meeting, and there would be no occasion to read them. They would only present a digest of them, and there would then be ample time for discussion. When a paper is not printed until two years after it is read it is not of much use. The time for printing papers should be at the time when they are burning questions.

Professor SKEATS : If the suggestion of Mr. Teece were practicable it would be eminently desirable ; but our experience goes to show that it is absolutely impossible.

Dr. WOOLNOUGH : We always find that there are a number of papers submitted which are cut out and are submitted to local societies afterwards. I think it would be impossible to print all the papers submitted beforehand, and also undesirable to do so. (Hear, hear.) I think a very strict censorship should be exercised over the papers presented to the Society.

The PERMANENT HONORARY SECRETARY : As regards the present meeting I have received authorisation from the local Council to print in Parts, and that will be an attempt to get prompt publication. As regards the matter of personal attendance at section meetings, which has been referred to, there are very great difficulties in keeping a large body of men and women together for even so short a period as one week, and the only possible way that I can see would be to keep them by force in some such institution as Darlinghurst, with a turnkey to see that everybody does the originally arranged business of his Section.

Professor HENDERSON : I would suggest as a way out of the difficulty that the social functions of this meeting should be cut out.

The PRESIDENT : This discussion has been all important. Every suggestion that has been made has been immediately contradicted by another member. The only suggestion that was not immediately opposed by some other member was that of Professor Henderson, and I am prepared to oppose that. (Hear, hear.) I think Professor Henderson will see that there are reasons against his suggestion. A great deal of the work to be done here by the Sections can be done in meeting, but members are enabled by social engagements to polish up their ideas by conversational friction of a very pleasant kind. (Hear, hear.) The officials of the Association will be forced to reflect over what has been said.

ANTARCTIC EXPEDITION.

The PRESIDENT : The only other business submitted from the Recommendation Committee is the request by Dr. Mawson that the Association should vote £1,000 towards the expenses of the proposed Antarctic Expedition. You will remember that a special committee was appointed to deal with that request, that committee consisting of the President, the Treasurer, the Permanent Honorary Secretary of the Association, the President and Secretary of the Geographical Section, and Dr. Mawson. The Committee has unanimously, after very careful consideration, adopted a recommendation. That recommendation has been put before the Recommendation Committee, and it was after discussion adopted without dissent, although there was a good deal of discussion. At the same time I feel, and we all feel, that the proposal we have adopted is so large and important, and so novel a one, that a full explanation is due to you before you are asked to endorse our recommendation. The financial question arose immediately. What is the position of this Association ? We have something approximating to £3,000 of our own. That has been, as was pointed out by your Honorary Treasurer, referred to wrongly as a Research Fund. The rules provide definitely that interest on a certain portion of our funds is earmarked as a Research Fund. The rest is not earmarked in any way. In the first place that £3,000 is vested as a trust under trustees, and the recommendation which I shall read to you later is in the form of a recommendation to be adopted by this Council and passed on to the trustees. It was felt by the Committee that although our savings are not specially earmarked as research grant funds, we cannot get away from the fact that we exist for the advancement of Science in Australia, and that if we have surplus funds that are not required for the ordinary working expenses of the Association, we are practically bound to expend those funds on the advancement of Australasian Science. (Hear, hear.) At all events we cannot possibly do better. I think we may regard ourselves as in the position of a trust body so far as this money is concerned, and undoubtedly we are entrusted with it for the purpose of the furtherance of the scientific work of Australia. (Hear, hear.) Each meeting of the Association is practically self-supporting. The fact that we have accumulated £3,000 shows that to be the case. Each meeting has on the average more than paid its way, except that we have been in the habit of applying to the State Governments for assistance in printing our volume. It was stated at the meeting on Thursday that if this grant of £1,000 were made it would weaken our hands in asking for £500 from the Government towards printing our volume. The view that the Committee took of this question was this—if the State Government asked us our position we are surely in no worse a position if we have to tell them that we hold about £2,000, having voted £1,000 towards a very important scientific object, than we would be if we told them we held about £3,000. (Hear, hear.) Another objection to the proposal to vote £1,000 is that we have never done anything like it before—it is unprecedented—that our votes are very much smaller. The Committee thought that the occasion of the request was also unprecedented—(hear, hear)—and that if £1,000 is a great deal more than our usual votes for scientific objects, still the object we are trying to support will require for its fulfilment a great deal more than the total expense of any ordinary work that we have given grants towards. This expedition will cost £40,000 ; £1,000 is not a very large proportion towards the total cost of the expedition, but it is a substantial sum, and in the opinion of the Committee it should be. It has been stated that this will be £1,000 taken out of the funds of the Association towards one object emanating from the Geographical Section, but a very little consideration shows that the expedition appeals to several Sections and the interests of the Association generally. (Hear, hear.) It appeals to some Sections more than others. It does not appeal very much to the Agricultural Section, as there is not likely to be much discovered in connection with that Section.

Dr. Mawson : Guano.

The President : I thought Dr. Mawson would have an answer. The expedition appeals particularly to Geography, also to Physics and the Section dealing with Meteorology and the Geological Section, and so on. It is the whole Association which is concerned, not only the Geography Section. In the next place, we feel that the proposal to support this expedition appeals to us in this way—not only are we in sympathy with the object itself, which appeals very greatly and deeply to the feelings of Australian nationality, but it also appeals to us if we look at it from the point of view of our own Association. If we take this definite step at the outset, and support the Mawson expedition in this substantial manner, we shall be practically taking up for our Association a very high position as the directing force in things scientific in Australia. (Hear, hear.) We shall indeed be taking up a higher position than this Association has previously taken. The next step will be to go to the Commonwealth Government and the public at large, and we feel it right that this Association approves, as we think it approves, highly of this object for its own sake as well as for the sake of the expedition, that we should proclaim ourselves at the outset the godfathers of the Mawson Expedition. (Applause.) Much more may be said in favour of the object. I am only submitting the matter to the Council to enable it to deal with it. The Committee has not only recommended that £1,000 be granted towards this expedition—it has recommended that that grant be made subject to definite conditions, and I propose to read the resolutions and call your attention to the conditions that we thought should be laid down :—

"That this Council recommends that it be a recommendation to the trustees that the sum of £1,000 be paid from the funds of the Association towards the expenses of the proposed Antarctic Expedition on the following conditions :

1. That the expedition be under the supreme command of Dr. Mawson, free from control by any authority outside Australia.
2. That the details of the scientific work and appointment of the members of the expedition be placed in the hands of a special committee of this Association, such committee to have full powers subject to the final approval of the leader of the expedition. But this condition shall be open to modification after consultation with the Commonwealth Government.
3. That Sir E. Shackleton's full consent to the first condition be first obtained, the President to communicate with him by cable for that purpose.
4. That the sum subscribed be spent upon instruments, which shall become the property of the Association after the conclusion of the expedition.

"That the following be the members of the special committee above referred to, with power to add to their number :

N.S.W.—Professors David, Wilson and Pollock, Messrs. Du Faur, Crummer, Carment and Maiden.

Victoria.—Professors Masson, Spencer, Skeats and Lyle, Messrs. G. H. Knibbs and H. Hunt, Drs. Hall and Norris.

South Australia—Professors Henderson, Mitchell and Stirling.

Queensland—Messrs. Roe and Shirley, Professor Steele.

West Australia—Sir Winthrop Hackett, Mr. A. Gibb Maitland.

Tasmania—Colonel Legge.

New Zealand—Professors Benham and Marshall.

The committee to work by sub-committees."

The object of Nos. 1 and 2 is to prevent any misunderstanding arising later as to who is to be the directing head of this expedition. There is doubt in some minds and in the press as to how far Sir Ernest Shackelton has declared himself to withdraw from the heading of the expedition. We desire it to be an Australian expedition under Dr. Mawson's leadership, and we made that condition in order to make it quite sure that there should be no misunderstanding in future. (Reading from "That Sir Ernest Shackelton" down to "for this purpose.")

In some previous expeditions misunderstanding arose as to who was the head. We desire at the outset that there should be none. The next recommendation of the committee is—reading from "That the details of the scientific work" down to "Commonwealth Government." There are three points there. The first is most important. We ask that our Association shall so far direct the whole policy of this expedition, that it shall, through a special committee appointed at the outset, arrange the details of the scientific work, and also to appoint the members of the expedition. But there are two provisos. First, that it shall be reserved to the head of the expedition, Dr. Mawson, to stamp with his final approval or disapproval the recommendations of that committee. That is necessary, because you cannot ask a man to go to the Antarctic as the head of an expedition, taking under his charge his own life and the lives of the expedition, if he is to have forced upon him companions whom he does not find he could like or trust. Therefore it is necessary that he shall have the final say. (Hear, hear.) In the next place another condition is attached—"That this supreme control by that committee and the head of the expedition should be subject to some modification if the Commonwealth Government desire it." We hope that they will give a large sum of money towards the cost, and they naturally wish to have a voice in the working of the expedition. The next condition and the last is—and I would like to say that this condition was suggested by Dr. Mawson himself—"That the sum subscribed be spent on scientific instruments which shall become the property of the Association after the conclusion of the expedition." (Loud applause.) That is the report of the special committee which has been referred to the Recommendation Committee and is now open for discussion.

Mr. Hamilton: May I ask the reason for "voted" being used instead of "paid"?

The President: "Paid" will be much more satisfactory.

The suggestion of Mr. Hamilton that the word "paid" be inserted in the report in lieu of the word "voted" was agreed to on the voices.

Mr. Knibbs : I think it should be made clear that we do not require Sir Ernest Shackelton's leave to do anything in connection with the Antarctic. (Hear, hear.) It implies that Sir Ernest Shackelton has some proprietary right in the matter, which we are not prepared to admit.

The President : My impression is, and the impression of the committee was, that Sir Ernest Shackelton has a proprietary right just in the same way that Mr. Knibbs would have, in connection with the investigation of some phenomena, in a paper in which he announces his intention to issue a second one. No one could prevent Professor Pollock or anybody else from jumping his claim, but he would not like to do it. I take it that that is Sir Ernest Shackelton's position. He has a patent right to the investigation of that part of the Antarctic coast, and until he hands over his claim to anybody else he has a prior right. Other nations are respecting his claim.

Mr. Knibbs : I do not think they are.

Dr. Mawson : In the first instance the plan was put forward by Sir Ernest Shackelton in the London press in March last. He asked could he go as leader and said he had £70,000 promised. I said I would consider it, and said I would go as scientific leader. He gave me the names of those gentlemen who had promised to support the expedition. One had promised £20,000. The expedition has been enlarged upon in the English press as "Shackelton's Expedition." But I know he is not going from letters and cables which I have received from him. In reply to one of my letters he said : "I could not possibly go to the Antarctic, and I am furthering the project for you as much as possible." He still keeps his name attached to it. I think now it can be withdrawn, as this scientific association states that it is taking it up, without fear of other nations stepping in, because it is on the basis of scientific etiquette. Lieut. Filchner, the German explorer, is raising £70,000 to go to a portion of the Antarctic which offers only an ice barrier. If that expedition goes he will be disappointed, and there will be no economic results. That expedition is on the way there now, but their equipment indicates not a polar but a sealing expedition, so it is not serious. Sir Ernest Shackelton has some rights, that is to say his name has been associated with it, and he has read a paper before the Society in London, but none of this money will be put to any use at all if he is associated with the expedition. I am assured by a private cable, and I would like the Society to be further assured, that Sir Ernest Shackelton will be a great help to this expedition in London. In fact, he has offered that I can have the "Nimrod" for the interest on its cost. (Hear, hear.)

Mr. KNIBBS : Suppose Sir Ernest Shackelton should say, "I am willing that Dr. Mawson should lead the expedition, but I desire my name to be associated with it." Where would we be then?

The PRESIDENT : Then I think we would be on the road to understanding where we are.

Mr. KNIBBS : We would be in the position of not paying any money ?

The PRESIDENT : No. We would be in a position to communicate further with him. The question might arise as to the value of the results of the expedition. Supposing he said he did not intend to part with the supreme control of the results of the expedition ? We want the cable worded in such a way that we know he is merely a friend in London, and that he does not want to interfere with the complete control by Dr. Mawson.

Mr. TEECE : I have heard nothing to convince me that Sir Ernest Shackelton is a permanent tenant of the South Pole or has even got an improvement lease there. The Japanese Expedition is on its way. I am quite unable to understand that any man or nation can claim an exclusive right to the exploration of the Antarctic regions.

THE PRESIDENT : Not the Antarctic regions, but just that portion of the Antarctic coast that the Australasian expedition is to deal with. That portion has been left to Shackelton because he has established his patent rights. He has handed over the dash to the Pole to Scott's expedition.

Mr. DUCKWORTH : We have no information from the Committee as to how it will stand with regard to the British Government and with other Governments who may be expected to contribute to this fund. In any case the results must go to England. (Voices : "No." "Why ?")

Dr. MAWSON : This is to be an Australasian National Expedition. The President of the Royal Society and of the Geographical Society whom I interviewed last year have expressed themselves in complete sympathy with us, and will do what they can. They have promised instruments, but are poor, because they gave every penny they had to the Scott Scientific Expedition.

Colonel LEGGE : I am assured by the President of the Royal Geographical Society in England that there will be no interference as regards the Geographical Society.

Professor HENDERSON seconded the motion, which was supported by Mr. Hamilton and carried unanimously.

The PRESIDENT : The committee suggested is a fairly large one. (Read the names of the proposed Committee.)

The suggestion is that this Committee should work by subcommittees as members are so widely scattered throughout Australia. In the first place the duties of the Committee will consist of first, approaching the Commonwealth Government with Dr. Mawson and his proposals, and do all it can to get the Commonwealth Government to support it, and for that purpose a special sub-committee might be appointed, and it would be easy to select a sufficient number of members who could attend to that without travelling long distances. Secondly, its duties would include the collection of money in each State from private individuals and possibly from State Governments, and for this purpose we should have to appoint a local committee in each State; such local committees to be formed out of this General Committee, and each local committee would have power to add to its number locally, so as to make influential local committees. Thirdly, there would be the very important duty to draw up the scheme of the scientific work of the expedition. There should be a special sub-committee to draft that work. One member of that committee should be Professor David, who has had vast experience in Antarctic work. There should be others there to represent meteorology, and so on. They would draft a scheme and circulate it by post so that every member of the Committee should have an opportunity of criticising it and getting it altered. Finally, the duties would include the appointment of members to the expedition, and the same sub-committee that deals with the scheme of scientific work might consider in the first instance how many and what sort of men should be appointed; and then very small sub-committees should set to work to find the right men. For example, we might have a sub-committee consisting of Professor Pollock and Professor Lyle to appoint a physicist, another to appoint a meteorologist, and another to appoint a medical man, and so on. All these actions of the sub-committees would have to be approved of by the whole Committee, but that could always be done by circulating the proposals in writing. (Hear, hear.) I thought it better to show that there is a practical way of working this Committee, scattered as it is over Australia and New Zealand.

Mr. Sugden supported the recommendation for the appointment of a committee as outlined by the President, and the proposal was carried unanimously.

Dr. Hall asked was provision made for the expenditure of money by Committees on printing and postage.

The President: I am glad you mentioned it, and I am informed by the Permanent Honorary Secretary that he will see to it.

Votes of Thanks.

The following votes of thanks were moved and carried with acclamation:—

To the Governor, on the motion of Professor Laurie, seconded by the Rev. Mr. Sugden.

To the Sydney University on the motion of Mr. Shirley, seconded by Colonel Legge.

To the Australian Club, the Warrigal Club, the Women's Patriotic League, and the University Club, on the motion of Mr. Knibbs, seconded by Professor Barrachi.

To the Press by Professor Henderson, seconded by Mr. Knibbs, and supported by the President.

To the Officials and Members of Corporations who had extended privileges to members of the Association (including the Chief Commissioner of Railways), moved by Professor Henderson, seconded by Dr. Hall.

To the President of the Association, on the motion of Mr. Teece, seconded by Mr. Roe.

To the Permanent Honorary Secretary, on the motion of the President, seconded by Mr. Shirley.

(The proceedings then terminated.)

RESOLUTIONS PASSED BY THE GENERAL COUNCIL.

SECTION A.

TIDAL SURVEY.—"The Association views with satisfaction the successful establishment by the New Zealand Government of the tidal survey, and trusts that at many of the outlying islands automatic tide gauges may be established, and the results systematically analysed. It directs that a copy of this resolution be forwarded to the Prime Minister of New Zealand."

"That a Committee be appointed to collect information as to the tides of the Pacific, to endeavour to have bench marks connected with all recording tide gauges (as has already been done in New Zealand) and to advise as to where tide-gauges should be established on the outlying islands."

"That the committee consist of Professor Chapman, Adelaide; Mr. G. H. Halligan, Sydney; Mr. P. Baracchi, Melbourne; Professor Moors, Sydney; Mr. C. E. Adams, Wellington. Mr. Adams to act as secretary."

GEOPHYSICAL OBSERVATORY AT BURRINJUCK.—"That the sum of £50 be voted to assist in defraying the expense of establishing a geophysical observatory near Burrinjuck reservoir, for the purpose of attempting to measure the amount of earth tilt under load."

MAGNETIC OBSERVATORIES.—"In view of the great scientific importance of continuous magnetic observations at selected stations, the Association most strongly urges the establishment of magnetic observatories at Perth and Port Darwin, to supplement the long-continued and extremely valuable magnetic work of the Melbourne Observatory. The Association learns with gratification that the reduction of the 40 years' observations of the Melbourne Observatory is now completed, and would earnestly request that the Victorian Government authorise the printing of the results." The foregoing resolution to be brought to the notice of the Commonwealth, Victorian, and Western Australian Governments.

SEISMOLOGICAL EQUIPMENT.—"The Association invites the attention of the Governments of Western Australia, South Australia, New South Wales, and Victoria, to the desirability of increasing and improving the seismological equipment of their respective observatories, in order to fulfil such modern requirement as are represented, for example, in the first order seismological station in the St. Ignatius' College Observatory at Riverview."

PHYSICAL AND CHEMICAL DATA.—" That a committee, consisting of Professor Masson, Professor Warren, Professor Laby, and Dr. Love as secretary, be appointed to co-operate with the international commission for the collection and annual publication of all determinations of physical, chemical, crystallographic, and engineering constants, and that a sum of £25 be granted towards the work of the committee."

MERIDIAN OBSERVATORY.—" That the Association respectfully draws the attention of the Government to the following resolution which was passed at the International Astrographic Conference held in Paris in 1909. This resolution the Association most strongly supports." Resolution referred to :—" Considering the very small number of observatories in the Southern Hemisphere organised for work of high fundamental precision, it is very desirable in the interests of science that a meridian instrument of the most modern type should be installed in Australia."

TEACHING OF ELEMENTARY GEOMETRY.—" That pursuant to the provisions of the resolution carried in Brisbane 1909, with regard to the teaching of elementary geometry, a committee, consisting of Professor Carslaw, Mr. Lucas, Mr. R. H. Roe, with Mr. P. Board as secretary, with power to add to their number, be appointed to carry out the instruction contained in the last half of the Brisbane resolution."

YASS-CANBERRA OBSERVATORY.—" That the Association expresses its gratification of the action taken by the Commonwealth Government in regard to the creation of an observatory at Yass-Canberra, and would recommend that, in order to comply with the request of the International Union for Solar Research, brought before the Council at the Brisbane meeting in January, 1909, such observatory be designed to fill, amongst other requirements, those of a solar observatory."

SECTION B.

" That a general discussion on ' The Eucalypts and their Products ' be brought forward at the Melbourne meeting."

SECTION C.

" That a committee be appointed to enquire into the question of the classification of the Permo-Carboniferous of Australia, with a view to the revision of the nomenclature, such committee to consist of Mr. W. H. Twelvetrees, E. F. Pittman, F. Chapman, A.

Gibb Maitland, B. Dunstan, E. C. Ball, Dr. G. B. Pritchard, Professor T. W. E. David, Dr. W. G. Woolnough, and Mr. W. S. Dun, Secretary."

"That a committee be appointed for recording Structural Features in Australasia, the committee to consist of Professor E. W. Skeats, Professor P. Marshall, Messrs. E. F. Pittman, W. H. Twelvetrees, W. Howchin, H. Y. L. Brown, A. Gibb Maitland, K. Ward, B. Dunstan, R. Speight, Dr. T. S. Hall, Dr. W. G. Woolnough, Professor T. W. E. David, Secretary.

"That a committee be appointed to investigate and report on the Glacial Phenomena in Australasia, to consist of Professor E. W. Skeats, Professor P. Marshall, Dr. W. G. Woolnough, Messrs. A. Gibb Maitland, B. Dunstan, G. West, W. Howchin, R. Speight, Professor T. W. Edgeworth David, Secretary."

"That a committee be appointed to investigate questions of Quaternary Climate in Australasia, to consist of Dr. H. I. Jensen, Messrs. C. A. Sussmilch, E. C. Andrews, R. Speight, Secretary."

"That the committee for the investigation of the Alkaline Rocks of Australasia be re-appointed, the committee to consist of Professors E. W. Skeats, T. W. Edgeworth David, P. Marshall, Messrs. W. H. Twelvetrees, R. A. Wearne, Dr. H. I. Jensen, Secretary."

"That a grant of £50 towards the expenses of the conduct of the investigation be made."

"That the Association cause a communication to be made to the Prime Minister of the Dominion of New Zealand, and place before him the desirability of proceeding with the work of describing and publishing the results of the examination of the collection of fossils made by the officers of the geological survey of New Zealand, and deposited in the Dominion Museum, Wellington."

SECTION D.

New Zealand and Islands—"That in the opinion of the Australian Association, the investigation of the continental shelf around New Zealand and the islands to the south of New Zealand is a work of pressing necessity, both of scientific and of economic reasons ; and the Association, while recognising the value of the work already done in this direction, would urge upon the New Zealand Government the desirability of taking advantage of the facilities offered by the stay of the Antarctic exploring ship Terra Nova in New Zealand to complete the survey of the surrounding seas by sounding and dredging as far as possible."

"The report of the committee for the Biological and Hydrographical Study of the New Zealand coast was approved, and the members—Prof. A. P. W. Thomas, M.A., F.L.S., Dr. W. B. Benham, D.Sc., F.R.S., A. Hamilton, E. R. Waite, F.L.S., and Prof. Chilton, M.A., D.Sc., Hon. Sec. and Convener—were re-appointed.

[The committee for deep-sea dredging off the east coast of Australia, (Mr. C. Hedley, Secretary) was discharged, on Mr. Hedley's motion.]

SECTION E.

Australian History.—" That in the opinion of this Association, it is desirable that the governing bodies of the Public Libraries in Sydney, Melbourne, Adelaide, Brisbane, Perth and Hobart, should communicate with the Secretary of State for the Colonies, asking that duplicates of the despatches that passed between the Governors of the colonies and the Secretaries of State, up to a date fixed upon by the Secretary of State, should be placed under their charge, and that a copy of this resolution be forwarded to the Secretary of each of the libraries aforementioned."

SECTION F.

Australian Aborigines.—" That the Association communicate with the State Premiers, inviting their attention to the advisability of adopting a uniform method of spelling Australian place names."

" That the system of orthography for native names of places adopted by the council of the Royal Geographical Society, the Foreign and Colonial Office, the Admiralty, and the War Office be used."

" That an organised scheme for the future of the Australian aborigines be formulated and submitted for the consideration of the Federal and State Governments ; and that the following be a committee to collect evidence, draw up and submit a proposed scheme to aid these authorities in the event of their consenting to take up the question :—Prof. J. T Wilson, Dr. Norris, Prof. Baldwin Spencer, Prof. Stirling (Adelaide), Mr. Gillen, Rev. Dr. G. Brown, Archdeacon Lefroy, Dr. Cleland, with power to add to their number."

SECTION H.

" That when an engineer has been president at one meeting, an architect shall be selected as president for the meeting following, and so on alternately."

SECTION I.

ANTHROPOMETRIC TESTS.—" (1) This Association recommends that all anthropometric measurements under the control of the Australasian Governments be based on the schedule of the British Anthropometric Committee. (2) That the advantage of utilising for this purpose the existing machinery for medical inspection of school children in the various States, and of the compulsory cadet service of the Commonwealth be urged on the authorities concerned.

VENTILATION IN BUILDINGS.—"(3) That a committee, consisting of Professors Masson, Lyle, and Osborne, Drs. Norris and Harvey Sutton, Mr. Tate, Colonel Watson, and the Public Works Architect of Victoria, be appointed to investigate the subject of ventilation in buildings, and that the committee be asked to present a report to the next meeting (Melbourne)."

SECTION J.

" That it is important in the interests of higher education that additional University teaching should be provided in the department of Philosophy, more especially in the subjects of Sociology and Experimental Psychology."

To be placed before the governing bodies of the Universities of Australasia.

GENERAL.

SCIENTIFIC LITERATURE.—" That a committee be appointed to consider the steps which should be taken with a view to the compilation of a list, as complete as possible, of the scientific serial periodical literature, both in public and private possession in each of the principal centres of Australia."

" That such committee consist of the *ex officio* officers, together with Mr. H. M. Petherick, of Melbourne, Dr. H. G. Chapman and Mr. W. S. Dun, of Sydney, Mr. William Angas and Prof. G. C. Henderson, of Adelaide, Prof. T. Flynn, of Hobart, Prof. A. J. Gibson and Dr. Hamlyn Harris, of Brisbane, with power to add to their number ; Prof. Wilson, Secretary."

PUBLICATION COMMITTEE.—It was approved that the Publication Committee consist of the secretaries of Sections, the General Treasurer, and the Permanent Honorary Secretary.

Time of Meeting.—It was proposed by Professor H. B. Kirk, of New Zealand, and carried—"That it be a recommendation to the Local Council for Victoria that the date of the next meeting should, if possible, be chosen in such a way as to economise the time of members coming from a distance."

Conservation of Water.—It was proposed by Colonel W. V. Legge, R.A., F.R.G.S., of Tasmania—"That in view of the vital importance of the conservation of water in Australia by the protection of forests and timber around the sources of its rivers and streams, it is advisable that a special committee be now appointed to deal with the question in the meantime, and also bring it to the notice of the several Governments of the Commonwealth, in order to prepare the way for a more successful result when dealing with the matter at the next (Melbourne) meeting."

"That the following be members of the special committee:—Leslie Wade, M. Inst. C.E., Chief Engineer for Water Supply and Irrigation, N.S.W.; Ellwood Mead, C.E., President, Water Supply Commission of Victoria; H. Mackay, Conservator of Forests, Victoria; Walter Gill, Conservator of Forests, South Australia; W. Reid Bell, State Hydraulic Engineer, Tasmania, with power to add to their number; Colonel Legge to be Secretary."

AUSTRALASIAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE—GENERAL BALANCE SHEET, SYDNEY OFFICE.

General Account, 1st July, 1908, to 30th June, 1910.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Subscriptions	149	3	5	By Balance at 30th June, 1908	74	8	11
,, Sales of Volumes	8	6	11	,, Legal Expenses	21	0	0
,, Balance	175	15	11	,, Clerical Assistance	33	3	0
				,, Printing and Stationery	46	9	3
				,, *Petty Cash and Expenses	35	13	6
				,, Bank Charges and Exchange	1	1	7
				,, Freight and Carriage	27	10	6
				,, Advertisements	13	19	6
				,, Rent	80	0	0
	£333	6	3		£333	6	3

Research Fund

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance at 30th June, 1908	204	17	3	By Amount lent on Mortgage at 30th June, 1908	2,668	0	0
,, Mortgage at 30th June, 1908	2,668	0	0	,, Prof. Marshall, Dunedin, a/c "Alkaline Rocks" Vote	20	0	0
,, Interest on Mortgage	186	15	2	,, R. A. Wearne, Ipswich	10	0	0
				,, H. S. Summers, Melbourne	10	0	0
				,, Exchange	0	3	6
				,, Balance at Current Account	351	8	11
	£3,059	12	5		£3,059	12	5

Mueller Memorial Fund.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance at Current Account, 30th June, 1908	60	15	11	By Amount lent on Mortgage	432	0	0
,, Mortgage, 30th June, 1908	432	0	0	,, Balance at Current Account	91	0	9
,, Interest on Mortgage	30	4	10				
	£523	0	9		£523	0	9

Audited and found correct.

D. CARMENT, Hon. Treasurer.
14th December, 1910.

RICHARD TEECE, } Auditors.
ROBERT A. DALLEN, }

* This represents the amount advanced by the Treasurer to the Hon. Secretary for petty cash. Of this there was a balance of £3 18s 6½d in his hands on 30th June, 1910. The "Research Fund," so called, is the entire capital of the Association.

AUSTRALASIAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE BRISBANE (1909) MEETING.

STATEMENT OF RECEIPTS AND EXPENDITURE.

Dr. Receipts.	£	s.	d.	Expenditure. Cr.	£	s.	d.
To Government Endowment	500	0	0	By Printing Volumes, 2,000	382	11	0
,, Gross Amount of Subscriptions Received	461	13	0	,, Postage *re* Volumes	73	0	8
,, Exchange Received	1	8	6	,, Advertising	47	14	9
,, Special Donation by W. B. Slade	10	0	0	,, General Printing	59	4	1
				,, Petty Cash, Postages, Telegrams, Stationery	52	3	5
				,, Clerical Assistance	42	10	0
				,, Hiring Furniture	40	11	6
				,, Labour Paid	33	4	0
				,, Excursions and Entertaining	84	19	0
				,, Goods Purchased	18	1	8
				,, Badges	20	0	0
				,, Rents	15	14	6
				,, Telephone Rent	9	13	0
				,, Synchronome Coy.	6	10	0
				,, Electric Light	1	0	0
				,, Typewriting	17	10	4
				,, Bank Charges	2	5	6
					£906	13	5
				,, Balance remitted to General Treasurer	66	8	1
	£973	1	6		£973	1	6

(Sgd.) A. NORTON,
Hon. Treasurer for Queensland.

Examined and found correct.

(Sgd.) HENRY MONTEITH

Brisbane, December 17th, 1910.

AUSTRALASIAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE—QUEENSLAND, 1909-1911.

BALANCE SHEET.

Dr.	£	s.	d.	Cr.	£	s.	d.
To 80 Subscriptions at £1	80	0	0	By Stamps	2	18	6
,, 34 Subscriptions at 10s.	17	0	0	,, Telegrams	0	2	6
,, Excess on three Cheques (1s., 1s., 6d.)	0	2	6	,, Due from Brisbane Meeting, Voucher from Hon. A. Norton	1	10	11
				,, Advertisements (voucher)	0	7	6
				,, Printing (voucher)	0	11	0
				,, Fee Account	0	5	0
				,, Exchange, Loss on	0	3	0
				,, Transfer of Account to Sydney	0	4	7
				,, Balance to Treasurer by Cheque	90	19	6
	£97	2	6		£97	2	6

AUSTRALASIAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE- VICTORIA BRANCH.

STATEMENT OF RECEIPTS AND PAYMENTS FOR THE PERIOD 7TH APRIL, 1909, TO THE 28TH FEBRUARY, 1911.

Receipts.	£	s.	d.	Expenditure.	£	s.	d.
To Balance in Bank, 7th April, 1909	4	19	10	By Stationery	2	2	6
,, Subscriptions for Sydney Meeting—				,, Postage	1	11	5
Members	70	0	0	,, Typing	0	5	0
Associates	11	0	0	,, Draft to Sydney	60	0	0
,, Overpayments	0	3	0	,, Overpayments Returned	0	3	0
,, Interest	0	10	9	,, Draft and Exchange	0	3	1
				,, Balance Remitted to General Treasurer	22	8	7
	£86	13	7		£86	13	7

Examined and found correct.
(Sgd.) J. T. BAINBRIDGE, F.I.A.V.

(Sgd.) T. S. HALL,
Local Secretary.

Feb. 28, 1911.

BALANCE SHEET OF THE AUSTRALASIAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE—

SOUTH AUSTRALIA.

STATEMENT OF RECEIPTS AND PAYMENTS FOR PERIOD FROM MAY 20TH, 1909, TO JUNE 30TH, 1911.

DR.

	£ s. d.	£ s. d.
To Balance, Cash in hand, May 20, 1909 ..	..	0 16 4
,, Interest Savings Bank, June 7, 1909	0 3 10	
,, Interest Savings Bank, June 7, 1910	0 1 4	
		0 5 2
,, Subscriptions Sydney Meeting, 1911—		
36 Members	36 0 0	
12 Associates	6 0 0	
		42 0 0
		£43 1 6

CR.

	£ s. d.
1909—	
By Postages, Remittance and Telegram	0 4 4
1910—	
,, Typist, 26 Circulars calling Meeting of Committee	0 2 0
,, Hussey & Gillingham, 250 Receipt Books ..	0 9 6
1911—	
,, W. K. Thomas & Co Advertising	1 7 6
,, Bonython & Co., Advertising	1 7 6
,, Postages, Telegrams, etc.	0 8 5
,, Remitted to Hon. Treasurer, Sydney	38 0 0
,, Cash in hand (W. Howchin)	1 2 3
	£43 1 6

(Sgd.) EDWARD H. RENNIE, Chairman Local Committee.

June 30th, 1911. (Sgd.) WALTER HOWCHIN Secretary Local Committee.

AUSTRALASIAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE—TASMANIA.

Statement of Receipts and Payments for Period ending January 12th. 1911.

Dr.	£	s.	d.	Cr	£	s.	d
To Subscriptions for Sydney Meeting	14	0	0	By Remittance to Hon. Treasurer, Sydney Office (6/10/10)	8	10	0
				,, Ditto (12/1/11)	3	12	3
				,, Printing	0	19	6
				,, Postages and Petty Cash	0	18	3
	£14	0	0		£14	0	0

(Sgd.) ROBERT HALL, Local Secretary.

AUSTRALASIAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE—COMMITTEE FOR THE BIOLOGICAL AND HYDROGRAPHICAL STUDY OF THE NEW ZEALAND COAST.

Statement of Accounts.

Dr. Receipts.	£	s.	d.	Expenditure. Cr.	£	s.	d.
To Balance as per Statement submitted to Adelaide Meeting (1907)	39	10	9	By Expenses " Nora Niven " Expedition	21	15	3
				,, Expenses Visit to West Coast Sounds	3	5	3
				,, Repairs, Freight, Petty Cash, Stamps, etc. ..	1	3	3
				,, Balance	13	7	0
	£39	10	9		£39	10	9

(Sgd.) R. SPEIGHT,
Acting Secretary for New Zealand.

AUSTRALASIAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE—NEW ZEALAND.

Statement of Accounts—February, 1911.

Dr. Receipts.	£	s.	d.	Expenditure. Cr.	£	s.	d.
To twenty-seven Members' Subscriptions	27	0	0	By Postage	0	8	0
,, Three Associates' (Ladies) Subscriptions ..	1	10	0	,, Draft of Bank of New South Wales	0	3	0
				,, Cost of Printing Supplementary Circular ..	0	13	6
					£1	4	6
				,, Balance	27	5	6
	£28	10	0		£28	10	0

(Sgd.) R. SPEIGHT,

Acting Secretary for New Zealand.

Above balance of £27 5s. 6d. was remitted to me by Bank Draft.

(Sgd.) D. Carment.—17/3/11

OBJECTS AND RULES OF THE ASSOCIATION

Alterations to rules proposed at the Sydney, 1911, meeting are set out in italics. To have the force of law it is necessary that they be confirmed at the Melbourne meeting, 1913.

OBJECTS OF THE ASSOCIATION.

The objects of the Association are to give a stronger impulse and a more systematic direction to scientific inquiry; to promote the intercourse of those who cultivate science in different parts of the Australasian States, New Zealand, and in other countries; to obtain more general attention to the objects of science, and a removal of any disadvantages of a public kind which may impede its progress.

RULES OF THE ASSOCIATION.

Members and Associates.

1. Members shall be elected by the Council.

2. The subscription shall be £1 for each Session, to be paid in advance.

3. A member may at any time become a Life Member by one payment of £10, in lieu of future annual subscriptions.

4. Ladies' (Associates') tickets (admitting the holders to the General and Sectional Meetings, as well as the Evening Entertainments) may be obtained by full members on payment of 10s. for each ticket. Ladies may also become members on the same terms as gentlemen.

Students attending lectures at any Australian University may become Associates on payment of 10*s*.

Sessions.

5. The Association shall meet in session periodically for one week or longer. The place of meeting shall be appointed by the Council two years in advance, and the arrangements for it shall be entrusted to the Local Committee.

MANAGEMENT OF THE AFFAIRS OF THE ASSOCIATION.

Council.

6. There shall be a Council consisting of the following :—(1) President and former Presidents, Vice-Presidents, Treasurers and Secretaries of the Association, and present and former Presidents, Vice-Presidents, and Secretaries of the Sections ; (2) Members of the Association delegated to the Council by Scientific Societies ; (3) Secretaries of Research Committees appointed by the Council.

Rule 6.—*There shall be a Council consisting of the following :—* (1) *Present and former Presidents, Vice-Presidents, Treasurers and Secretaries of the Association, and present and former Presidents and Secretaries of the Sections and local Secretaries.* (2) *Members of the Association delegated to the Council by Scientific Societies.* (3) *Secretaries of Research Committees appointed by the Council.*

Delegates.—*Scientific Societies shall be invited by the Local Committees of the State in which the ensuing meeting is to be held to delegate members to the General Council. The number of such delegates is not to exceed one for every hundred members of the delegating societies. Such delegates shall be members of the General Council only for the session to which they are delegated.*

(New Rule in lieu of old Rule 6.)

7. The Council shall meet only during the Session of the Association, and during that period shall be called together at least twice.

Local Committees.

8. In the intervals between the Sessions of the Association, its affairs shall be managed in the various States by Local Committees. The Local Committee of each State shall consist of the Members of Council resident in that State.

Officers.

9. The President, five Vice-Presidents (elected from amongst former Presidents), a General Treasurer, one or more General Secretaries and Local Secretaries shall be appointed annually by the Council.

Rule 9.—*The Officers shall include a President, five Vice-Presidents, a General Treasurer, and Local Secretaries and Treasurers, who shall be appointed by the General Council at each meeting of the Association and shall take office at the next following meeting. There shall also be a Permanent Honorary Secretary, who shall hold office until his appointment be terminated by death or resignation, or by resolution of the General Council. The mover of such resolution shall give not less than three months' notice in writing.*

(New Rule in lieu of old Rule 9.)

Reception Committee.

10. The Local Committee of the State in which the Session is to be held shall (recommended that the word "*may*" be substituted for "shall") form a Reception Committee to assist in making arrangements for the reception and entertainment of the visitors. This Committee shall have power to add to its number.

OFFICE.

11. The permanent Office of the Association shall be in Sydney.

MONEY AFFAIRS OF THE ASSOCIATION.

12. The financial year shall end on the 30th June.

13. All sums received for life subscriptions and from the sales of back numbers of Reports shall be invested in the names of three Trustees appointed by the Council, and the interest arising from such investment shall be reserved for grants in aid of scientific research.

14. The subscriptions shall be collected by the Local Secretary in each State, and forwarded by him to the General Treasurer.

15. The Local Committees shall not have power to expend money without the authority of the Council, with the exception of the Local Committee of the State in which the next ensuing Session is to be held, which shall have power to expend money collected or otherwise obtained in that State. Such disbursements shall be audited, and the Balance-sheet and the surplus funds forwarded to the General Treasurer.

16. All cheques shall be signed either by the General Treasurer and the General Secretary or by the Local Treasurer and the Secretary of the State in which the ensuing Session is to be held.

17. Whenever the balance in the hands of the Banker shall exceed the sum requisite for the probable or current expenses of the Association, the Council shall invest the excess in the names of the Trustees.

18. The whole of the accounts of the Association—*i.e.*, the local as well as the general accounts—shall be audited *before each meeting of the Association* by two Auditors appointed by the Council, and the Balance-sheet shall be submitted to the Council at its first meeting thereafter.

MONEY GRANTS.

19. *Grants of money for the furtherance of specific objects of scientific research may be made by the General Council on the recommendation of the Recommendation Committee.*

Committees and individuals to whom grants of money have been entrusted are required to present to the following meeting a report of the progress which has been made, together with a statement of the sums which have been expended. Any balance shall be returned to the General Treasurer.

20. In each Committee the Secretary is the only person entitled to call on the Treasurer for such portions of the sums granted as may from time to time be required.

21. In grants of moneys to Committees, or to individuals, the Association does not contemplate the payment of personal expenses to the members or to the individual.

Sections of the Association.

22. The following Sections shall be constituted :—

A.—Astronomy, Mathematics and Physics.
B.—Chemistry, with Pharmacy as a sub-Section.
C.—Geology and Mineralogy.
D.—Biology.
E.—Geography and History.
F.—Ethnology and Anthropology.
G.—Social and Statistical Science.
H.—Engineering and Architecture.
I.—Sanitary Science and Hygiene.
J.—Mental Science and Education.
K.—Agriculture.
Veterinary Science shall be a sub-Section of Agriculture.

Sectional Committees.

23. The President of each Section shall take the chair and proceed with the business of the Section not later than 11 a.m. In the middle of the day an adjournment for luncheon shall be made, and at 4 p.m. the Sections shall close.

24. On the second and following days the Sectional Committees shall meet at 10 a.m.

25. The Presidents, Vice-Presidents, and Secretaries of the several Sections shall be nominated by the Local Committee of the State in which the next ensuing Session of the Association is to be held, and shall have power to act until their election is confirmed by the Council. From the time of their nomination—which shall take place as soon as possible after the Session of the Association—they shall be regarded as an Organising Committee, for the purpose of obtaining information upon papers likely to be submitted to the Sections, and for the general furtherance of the work of the Sectional Committees. The Sectional Presidents of former years shall be *ex officio* members of the Organising Committees.

26. The Sectional Committees shall have power to add to their number.

27. The Committees for the several Sections shall determine the acceptance of papers before the beginning of the Session. It is therefore desirable, in order to give an opportunity to the Committee of doing justice to the several communications, that each author should prepare an abstract of his paper, of a length suitable for insertion in the published Transactions, Reports, or Proceedings of the Association, and that he should send it, together with the original paper, to the Secretary of the Section before which it is to be read, so that it may reach him at least a fortnight before the Session.

There shall be a time limit set for authors of papers read before the Association, which shall not be exceeded except by special arrangement made beforehand with the sectional committee.

28. Members may communicate to the Sections the papers of non-members.

29. The author of any paper is at liberty to reserve his right of property therein.

30. No report, paper, or abstract shall be inserted in the volume of Transactions, Reports, or Proceedings unless it be handed to the Secretary before the conclusion of the Session.

31. The Sectional Committee shall report to the Publication Committee what papers it is thought advisable to print.

32. They shall also take into consideration any suggestions which may be offered for the advancement of Science.

Research Committees.

33. *It shall be in the power of the Council to appoint Research Committees on the recommendation of the Recommendation Committee.*

In recommending the appointment of Research Committees, all members of such Committees shall be named, and one of them, who has notified his willingness to accept the office, shall be appointed to act as Secretary. The numbers of members appointed to serve on a Research Committee should be as small as is consistent with its efficient working. Individuals may be recommended to make reports.

34. All recommendations adopted by Sectional Committees shall be forwarded without delay to the Recommendation Committee; unless this is done, the recommendation cannot be considered by the Council.

Official Journal.

35. At the close of each meeting of the Sections the Sectional Secretaries shall correct, on a copy of the Official Journal, the list of papers which have been read, and add to them those appointed to be read on the next day, and send the same to the General Secretary for printing.

Recommendation Committee.

36. The Council at its first meeting in each session shall appoint a Committee of Recommendations to receive and consider the reports of the Research Committees appointed at the last Session, and the recommendations from Sectional Committees. The Recommendation Committee shall also report to the Council, at a subsequent meeting, the measures which they would advise to be adopted for the advancement of Science.

37. All proposals for the appointment of Research Committees and for grants of money (see Rules 19-21) must be sent in through the Recommendation Committee.

Delete this Rule as unnecessary. (See Rules 19 and 33).

Publication Committee.

38. (37). The Council shall each Session elect a Publication Committee, which shall receive the recommendation of the Sectional Committees with regard to publication of papers, and decide finally upon the matter to be printed in the volume of Transactions, Reports or Proceedings.

Alteration of Rules.

39. (38). No alterations of the Rules shall be made unless due notice of all such additions or alterations shall have been given at one meeting and carried at another meeting of the Council, held during a subsequent Session of the Council.

PRESIDENTS, VICE-PRESIDENTS, SECRETARIES, AND TREASURERS, FROM THE COMMENCEMENT.

SYDNEY, 1888.

President.	Vice-Presidents.	Hon. Secretaries.	Hon. Treasurers.
H. C. Russell, B.A., F.R.S., F.R.A.S. (Sydney).	The Hon. Dr. J. W. Agnew (Tasmania).	Professor A. Liversidge, M.A., F.R.S., Permanent Hon. Sec. (N.S.W.).	Sir Ed. Strickland, K.C.B., F.R.G.S. (New South Wales).
	The Hon. Sir Frederick Darley, Knt. (N.S.W.). C. W. De Vis, M.A. (Queensland). The Mayor of Sydney, Alderman John Harris. Sir James Hector, K.C.M.G., M.D., F.R.S. (New Zealand). The Hon. James Inglis, M.P. (N.S.W.). Professor W. C. Kernot, M.A., C.E. (Victoria). The Hon. Sir W. M. Manning, LL.D., M.L.C. (Sydney). The Hon. H. N. MacLaurin, M.A., M.D., LL.D. (Sydney). Professor E. H. Rennie, M.A., D.Sc. (South Australia). Sir Alfred Roberts, M.R.C.S. (N.S.W.).	George Bennett, M.D., F.L.S., F.Z.S. (N.S.W.).	

PRESIDENTS, VICE-PRESIDENTS, SECRETARIES, AND TREASURERS FROM THE COMMENCEMENT—*Continued.*

President.	Vice-Presidents.	Hon. Secretaries.	Hon. Treasurers.
MELBOURNE. 1890.			
Baron von Mueller, K.C.M.G., F.R.S., M. and Ph.D. (Victoria).	His Excellency Sir Robert G. C. Hamilton, K.C.B. (Tasmania).	Professor A. Liversidge.	H. C. Russell, B.A., C.M.G., F.R.S., F.R.A.S.
	Professor Liversidge, [M.A., LL.D., F.R.S. Sir Jas. Hector. Professor E. C. Stirling, M.A., M.D. (South Australia). W. Saville-Kent, F.L.S., F.R.S. (Queensland). Professor W. C. Kernot.	Professor W. Baldwin Spencer, M.A. (Victoria).	
CHRISTCHURCH, 1891.			
Sir Jas. Hector, K.C.M.G., M.D., F.R.S.	His Excellency Sir R. G. C. Hamilton, K.C.B.	Professor A. Liversidge.	H. C. Russell.
	A. Leibus, M.A., Ph.D., F.C.S. (N.S.W.). Professor W. C. Kernot. W. Saville-Kent. Professor E. C. Stirling, M.D., M.A.	F. W. Hutton, F.G.S. (New Zealand).	H. R. Webb, F.R.M.S. (Christchurch, N.Z.).

HOBART, 1892.

His Excellency Sir Robert G. C. Hamilton, K.C.B., LL.D.	Professor W. C. Kernot.	Professor A. Liversidge.	H. C. Russell.
	Hon. A. Norton, M.L.C. (Queensland). Rev. Thomas Blackburn (South Australia). H. C. Russell, C.M.G., B.A., F.R.S.	A. Morton (Tasmania).	J. B. Walker, F.R.G.S. (Tasmania).

ADELAIDE, 1893.

Professor Ralph Tate, F.G.S., F.L.S. (South Australia).	The Right Hon. the Earl of Kintore, P.C., G.C.M.G. (South Australia). H. C. Russell.	Professor A. Liversidge.	H. C. Russell.
	Baron F. von Mueller, K.C.M.G. Ph.D., F.R.S. Sir James Hector. Sir Robert Hamilton.	Professor Rennie, M.A., D.Sc. Professor Bragg, M.A. (South Australia).	Fredk. Wright (South Australia)

BRISBANE, 1895.

The Hon. A. C. Gregory, C.M.G., M.L.C. (Queensland).	His Excellency Sir Henry Wylie Norman, G.C.B., G.C.M.G., C.B. (Queensland).	Professor A. Liversidge. John Shirley, B.Sc. (Queensland).	H. C. Russell. Hon. A. Norton, M.L.C.
	H. C. Russell. Baron F. von Mueller. Sir James Hector. Professor Ralph Tate.		

Presidents, Vice-Presidents, Secretaries, and Treasurers from the Commencement—*Continued.*

President.	Vice-Presidents.	Hon. Secretaries.	Hon. Treasurers.
SYDNEY, 1898.			
Professor A. Liversidge, M.A., LL.D., F.R.S., etc.	H. C. Russell.	Professor A. Liversidge.	H. C. Russell.
	Sir James Hector. Professor Ralph Tate. The Hon. A. C. Gregory, C.M.G., M.L.C.		
MELBOURNE, 1900.			
R. L. J. Ellery, F.R.S., etc.	H. C. Russell.	Professor A. Liversidge.	H. C. Russell.
	Sir James Hector. Professor Ralph Tate. The Hon. A. C. Gregory. Professor A. Liversidge.	Professor W. Baldwin Spencer. F. F. J. Love, M.A., F.R.A.S. (Melbourne).	C. R. Blackett, F.C.S. (Melbourne).
HOBART, 1902.			
Captain F. W. Hutton, F.R.S., F.G.S.		Professor A. Liversidge.	H. C. Russell.
		Alex. Morton.	R. M. Johnston, F.S.S.

DUNEDIN, 1904.

Professor T. W. Edgeworth David, B.A., F.R.S., F.G.S.	H. C. Russell. Sir James Hector. Hon. A. C. Gregory. Professor A. Liversidge. R. L. J. Ellery.	Professor A. Liversidge. G. M. Thomson.	David Carment, F.I.A.

ADELAIDE, 1907.

A. W. Howitt, C.M.G., D.Sc., F.G.S.		Professor A. Liversidge. W. Howchin. Dr. J. P. V. Madsen.	David Carment.

BRISBANE, 1909.

Professor W. H. Bragg, M.A., F.R.S.	Sir Pope Cooper Sir Arthur Morgan. Hon. J. T. Bell, M.L.A. J. W. Blair, M.L.A. G. H. Knibbs.	Professor A. Liversidge. (J. H. Maiden, acting). John Shirley.	David Carment.

SYDNEY, 1911.

Professor Orme Masson, D.Sc., F.R.S.	Professor Liversidge. Professor David. Professor Bragg.	J. H. Maiden.	David Carment.

DATE AND PLACE, PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF SECTIONS FROM THE COMMENCEMENT.

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
Section A. Astronomy, Mathematics, and Physics			
1888 Sydney	R. L. J. Ellery, F.R.S., Melbourne.	—	Professor R. Threlfall, M.A.
1890 Melbourne	Professor R. Threlfall, M.A., Sydney.	Professor T. R. Lyle, M.A.	E. F. J. Love, M.A. W. Sutherland, M.A.
1891—Christchurch	Professor T. R. Lyle, M.A., Melbourne.	C. H. H. Cook, M.A.	A. C. Gifford, M.A.
1892—Hobart	Professor W. H. Bragg, M.A., Adelaide.	The Archbishop of Hobart. A. B. Briggs.	Captain Shortt, R.N. W. E. Shoobridge.
1893—Adelaide	H. C. Russell, B.A., F.R.S., C.M.G., Sydney.	Sir Charles Todd, K.C.M.G., M.A., F.R.S., F.R.A.S. J. J. Stuckey, M.A.	R. W. Chapman, M.A.
1895—Brisbane	Alexander McAulay, M.A., Hobart.	Clement Wragge, F.R.M.S. C. H. Hodges, M.A. J. E. Davidson.	J. P. Thomson.
1898 Sydney	P. Baracchi, F.R.A.S., Melbourne.	R. L. J. Ellery, C.M.G., F.R.S. Professor Alex. McAulay, M.A. Professor T. R. Lyle, M.A.	Professor R. Threlfall, M.A. J. Arthur Pollock, B.Sc. G. H. Knibbs, F.R.A.S.
1900 Melbourne	G. H. Knibbs, F.R.A.S.	P. Barracchi, F.R.A.S.	R. J. A. Barnard, M.A. E. G. Hogg, M.A.
1902—Hobart	Professor R. W. Chapman, M.A., B.C.E., Adelaide.	H. C. Kingsmill, M.A. F. M. Young, B.A. W. Aikenhead, M.H.A.	Professor A. McAulay, M.A. W. F. D. Butler, B.Sc.
1904—Dunedin	Professor W. H. Bragg, M.A., Adelaide.	Professor G. H. H. Cook, M.A. C. W. Adams, C.E. J. W. A. Marchant.	C. Coleridge Farr, D.Sc. J. S. S. Cooper, M.A., B.Sc.
1907—Adelaide—	E. F. J. Love, M.A., Melbourne.	Professor W. H. Bragg, M.A. Professor J. A. Pollock, D.Sc. R. F. Griffiths.	J. Dalby, B.A.

1909—Brisbane	Professor J. A. Pollock, D.Sc., Sydney.	R. H. Roe, M.A.	K. ff. Swanwick, B.A., LL.B.
1911—Sydney	Professor T. H. Laby, B.A., Wellington, N.Z.	George D. Hirst, F.R.A.S.	Professor E. M. Moors, M.A. O. U. Vonwiller, B.Sc.

Section B.—Chemistry

1888—Sydney	Professor J. G. Black, D.Sc., M.A., Dunedin.	A. Leibius, Ph.D., M.A., etc. Prof. A. Liversidge, M.A., F.R.S. Professor E. H. Rennie, M.A.	W. M. Hamlet, F.I.C., F.C.S.
1890—Melbourne	Professor E. H. Rennie, M.A., D.Sc., Adelaide.	C. R. Blackett, F.C.S.	Professor Orme Masson, M.A., D.Sc.
1891 Christchurch	Professor Orme Masson, M.A., D.Sc., Melbourne.	Professor A. W. Bickerton, F.C.S. W. S. Key, F.C.S.	George Gray, F.C.S.
1892 Hobart	W. M. Hamlet, F.I.C., F.C.S., Sydney.	W. F. Ward, A.R.S.M. Samuel Clemes.	A. J. Taylor, F.L.S. H. T. Gould.
1893—Adelaide	C. N. Hake, F.C.S., F.I.C., Melbourne.	T. C. Cloud, F.C.S. G. Goyder, Jun., F.C.S. A. Sutherland, M.A.	T. J. Greenway, F.C.S., F.I.C
1895 Brisbane	J. H. Maiden, F.L.S., Sydney.	J. B. Henderson. George Henry Irvine. A. S. Denham.	George Watkins.
1898—Sydney	—	Professor E. H. Rennie, M.A., D.Sc. Richard T. Bellemey, M.P.S.	W. M. Hamlet, F.I.C., F.C.S.
1900—Melbourne	F. B. Guthrie, F.C.S.	Prof. Mica Smith, B.Sc. W. M. Hamlet, F.I.C., F.C.S.	A. W. Craig, M.A., F.C.S. W. P. Wilkinson.
1902—Hobart	Professor Mica Smith, B.Sc., Ballarat.	W. F. Ward, A.R.S.M. S. Clemes.	Professor Neil Smith, M.A. G. C. Smith.
1904—Dunedin	J. Brownlie Henderson, Brisbane	Professor Easterfield, Ph.D. Professor W. E. Evans, M.A., B.Sc. Professor Fred. D. Brown, M.A., B.Sc., F.C.S. Geo. Gray, F.C.S.	Professor Evans.

DATE AND PLACE, PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF SECTIONS FROM THE COMMENCEMENT—*Continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
	Section B.—*Continued.*		
1907—Adelaide	R. Sticht, B.Sc., E.M., Tasmania	Professor Rennie, D.Sc. G. A. Goyder, F.C.S. W. T. Cooke, D.Sc. G. C. McMurtry, A.R.S.M., A.R.C.S. J. H. Young.	A. J. Higgin, F.I.C.
1909—Brisbane	Professor Easterfield, M.A., Ph.D., F.C.S., Wellington.	J. B. Henderson, F.I.C., F.C.S. A. B. Chater.	J. C. Brünnich, F.I.C., F.C.S. Geo. Watkins (Pharmacy Subsection).
1911—Sydney	Professor Bertram D. Steele, D.Sc., Brisbane.	W. M. Hamlet, F.I.C. T. S. Loney.	Professor C. Fawsitt, D.Sc. A. Forster (Pharmacy Subsection).
	Section C.—Geology and Mineralogy		
1888—Sydney	Robert L. Jack, F.R.G.S., F.G.S., Brisbane.	T. W. Edgeworth David, B.A., F.G.S.	Robert Etheridge, Jun.
1890—Melbourne	Professor F. W. Hutton, M.A., F.G.S., C.M.Z.S., Christchurch.	Professor McCoy, C.M.G., M.A., D.Sc.	James Stirling.
1891—Christchurch	R. A. Murray, F.G.S., Melbourne.	Professor A. P. Thomas, M.A., F.L.S., F.G.S. H. Hill, B.A., F.G.S.	J. D. Enys, F.G.S.

1892—Hobart	Professor T. W. E. David, B.A., F.G.S., Sydney.	T. Stephens, M.A., F.G.S. A. Montgomery, M.A.	F. Belstead. B. Shaw.
1893—Adelaide	Sir Jas. Hector, K.C.M.G., M.D., F.R.S., Wellington.	Sir Henry Ayres, K.C.M.G., F.G.S. H. Y. L. Brown, F.G.S. J. V. Parkes.	W. Howchin, F.G.S.
1895—Brisbane	Professor T. W. E. David, B.A., F.G.S., Sydney.	W. H. Rands. William Ernest Fryar.	W. A. Hargreaves, M.A., B.C.E.
1898—Sydney	Professor F. W. Hutton, F.R.S., F.G.S., New Zealand.	W. Howchin, F.G.S. R. L. Keach, F.G.S.	T. W. E. David, B.A., F.G.S. E. F. Pittman, A.R.S.M.
1900—Melbourne	Professor Ralph Tate, F.G.S., F.L.S., Adelaide.	A. G. Maitland, F. G.S. A. Montgomery, M.A.	F. S. Hall, M.A. G. B. Pritchard.
1902—Hobart	T. S. Hall, M.A., Melbourne.	Thomas Stephens, M.A., F.G.S. R. M. Johnston, F.SS.. W. H. Twelvetrees, F.G.S. G. A. Waller. W. F. Petterd, C.M.Z.S.	
1904—Dunedin	W. H. Twelvetrees, F.G.S., Hobart.	H. Hill.	Professor P. Marshall, M.A., D.Sc., F.G.S. O. G. Adams, A.R.S.M. E. H. Mulgan, M.A.
1907—Adelaide—	A. Gibb Maitland, F.G.S., Perth.	Professor E. W. Skeats D.Sc. Professor T. W. E. David, B.A., F.R.S. W. Howchin, F.G.S. W. G. Woolnough, D.Sc. W. H. Twelvetrees, F.G.S.	D. Mawson, B.E., B.Sc.
1909—Brisbane	Professor E. W. Skeats, D.Sc., Melbourne.	Benjamin Dunstan. R. A. Wearne, B. A.	Lionel C. Ball, B.E. Walter E. Cameron, B.A.
1911—Sydney	Professor P. Marshall, D.Sc., F.G.S., Dunedin.	E. F. Pittman, A.R.S.M. Professor E. W. Skeats, D.Sc. W. G. Woolnough, D.Sc.	W. S. Dun.

DATE AND PLACE, PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF SECTIONS FROM THE COMMENCEMENT—*Continued.*

Section D.—Biology

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
1888—Sydney	Professor Ralph Tate, F.L.S., F.G.S., Adelaide.	—	Professor W. A. Haswell, M.A., D.Sc.
1890—Melbourne	Professor A. P. Thomas, M.A., F.L.S., Auckland.	P. H. MacGillivray, M.A., M.R.C.S.	A. Dendy, M.S.C., F.L.S.
1891—Christchurch	Professor W. A. Haswell, M.A., D.Sc., Sydney.	Professor T. J. Parker, B.Sc., F.R.S. Sir W. Buller, K.C.M.G., F.R.S. Thomas Kirk, F.L.S. T. F. Cheeseman, F.L.S.	C. Chilton, M.A., B.Sc. C. M. Thomson, F.L.S.
1892—Hobart	Professor W. Baldwin Spencer, M.A., Melbourne.	Colonel Legge, R.A. W. F. Petterd, C.M.I.S. Augustus Simson.	P. S. Seager. L. Rodway, L.D.S.
1893—Adelaide	C. W. De Vis., M.A., Brisbane.	Rev. T. Blackburn, B.A. M. Holtze, F.L.S. E. C. Stirling, C.M.G., M.D., F.R.S.	W. L. Cleland, M.B.
1895—Brisbane	Professor Arthur Dendy, D.Sc., F.L.S., Christchurch.	F. Manson Bailey, F.L.S. W. MacIlwraith.	J. F. Bailey. J. H. Simmons.
1898—Sydney	Professor C. J. Martin, M.B., D.Sc., Melbourne.	Professor J. T. Wilson, M.B., Ch.M. J. J. Fletcher, M.A., B.Sc.	Professor W. A. Haswell, M.A., D.Sc., F.R.S. J. H. Maiden, F.L.S. J. J. Fletcher, M.A., B.Sc.

1900—Melbourne	J. J. Fletcher, M.A., B.Sc.	Professor W. B. Benham, D.Sc. A. H. S. Lucas, M.A., B.Sc. C. J. Martin, M.B., D.Sc.	W. Fielder, F.R.M.S. J. G. Luehmann, F.L.S.
1902—Hobart	Professor W. B. Benham, D.Sc., Dunedin, N.Z.	Colonel W. V. Legge, R.A. A. M. Lea. W. F. Petterd, C.M.Z.S. Augustus Simson. W. L. May. Malcolm Harrison. Dr. L. Holden.	L. Rodway, L.D.S. P. S. Seager. W. A. Weymouth.
1904—Dunedin	Colonel W. V. Legge, R.A., F.L.S., F.R.A.S., Hobart.	Professor C. Chilton, M.A., D.Sc. T. F. Cheeseman, F.L.S. C. Hedley, F.L.S. Captain Hutton, F.R.S. H. Suter. Professor A. P. W. Thomas, M.A., F.L.S.	L. Cockayne, Ph.D. F. W. Hilgendorf, M.A., D.Sc.
1907—Adelaide	J. H. Maiden, F.L.S., Sydney.	Professor R. J. A. Berry, M.D. Professor J. A. Ewart, D.Sc., Ph.D. C. Hedley, F.L.S. Rev. T. Blackburn, B.A. J. C. Verco, M.D. W. B. Poole.	W. Fuller.
1909—Brisbane	C. Hedley, F.L.S., Sydney.	A. J. Turner, M.D. W. J. Byram. C. W. Holland.	Rowland Illidge.
1911—Sydney	F. M. Bailey, F.L.S., Brisbane.	Professor J. T. Wilson, M.B., F.R.S. H. G. Chapman, M.D. R. T. Baker, F.L.S.	C. Hedley, F.L.S.

DATE AND PLACE, PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF SECTIONS FROM THE COMMENCEMENT—*Continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
		Section E.—Geography	
1888—Sydney	Hon. John Forrest, C.M.G., F.R.G.S., Perth, W.A.	G. F. Griffiths, F.R.G.S., F.G.S.	J. H. Maiden, F.R.G.S., F.L.S F.C.S.
1890—Melbourne	W. H. Miskin, F.E.S., Sydney.	Commander Crawford Pasco, R.N. A. C. Macdonad, F.R.G.S.	G. S. Griffiths, F.R.G.S., F.G.S.
1891—Christchurch	G. S. Griffiths, F.R.G.S., F.G.S., Melbourne.	S. Percy Smith, F.R.G.S. F. R. Chapman.	R. M. Laing, M.A., B.Sc.
1892—Hobart	Commander Crawford Pasco, R.N., Melbourne.	E. A. Counsell, F.R.G.S. J. R. McClymont, M.A. Rev. J. B. Woolnough, M.A.	F. M. Young, B.A.
1893—Adelaide	A. C. Macdonald, F.R.G.S., Melbourne.	Sir S. Davenport, K.C.M.G. Sir J. Elder, G.C.M.G. David Murray. A. W. Goyder, C.M.G.	J. W. Jones.
1895—Brisbane	Baron F. von Mueller, K.C.M.G., Ph.D., F.R.S., Melbourne.	J. N. Waugh, M.D. D. S. Thistlewaite, C.E. Ernest Favenc.	Major A. J. Boyd.
1898—Sydney	Sir James Hector, K.C.M.G., F.R.S., M.D., New Zealand.	Hon. P. G. King, M.L.C., F.R.G.S. A. C. Macdonald, F.R.G.S.	H. S. W. Crummer. John F. Mann.
1900—Melbourne	W. H. Tietkens, F.R.G.S.	C. Winnecke, F.R.G.S. A. C. Macdonald, F.R.G.S. A. W. Howitt, F.G.S.	T. W. Fowler, M.C.E., F.R.G.S. A. J. Wright, F.R.G.S., F.R. Col. Inst.

1902—Hobart	Rev. Geo. Brown, D.D., Sydney.	F. J. Young, B.A. E. A. Counsel, F.R.G.S. J. R. McClymont, M.A. Rev. J. B. Woolnough, M.A. A. B. Watchorn. C. M. Tenison.	J. W. Beattie.
1904—Dunedin	Professor J. W. Gregory, D.Sc., F.R.S., Melbourne.	Hon. C. C. Bowen, M.L.C. Martin Chapman. Thomas Tanner.	J. S. Tennant, M.A., B.Sc.
1907—Adelaide—	T. W. Fowler, M.C.E.	Hon. Sir Langdon Bonython. T. Gill, I.S.O. W. Strawbridge. T. Parkhouse.	H. P. Moore. W. H. Selway.
1909—Brisbane	A. H. S. Lucas, M.A., B.Sc.	Geo. Phillips. John MacDonald. A. A. Spowers. C. B. Lethem.	Arthur Exley.
1911—Sydney	Professor G. C. Henderson, M.A. Adelaide.	Captain J. H. Watson. E. Du Faur, F.R.G.S.	H. W. S. Crummer.

Section F.—Ethnology and Anthropology

1888—Sydney	A. Carroll, M.D., Sydney.	—	John Fraser, B.A., LL.D.
1890—Melbourne	Hon. J. Forrest, C.M.G., M.L.C., Perth, W.A.	A. W. Howitt, F.G.S.	Rev. Lorimer Fison, M.A.
1891—Christchurch	A. W. Howitt, F.G.S., Melbourne.	Hon. W. B. D. Mantell, M.L.C., F.G.S. T. M. Hocken, M.R.C.S. Edward Tregear, F.R.G.S.	A. Hamilton.

DATE AND PLACE, PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF SECTIONS FROM THE COMMENCEMENT—*Continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
	Section F.—*Continued.*		
1892—Hobart	Rev. Lorimer Fison, M.A., Melbourne.	Rev. Geo. Clarke. James Barnard.	J. B. Walker, F.R.G.S.
1893—Adelaide	Rev. Samuel Ella, Sydney.	Rev. W. R. Fletcher, M.A. A. T. Margarey. T. A. Parkhouse. T. Worsnop.	T. Gill.
1895—Brisbane	Thomas Worsnop, Adelaide.	Thomas Petrie. Joseph Laŭterer, M.D.	Archibald Meston.
1898—Sydney	A. W. Howitt, F.G.S., Melbourne.	Professor W. Baldwin Spencer, M.A. Rev. L. Fison, M.A., LL.D.	John Fraser, B.A., LL.D.
1900—Melbourne	F. J. Gillen, S.M.	Rev. Geo. Brown, D.D. W. E. Roth, B.A., M.R.C.S.	Rev. L. Fison.
1902—Hobart	Dr. W. E. Roth, B.A., M.R.C.S., Cooktown, Queensland.	Rev. Geo. Clarke. F. J. Young, B.A., Dr. Arthur Clarke.	W. H. Hudspeth, LL.D.
1904—Dunedin	Professor W. Baldwin Spencer, M.A., F.R.S., Melbourne.	Professor J. Brown, M.A. Alexander Morton. S. Percy Smith. Edward Tregear.	Augustus Hamilton. W. H. Skinner.
1907—Adelaide	R. Parkinson, Bismarck Archipelago.	Professor E. C. Stirling, C.M.G., M.A., M.D. F. J. Gillen. F.A.S.	T. Gill, I.S.O.
1909—Brisbane	Augustus G. Hamilton, Wellington.	Professor S. B. J. Skertchly.	Jas. Johnston.
1911—Sydney	Edward Tregear, Wellington.	Rev. B. Danks. F. J. Gillen.	Rev. Dr. Brown.

Section G.—Social Science and Agriculture

1889—Sydney	H. H. Hayter, C.M.G., Melbourne.	—	A. C. Wylie.
1890—Melbourne	R. M. Johnston, F.L.S., Hobart.	Professor J. S. Elkington, M.A., LL.B.	H. K. Rusden, F.R.G.S. A. Sutherland, M.A.
1891—Christchurch	Hon. G. W. Cotton, M.L.C., Adelaide.	W. T. L. Travers, F.L.S. W. R. E. Brown.	A. de Bathe Brandon, B.A. A. T. Bothamley.
1892—Hobart	R. Teece, F.I.A., Sydney.	Hon. A. J. Clarke, M.C.C. Hon. A. J. Brown, M.H.A. A. J. Ogilvy.	R. M. Johnston, F.L.S.
1893—Adelaide	H. C. L. Anderson, M.A., Sydney	Josiah Boothby, C.M.G. Professor Lowrie, B.Sc. L. H. Sholl. J. H. Symon, Q.C.	E. Pariss Nesbit.
1895—Brisbane	Professor Walter Scott, M.A., Sydney.	Sir John Madden, Knt., C.J., Victoria. Hon. A. J. Thynne, M.L.C. J. H. McConnell. Peter McLean. Alex. Paterson. John Cran.	Littleton E. Groom, M.A., LL.M. (Social Science). William Soutter (Agriculture).
1898—Sydney	R. M. Johnston, F.L.S., F.S.S., Hobart.	Hon. H. N. MacLaurin, M.D., M.L.C., LL.D. R. Teece, F.I.A., F.F.A. W. McMillan, M.L.A. E. M. Shelton, M.Sc. W. Farrar, M.A.	R. R. Garran, B.A. F. B. Guthrie, F.C.S.
1900—Melbourne	Professor W. Lowrie, M.A., B.Sc. Professor W. Jethro Brown, M.A., LL.D. (President of Subsection of Economics).	R. M. Johnston, F.S.S. J. H. Maiden, F.L.S. D. Martin.	D. McAlpine. J. J. Fenton.

DATE AND PLACE, PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF SECTIONS FROM THE COMMENCEMENT—*Continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
Section G.—*Continued.*			
1902—Hobart	T. A. Coghlan, F.S.S., Sydney. J. H. Maiden, F.L.S., Sydney (President of Subsection of Agriculture).	Mr. Justice A. J. Clarke. Hon. G. T. Collins, M.E.C. Hon. J. N. Brown, M.E.C. Hon. G. R. Fitzgerald, M.E.C. Hon. John Henry, M.E.C. R. M. Johnston, F.S.S. A. J. Ogilvy. Thos. Tabart. H. J. Colbourn. A. Conlon.	F. W. Hudspeth. A. L. Evans.
Section Gl.—Social and Statistical Science			
1904—Dunedin	—	Mr. Justice Dennison.	C. E. Adams, B.Sc. Donald Reid, jun., M.H.R.
1907—Adelaide—	Professor F. Anderson, M.A. Sydney.	Professor J. Brown, LL.D. G. H. Knibbs, F.R.A.S. T. A. Coghlan, F.S.S.	R. J. M. Clucas.
1909—Brisbane	G. H. Knibbs, F.S.S., F.R.A.S. Melbourne.	Thornhill Weedon, F.S.S. Alderman J. Crase.	J. F. Bailey.
1911—Sydney	E. W. H. Fowles, M.A., LL.B., Brisbane.	G. H. Knibbs, F.R.A.S. Hon. Sir William McMillan, K.C.M.G. R. Teece, F.I.A.	A. Duckworth, F.R.E.S.

Section G2.—Agriculture

1904—Dunedin	J. D. Towar, Adelaide.	Professor J. A. Gilruth, M.R.C.V.S. T. W. Kirk. Henry Matthews.	H. V. Fulton. Henry Wilkie, F.R.C.V.S.
1907—Adelaide	T. Cherry, M.D., Melbourne.	Professor Perkins.	Professor W. Angus, B.Sc.
1909—Brisbane	H. W. Potts, F.C.S., F.L.S.	E. G. C. Scriven. L. G. Corrie, F.L.S. F. W. Woodroffe.	J. F. Bailey.
1911—Sydney	Professor W. Angus, B.Sc., Adelaide.	H. W. Potts, F.L.S. Professor R. Watt, M.A., B.Sc.	F. B. Guthrie, F.I.C.

Section H.—Engineering and Architecture

1888—Sydney	Professor W. C. Kernot, M.A., C.E., Melbourne.	—	John Sulman, F.R.I.B.A. H. Deane, M.A., M.I.C.E.
1890—Melbourne	Professor W. H. Warren, M.Inst. C.E., Sydney.	H. C. Mais, M.Inst., C.E. A. Purchas, C.E.	A. C. Sachse, C.E.
1891—Christchurch	John Sulman, F.R.I.B.A., Syd.	R. Wilson, F.R.S.E., M.I.C.E. E. Dobson, M.I.C.E. C. Napier Bell, M.I.C.E. W. N. Blair, M.I.C.E.	R. J. Scott, A.M.I.C.E.
1892—Hobart	C. Napier Bell, M.I.C.E., C.E., New Zealand.	C. H. Grant, C.E. James Fincham, C.E. F. Kayser. C. W. James, C.E., A.M.I.C.E.	W. W. Eldridge. A. North.
1893—Adelaide	R. J. Scott, A.M.I.C.E., New Zealand.	Hon. J. Martin, M.L.C. A. B. Moncrieff, M.Inst.C.E. J. H. Reed.	J. T. Arrow, A.M.I.C.E.
1895—Brisbane	James Fincham, M.Inst., C.E., Tasmania.	H. C. Stanley, M.Inst.C.E. A. B. Bradley, A.M.Inst.C.E. Richard Gailey. G. Phillips, C.E., M.L.A.	
1898—Sydney	A. B. Moncrieff, M.Inst.C.E., M. Am. Soc. C.E., Adelaide.	H. Deane, M.A., M.Inst. C.E. G. A. Mansfield. Professor W. H. Warren, M. Inst.C.E., Wh. Sc.	J. W. Grimshaw, M.Inst.C.E., M.I. Mech. E. H. C. Kent, M.A.

DATE AND PLACE, PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF SECTIONS FROM THE COMMENCEMENT—*Continued.*

Section H.—*Continued*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
1900—Melbourne	H. Deane, M.A., M.Inst., C.E.	Lloyd Taylor, F.R.I.B.A., F.R.V.I.A. H. C. Mais, M.Inst.C.E., M.I. Mech. E.	A. W. Arnott, C.E. A. M. Henderson, M.C.E., F.R.V.I.A. W. H. Nimmo, C.E.
1902—Hobart	Percy Oakden, A.R.I.B.A., Melbourne.	J. J. McCormick, M.Inst.C.E. R. C. Patterson, M.H.A. C. Hudson. G. B. Edwards. R. F. Richards. G. Dudley Salier. Orlando Baker. C. C. Nairn. A. C. Parker. C. B. Target. P. E. Green. F. Kayser. W. W. Eldridge.	James Fincham, C.E. Alan Walker, A.R.I.B.A.
1904 Dunedin	H. Deane, M.A., M.I.C.E., Syd.	Howard Jackson. Professor R. J. Scott.	C. M. Barr, M.I.C.E. S. Hurst Seager.
1907—Adelaide—	W. Thwaites, M.A., Melbourne.	Professor W. H. Warren, M.I.C.E. A. B. Moncrieff, M.I.C.E. J. Vicars, M.E.	R. W. Chapman, M.A., B.C.E.
1909—Brisbane	Professor R. W. Chapman, M.A., B.C.E., Adelaide.	N. G. Bell, M.I.C.E. C. H. Maddison. W. Poole, B.E., F.G.S. Henry Deane, M.A.	Norman M. Bell.
1911—Sydney	Ellwood Mead, Melbourne.	Col. W. L. Vernon, F.R.I.B.A. H. Sulman, F.R.I.B.A. Professor W. H. Warren, M.I.C.E	A. J. Gibson, A.M.Inst.C.E.

Section I.—Sanitary Science and Hygiene

1888—Sydney	J. Bancroft, M.D., Brisbane.	- -	J. T. Wilson, M.B., C.M. F. B. Kyngdon.
1890—Melbourne	J. Ashburton Thompson, M.D., D.P.H., Sydney.	A. P. Akehurst. G. Gordon, C.E.	G. A. Syme, M.B., F.R.C.S.
1891—Christchurch	Hon. Allan Campbell, M.D., M.L.C., Adelaide.	Professor J. A. Scott, M.D. I. de Zouche. C. Nedwill, M.D.	F. Ogston, M.D.
1892—Hobart	Professor W. H. Warren, M.Inst. C.E., Sydney.	Hon. P. O. Fysh, M.L.C. C. E. Barnard, M.D. E. O. Giblin, M.D.	A. Mault.
1893—Adelaide	A. Mault, Hobart.	Hon. Allan Campbell, M.L.C. H. C. Whittell, M.D.	T. Borthwick, M. D.
1895—Brisbane	J. W. Springthorpe, M.A., M.D., M.R.C.S., Melbourne.	F. H. Vivian Voss, F.R.C.S. A. E. Salter, M.B. J. H. Little, M.B.	David Hardie, M.D.
898—Sydney	Hon. Allan Campbell, M.L.C., L.R.C.P., &c., Adelaide.	D. Hardie, M.B. J. W. Springthorpe, M.A., M.D. J. Ashburton-Thompson, M.D.	Frank Tidswell, M.B., Ch.M., D.P.H.
1900—Melbourne	J. Jamieson, M.D.	D. Astley Greswell, M.D.	B. A. Smith, M.C.E. J. W. Springthorpe, M.A., M.D.
1902—Hobart	Sir Thos Fitzgerald, M.R.C.S.E., Melbourne.	Hon. P. O. Fysh, M.E.C. Hon. G. Butler, M.D. Gregory Sprott, M.D. C. E. Barnard, M.D. Hon. W. W. Perkins. Thos. Bennison, E. J. Crouch, M.R.C.S. E. L. Crowther, M.D.	A. Mault.
1904—Dunedin	Frank Tidswell, M.B., &c., Sydney.	Dr. J. M. Mason. Dr. E. Jennings Dr. P. A. Lindsay.	Dr. W. Evans. Dr. W. Marshall MacDonald.
1907—Adelaide	R. Greig Smith, D.Sc., Sydney.	J. B. Cleland, M.B. E. Black, M.B. J. R. Baker. T. G. Ellery.	T. Borthwick, M.D., Ch.M. J. E. Mitton.

DATE AND PLACE, PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF SECTIONS FROM THE COMMENCEMENT—*Continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
Section I.—*Continued*			
1909—Brisbane	J. Mason, M.D., New Zealand.	John Thomson, M.B.	Alfred Sutton, M.R.C.S.
1911—Sydney	W. Perrin Norris, M.D., Ph.D., Melbourne.	W. G. Armstrong, M.B., D.P.H. Reuter E. Roth, M.R.C.S., D.S.O. E. S. Stokes, M.B.	R. Greig Smith, D.Sc.
Section J.—Mental Science and Education			
1888—Sydney	Professor E. V. Boulger, M.A., D.Litt., Adelaide.	—	E. L. Montefiore.
1890—Melbourne	Hon. J. W. Agnew, M.D., M.L.C. Hobart.	Professor Tucker, M.A. J. Hamilton Clarke, Mus.Bac.	Louis Henry, M.D. Tennyson Smith.
1891—Christchurch	R. H. Roe, M.A., Brisbane.	Professor F. W. Haslam, M.A. G. F. Tendall, Mus.Bac., Oxon.	A. Wilson, M.A. A. J. Merton.
1892—Hobart	Professor E. E. Morris, M.A., Melbourne.	Hon. J. W. Agnew, M.D. Rev. Thomas Kelsh. Russell Young.	F. J. Young, B.A.
1893—Adelaide	Professor Henry Laurie, LL.D., Melbourne.	His Honour Chief Justice Way, D.C.L. Professor E. V. Boulger, M.A., D.Lit. H. P. Gill. J. A. Hartley, B.A., B.Sc.	J. A. Sunter, B.A
1895—Brisbane	Professor Francis Anderson, M.A., Sydney.	Hon. T. J. Byrnes, B.A., LL.D., M.L.A. Reginald H. Roe, M.A. J. Brunton Stephens. Thomas Bradbury.	J. L. Woolcock, B.A. (Mental Science). J. J. Dempsey (Education).

1898—Sydney	John Shirley, B.Sc., Brisbane.	Hon. A. Garran, LL.D., M.A. R. H. Roe, M.A.	Professor Francis Anderson, M.A. J. B. Peden, B.A. J. R. Bavin, B.A., LL.B.
1900—Melbourne	W. L. Cleland, M.B.	Rev. A. Gosman, D.D. F. C. Eddy, M.A. H. Jackson, M.A.	Rev. E. H. Sugden, M.A., B.Sc. J. T. Collins, M.A., LL.M.
1902—Hobart	Professor Arnold-Wall, M.A., Christchurch.	Rev. Geo. Clarke. Right Rev. Dr. Delany. C. M. Tenison. Rev. Thomas Kelsh. Geo. Masters, M.A. Russell Young. Thos. Stephens, M.A. Rev. Dr. Scott. Professor McDougall, M.A. Professor W. H. Williams, M.A. W. H. Dawson. C. J. Barclay.	C. B. Petersen. M. M. Ansell, LL.B.
1904—Dunedin	John Shirley, B.Sc., Brisbane	F. J. Young, B.A. Professor T. G. R. Blunt, M.A. Geo. Hog en, M.A. Sir Robert Stout, K.C.M.G. Right Rev. Bishop Wallis, D.D. T. S. Weston.	William Gray, M.A. T. D. Pearce, M.A. C. R. D. Richardson, B.A.
1907—Adelaide	F. Tate, M.A., Melbourne.	Professor F. Anderson, M.A. Rev. H. Girdlestone, M.A. A. Williams. W. L. Cleland, M.B.	A. Scott, B.A.
1909—Brisbane	Peter Board, M.A., Sydney.	Right Rev. Dr. Donaldson J. S. Badger.	D. R. McConnel, M.A.
1911—Sydney	Rev. E. H. Sugden, M.A., Melbourne.	John Morris. Professor H. Laurie, LL.D. Peter Board, M.A.	Arthur Giles, B.A.

INAUGURAL ADDRESS

BY THE PRESIDENT·

Professor ORME MASSON, M.A., D.Sc., F.R.S.

THE Association over which I have now the honour to preside was founded, as you know, twenty-three years ago for the Advancement of Science in Australasia. This is, however, only its thirteenth meeting; for, while it was yet young, its guardians decided that it should celebrate its birthday but once in two years. Workers in Science in this part of the world are still not very numerous, and are separated by great distances from any central meeting place; and so it is perhaps wise that their federation should continue this system of biennial meetings till that very Advancement of Science and of Australasia which it lives to promote shall have prepared the way for more frequent congresses.

This is our third meeting in Sydney. The first was the foundation meeting of 1888, and the second was held ten years later. Sydney, the premier city of Australasia, is also the premier city of our Association, and for this there is a very special reason, which I think we should never allow ourselves to forget. I refer, of course, to the fact that our actual founder was Professor Liversidge, of the University of Sydney. He it was who conceived the idea, worked it up, and made of it an accomplished fact. For many years, as Honorary Secretary, he laboured for the young Association with parental affection and self-sacrifice; and he was President at the second Sydney meeting, when it was ten years old. During his long period of University service here, from 1872 till his retirement in 1907, he did much for the progress of Science in Australia, both as an original worker in mineralogy and chemistry and as a teacher and organiser; but probably he left no more lasting memorial of his activity at this side of the world than this Association. We may rejoice that he is still actively working for Science, though we have lost him. I met him a few weeks ago in London, and he sent his cordial good wishes for the success of our meeting.

It is of special interest at the present time to look back to the events which first led our founder to take action. In 1884 Mr. Caldwell, a Scottish naturalist, who was then pursuing investigations in Australia, observed the oviparous character of the platypus, and this important discovery was communicated by cable to the British Association, then holding its meeting in Montreal. Great interest was aroused, and this led to talk about the chances of a visit by the British Association to Australia at some future date. The difficulties of time and cost, however, were then deemed insuperable, and Professor Liversidge, in a letter to the Sydney Press (of September the 16th, 1884) wrote as follows :

"Therefore, instead of looking for a near visit from the Association, I would suggest that we should rather be preparing the way for issuing an invitation later on . . . and, as a preliminary step, . . . that we might try to bring about a federation or union of the members of the various scientific societies in Australia, Tasmania and New Zealand into an Australasian Association for the Advancement of Science on the lines of the British Association."

No immediate action followed ; but Professor Liversidge again bestirred himself two years later and brought about a meeting of delegates which soon carried out his scheme.

Two important facts are clearly proved by the letter I have just quoted. The first is that our Association was formed avowedly as a first step towards securing a visit by the British Association to Australia ; and to this I shall refer again later. The second is that the British Association was, from the outset, adopted as our model. It is indeed the parent of many younger and lesser Associations in other parts of the world. Most of these have histories as yet comparatively uneventful ; but each, like ours, can claim share in a glorious heritage and draw from the records of the great parent Association that inspiration which may help to make its own future fame. Our very title proclaims our descent and our desire to carry on the traditions of our parent. And what story can we read in the parental name itself ?

"The British Association for the Advancement of Science" clearly implies a dual intention on the part of its founders. It is often said that Science knows no nationality. If this means that the pursuit of knowledge is the common right of mankind, and that truth, when found, belongs to all men, irrespective of political boundaries and national enmities, it is a principle unassailable.

But if it means that the scientific worker, the pursuer of knowledge, is so inhuman a thing as to be devoid of national sentiment and find in it no inspiration for his special calling, it is emphatically untrue. Few, if any, men have done more for science than the Frenchman Pasteur. Of him—and of how few others ?—it can be said that he founded a new science—a special department of knowledge—established its principles and its technique, proved its results, and lived to see them universally appreciated. Humanity benefits, but Pasteur's work was the result of the combination of two forces—his own inherent scientific genius and his love of France, and no one acquainted with his life can doubt that the second was almost as potent as the first. A similar national sentiment inspired much of the best work of Kelvin, Huxley, and others of our own greatest men, and it clearly appears in the conception of the British Association. Its object was the Advancement of Science, but it was an Association of British workers, moved by the love of their country as well as of Science, convinced that the advancement of the one must necessarily depend on that of the other, and determined that scientific progress should be made *in* their country, *by* their country, *for* their country and the world. That their object has been achieved in great part is certain. The reports of the annual meetings of the British Association since its foundation in 1831, its presidential and sectional addresses, papers, debates, and committee's reports, are an index to the annual progress of Science itself all the world over, and show how large a share of that progress was truly British. Less directly, but quite convincingly to those who know something of the history of events, the success of the Association is shown by the great developments in scientific education and organisation throughout Great Britain within the last two generations—the multiplication of societies that deal with special branches of Science, the enormous increase in the bulk of their annual publications of original research, the introduction of genuine Science work into schools and the older Universities, and the foundation of many new Universities which devote a great part of their resources to such work. That much still remains to be done is also certain, and none know it better than the present leaders of the British Association. Britain still lags behind, it is true ; but it is not with the number of its scientific workers that fault is now to be found, nor with their training and capabilities, nor even with the facilities offered them for their special work ; but the diffusion of the scientific spirit among the general public is still far from complete, and Britain's public men and manufacturers do not seem yet to have learned that on it depends their own progress and that of their country. Even here, however, much improvement is manifest, and we may hope that, in the course of another generation or so, the Advancement of Science in this sense will be complete enough to put Britain on level terms with its rivals.

For more than half a century the national sentiment implied in its name did not lead the British Association beyond the confines of Great Britain and Ireland, its annual meetings being held in turn in the leading cities there. But it was inevitable that, sooner or later, a broader view should be taken of its self-imposed responsibilities; for is not the modern growth of the British Empire beyond the seas itself the outcome and the very embodiment of the Advancement of Science? If the Empire holds together as a great living organism, with parts mutually dependent and working in healthy unison, what are its nerves but electric cables? And what maintains its circulation but that triumph of mechanical engineering—the modern ocean steamship? The growth of the Imperial sentiment, as we know it now, the feeling that Britain no longer consists of the little mother country with distant and scattered dependencies, but is one great united nation, dwelling where duty calls it—these are in fact the outcome of the growth of Science rather than of Politics. And so it came about that the British Association ceased to interpret its name in the old-fashioned narrower sense, and adopted the view that Britain is where the British race is settled. Its first excursion overseas is memorable—the meeting in Montreal in 1884 under the presidency of Lord Rayleigh. Since then it has twice again visited Canada, holding meetings at Toronto in 1897 and Winnipeg in 1909. In 1905 the Association definitely confirmed its acceptance of Imperial responsibilities by holding its annual meeting in South Africa; and here a departure was made from established custom, for the meeting was not confined to one centre, but visited different cities in turn.

I have spoken already of the earliest attempt to bring about a visit of the British Association to this southern home of the British people—Australia. The proposal was discussed again some years later, and again was found impracticable. In 1909, however, it was mooted once more in Melbourne; and the matter was then brought under the notice of this, our own, Association, of the Universities and scientific societies of Australia, and of the

Federal and States Governments. All united in cordial support of the proposal, and old financial difficulties were dispelled by the far-sighted generosity of our political rulers. The Government of the Commonwealth, acting officially for all Australia, sent a formal invitation, which was unanimously accepted by the British Association for the year 1914. It was my good fortune to attend the Sheffield meeting last September, and to speak there with the High Commissioner as the inviting deputation; and I can bear testimony to the hearty feeling that prevailed and to the strong desire shown by many of Britain's most distinguished scientific men to profit by this opportunity of seeing Australia, to study its science on the spot, and to play a part in what will surely prove a great event in the history of Imperial unity. It remains for us here to do our part in the time that intervenes to make the meeting of 1914 as brilliant, as memorable, as it should be; and I know that our own members, who are interested most in the scientific work of the Congress, will labour to this end with those to whom its Imperial significance chiefly appeals. As far as possible, it will have to be arranged that the British Association shall visit and receive its welcome in each State in turn, so that a very large amount of local organisation will be called for. For this, of course, there is plenty of time within the next three years. Meanwhile we may congratulate ourselves and our founder, Professor Liversidge, that the hopes which led him to form this Association are at last realised. The British Association's visit to Australia is assured.

I have referred to the fact that national progress—indeed, the progress of man—depends on the Advancement of Science, but I would not be understood to mean by this that all progress is necessarily material. Too often, I think, people take us in this sense; and perhaps it is sometimes our own fault that they confuse science with useful inventions or processes which result from the application of Science to practical problems. These are, of course, important, inevitable, and heartily welcome. But Science itself is the true knowledge of the workings of Nature, and any new glimpse of the truth is its advancement. And who can doubt that man's progress on the mental and moral side is as dependent as his material well-being on this search for truth? Or that it is best from every point of view for the votaries of Science, as a rule, to leave practical results to take care of themselves and make the increase of natural knowledge their single aim? There is no more fascinating or absorbing quest—none, I venture to say, which is governed by so strict an ethical code—none which does more at the same time for man's mental elevation and for his proper humiliation.

I propose to say something of the advancement of Chemical Science (which is the only branch I am at all competent to deal with) during the lifetime of this Association. I shall not attempt anything like a complete or detailed account, which would be out of place and indeed impossible. My object is rather to illustrate the nature of the scientific quest and to indicate some of its main lines at the present time.

Let me first remind you that during the 19th century chemists learned to think in molecules and atoms. To them, matter of any sort is a collection of molecules, similar or dissimilar, constantly moving in space with more or less freedom, crowded and mutually hampered when aggregated as solid or liquid, relatively free but occasionally colliding when scattered as gas. And each such molecule is itself a more or less complex system of smaller parts—the so-called atoms—atoms which are similar in the molecule of an element but dissimilar in that of any one of the infinite variety of compound substances. And these atoms, too, are moving within the molecule, but are still held together by their mutual attractions. while the molecular system moves as a whole through space. These intra-molecular atomic motions are not inconsistent with the maintenance of a definite and orderly arrangement, which gives to the molecule a characteristic structure or architecture, and this structure distinguishes one kind of molecule essentially from other kinds, and indeed is the cause of many of the properties which we recognise in that multitudinous collection of the molecules which we call a sample of the substance. Somewhat similarly, the solar system, moving in space, is distinguished from other heavenly systems by the individuality of the sun and planets which compose it and which, despite their important movements within the system, hold together and give to it a structure or configuration that is peculiarly its own. Nor is the molecule less real to the chemist than is the solar system to the astronomer. True, it is so minute that he never sees it, and all his knowledge of it is merely the result of logical inference from actually observed phenomena. But is there so much difference after all ? Does anyone really see the solar system ? Are the larger and smaller spots of light that we see in the sky (with or without the telescope) a really self-evident revelation of the complicated story told us by astronomers ? Is not this also a triumphant illustration of the power of mind to argue truthfully from what we see to what we cannot see, but may none the less know ?

Our knowledge of the existence of molecules and the laws of their movements in space came mainly from the study of gases. Our knowledge of the atoms which compose them and of their characteristic groupings or configurations came from the study of those so-called chemical changes which occur when different sorts of molecules collide together under favourable conditions—changes which result in the re-arrangement of the atoms to foım new sorts of molecules, and which therefore convert old forms of matter into new. Luckily for science, all these chemical changes, from which we can learn so much, are subject to our own control and can be brought about at will as soon as we have learned the requisite conditions ; and thus chemistry is pre-eminently an experimental science, unlike astronomy ; for astronomy, after all, can only observe nature and can never force her hand.

For chemical action to occur between molecules, they must be free to collide with one another, so as to bring their constituent atoms within the range of new attractions. The solid state of aggregation hardly permits of this ; but the conditions may be favourable when gas is mixed with gas, or liquid with liquid, or when gases, liquids or solids are dissolved in a suitable liquid. So important, indeed, is the process of solution as a condition antecedent to chemical change that chemists have long felt impelled to make the nature of that process itself a special study. I need hardly remind you that most of the chemical changes that interest the geologist and most of those in the domain of the physiologist are changes that occur between substances in solution ; nor that, though there are many other solvents, water is, as a fact, by far the most frequent one in nature. Hence it was natural that chemists should pay great attention to the study of aqueous solutions.

At the Christchurch meeting in 1891, in a presidential address to Section B, I directed members' attention to the then recent work on solution by van't Hoff and Arrhenius and to the new light which it had thrown on our views about molecules and their chemical changes. Briefly, van't Hoff ascertained from an examination of the experimental work of Pfeffer on osmotic pressure, that of Raoult and others on the vapour pressures and freezing points of solutions, and from other evidence, that the molecules of dissolved substance follow the same quantitative mathematical laws connecting their concentration, pressure, and temperature as those long ago known to apply to the molecules of a gas. Hence I then spoke of the whole resulting theory as "the gaseous theory of solution," and ventured to liken a gas or vapour to a solution of matter in space and a liquid to a solution of space in matter; and I pointed out certain deductions from the theory which are now familiar. It was known then, however, that solutions of acids, alkalis, and salts, in water—or, in other words, that electrolytic solutions—are apparent exceptions to the van't Hoff law; and it was Arrhenius's explanation of this, adopted by van't Hoff, that rendered the whole subject so vitally interesting to chemists. His hypothesis was that the molecule of any such compound, when dissolved in water, tends automatically to break into two parts, each of which is an atom or group of atoms carrying one or more unit charges of electricity, positive in the one case, negative in the other, so that the solution as a whole remains electrically neutral. Further, these two "ions," when separated, move independently through the solvent, can recombine when they meet to form the original kind of molecule, and can separate again, so that each ion leads a definite fraction of its life in the free state; they may take part, when free, in other chemical changes by collision with molecules of the solvent or with other molecules or ions present in the solution; and in an electric field they tend to move towards opposite poles and are, in fact, the actual carriers of the electricity, and thus constitute the current. Thus arose the ionic theory of electro-chemistry and of chemical change. Hardly any other modern development has been so productive of research during the last quarter of a century.

To make its significance clearer, let me point out that the theory threw a quite fresh light on the question of the relationship between electricity and chemical phenomena. The work of Faraday had actually led to the view, put forth later by Helmholtz, that electricity, like matter, is atomic; and there was an accumulation of evidence that material atoms and electrical atoms do in fact combine; but it was Arrhenius and van't Hoff who first opened the minds of chemists to the view that such combinations form spontaneously and in quantity under normal conditions, and that many of our most familiar chemical changes are due to collisions of these material-electrical systems, and not to those of molecules built entirely of material atoms. The first and simplest conception of the ion—and at least a useful one to start with—is that it is a combination of one or more material atoms with one or more electrical atoms, either of the kind called negative or of the kind called positive ; and this may involve the conception that an originally wholly material molecule interacts in solution with an originally wholly electrical molecule (a neutral combination of the positive and negative electrical atoms) to form two dissimilar ions, each containing a fraction of the material molecule combined with a fraction of the electrical molecule. Such an action is essentially reversible, two ions of the opposite kind being liable, when they collide, to reform the original molecules—the wholly material and the neutral electrical ; and quite similarly, new combinations may result from the collisions of ions originally formed from different substances. Thus, less than a quarter of a century ago the mental vision of the chemist became enriched. Molecules he had known, and he was more or less familiar with their atomic structure. The birth of new molecules by atomic re-arrangement at the moment of molecular impact was a favourite conception of his. Now ions, or molecules containing both material and electrical atoms, were discovered to his vision, and he became absorbed in studying them and the results of their encounters.

No such new idea is ever accepted at once and by all. There are always difficulties, or apparent difficulties, in the way. Some are struck chiefly by the difficulties and figure at first, at least, as opponents of the theory ; others are struck mainly by its beauty and manifest advantages and incline to accept it ; all, if they be properly constituted, agree to abide by the results of further investigation. And the results of such research are, as a rule, to show that the theory, if correct in its essentials, requires more or less modification in its details, but is capable of large extension. So it has proved with the ionic theory. The result of a huge mass of later quantitative investigation has been, I think, to prove the following facts :—Ions *are* formed spontaneously by the solution of certain kinds of molecules in certain kinds of solvents, as, for instance, by that of salts in water. This " ionisation " *does* result in the divorce of one part of the material molecule from the other, as, for instance, of the sodium from the chlorine of common salt, and in the charging of the one positively and of the other negatively. The ions so formed *do* migrate independently in the solution, and may become independent agents of chemical change ; and they *do* serve as the actual carriers of the current. But they do *not*, as a rule, follow the expected simple mathematical law as to the frequency of their encounters—the law which it was thought should regulate the numerical relation at any moment between the free ions and the unionised molecules ; and here we have the chief difficulty, the fact which, more than any other, still blocks the way in spite of much labour spent upon its investigation. It does not prove the theory wrong, but it shows that there are facts about it not yet fully understood ; and the want of that complete understanding is at present a serious difficulty in many researches.

Apart from this, the ionic theory in its essence is now well established. The independent migration through the solvent of positively and negatively electrified ions containing the divorced constituents of the original salt molecules has actually been proved by special methods, and the velocities of migration of several kinds of ion under known conditions have been experimentally measured. The results obtained in this way admit, in my opinion, of no other interpretation than that which we owe to van't Hoff and Arrhenius. Moreover, the theory has stimulated chemists to investigate solutions in other solvents than water, and has thus opened up a field which is already rich in results. Some of these were anticipated by the theory, others are as yet incompletely explained, so that much new light may be looked for from further work in the same direction. As another illustration of the fruitfulness of ionic ideas, I may point to all that has been done by Nernst and others in the development of what may be called the ionic theory of electro-motive force. Here, as elsewhere, new foundations have been provided, and on them is being built from the stones of the old edifice a greatly enlarged and more beautiful superstructure.

In one way the ionic theory has been, or is in the course of being, extended and improved. Before it was heard of at all, chemists who interested themselves specially in the process of solution were inclined to assume the existence of specific attractions between the molecules of the dissolved substance and those of the solvent, and the formation, in consequence, of complex molecules containing both of these combined, and migrating as such among the more numerous unaltered solvent molecules. This view, unaided, did not lead to any very definite results, for it was qualitative rather than quantitative. The van't Hoff law turned thoughts in another direction, and, being quantitative, proved much more fertile ; but it dealt with the behaviour of the dissolved molecules when in solution, and tacitly set aside the question of whether or not some of the solvent was first used up by chemical combination with the solute. And the ionisation theory followed suit, for the ions were not originally supposed to contain anything but atoms derived from the salt and electrical atoms. Or, if it *was* thought (as some certainly *did* think) that the process of ionisation is preceded or accompanied by the formation of complexes in which solvent molecules play a part, there were then no quantitative data by which this idea could be tested, and it was best to set it aside till the main question of ionisation itself could be settled. That having been done, however, by chemical and electrical investigations which leave no room for doubt, it is natural and altogether satisfactory to find experimenters reopening the older question in its newer form, and gradually accumulating evidence that the ions themselves do contain solvent molecules as well as those material and electrical atoms of which I have spoken. Satisfactory, I say, for since the same solid dissolves well in one liquid and badly in another, and the same liquid acts as a good solvent to one solid and a bad one to another, it is obvious on the face of it that we have to deal at the outset with specific affinities, or, in other words, that some chemical combination does occur between solvent and solute. The theory of this " hydration of the ions " is still very incomplete, but our interest in it is increasing. It must, however, be pointed out that it supplements, but in no way contradicts, the ionic theory as originally set out by Arrhenius.

From a totally different line of experimental work, ionic ideas have received verification that was certainly not looked for by chemists. I refer to the brilliant series of researches on the conduction of electricity through gases at low pressures which we associate chiefly with the names of Crookes, Lenard, Röntgen, and Sir J. J. Thomson and his school at the Cambridge Cavendish Laboratory. For the outcome of this is the proof that electrical atoms, of the same magnitude as that deduced from the study of solutions, can exist in so-called vacuum tubes, either combined with material atoms in the form of gaseous ions or actually moving in the free state. And we have even definite information about the distinguishing characteristics of the negative and the positive electrical atoms and about their masses relatively to the material atoms of the chemist. The negative electrical atom—or, to use its proper name, the " electron "—is of the order one-thousandth of the mass of the hydrogen atom, while the positive one is a much bigger entity, and possibly has no real existence apart from matter. Work in this direction and in the allied field of radio-activity (to which I shall refer again) has not only established beyond dispute the existence of ions and electrons, but opened up the most far-reaching enquiries and speculations as to the constitution and true relations of ions, electrons, and material atoms.

In the meantime let us go back to the movements of molecules and ions in the medium in which they find themselves—pure space in the case of gases, space largely crowded by solvent molecules in the case of any dissolved substance. I have already spoken of chemical changes (the production of new matter from old) as resulting in general from the collision of such molecules or ions with one another; but as this idea underlies a whole field of experimental chemistry which has been much exploited in recent years, let us examine it a little more closely.

The production of new matter from old takes time, but some chemical changes are extremely rapid, while others are extremely slow; and others, again, proceed at such moderate rates as to make it possible for us to observe them quantitatively throughout their course. We may define the rate of any action as the number of molecules of the new substance produced in unit space in unit time. Now this velocity must depend on the number of effective collisions in unit space in unit time in any case where the formation of a new molecule occurs only as the result of such a collision, and the number of effective collisions must be determined by three factors. These are—(1) the kinds of molecule concerned (that is, the specific characters of the original substances); (2) the number of each kind present in unit space (that is, the concentration of that substance); and (3) the velocities with which they are moving. Now, when we study the rate of any particular chemical change, the first of these factors is invariable, while if we work at a fixed temperature we render the third factor also constant; and thus we may readily study the influence of varying concentrations on the rate of progress of the action. Now the character of this influence, or the form of the equation which expresses it, depends on the exact mechanism of the change, as is obvious if one considers the question from the point of view of the chances of an effective collision occurring at any given moment. If a collision of two different kinds of molecule is necessary, the velocity of the action is always proportional to the concentration of each of two different substances; but if the action depends on the collision of two similar molecules, its velocity will vary as the square of the concentration of a single substance. Such actions are known as bimolecular, and may be distinguished as dissimilar and similar bimolecular actions. But we have also unimolecular actions, where the velocity is proportional to the first power of the concentration of a single substance; and in such cases we may assume that no actual collision is necessary, but that the molecules concerned become automatically changed or shattered by their own inherent energy. We may also distinguish pseudo-unimolecular actions, which are really dissimilar bimolecular actions in which one of the substances concerned is present in such overwhelming quantity as to retain a practically unvarying concentration. Actions of this sort are illustrated by those cases where a small quantity of substance dissolved by a large quantity of water slowly combines with some of it to form new products. Cases in which more than two molecules must simultaneously collide before action can occur are conceivable, but need hardly be considered ; for if all the substances concerned be present in reasonably small concentration the actual chances of such treble or quadruple collisions are negligibly minute. But the same final result is often found to be arrived at in another way. For example, two of the original substances may unite to form an intermediate product, which again reacts with a third original substance to form the final product. The rate of the action here depends not on a single trimolecular, but on two consecutive bimolecular actions, each with its own velocity ; and that of the second is governed partly by the concentration from moment to moment of an intermediate compound, the very existence of which may be unsuspected until the dynamics of the whole action are brought under experimental observation. Such consecutive actions frequently occur, and both the theory and the practice of their investigation is often full of difficulty. Again, it often happens that the products of a given action tend to undergo a reverse action, so as to reproduce the original substance or substances. In such a case complete action can never occur in either direction, but, whichever end of the system we start from, it always arrives at a condition of mobile equilibrium between the old molecules and the new—at a system containing both sorts, mixed in proportions characteristic of the particular case. Here we have really to do with consecutive actions, interdependent and opposed, and both may be unimolecular, or both bimolecular, or one unimolecular and one bimolecular. These reversible changes are of peculiar interest, for they include many of the most important chemical actions known to us, and their study opens up the whole question of chemical equilibrium.

I have told you already that the molecules of salts and the ions produced from them do not, as a rule, conform to the theoretical law which was expected to govern their equilibrium with one another. This is the law of reversible actions, of which I have just been speaking—a law which well explains the results in other cases, but not in that of ionisation, where other influences seem to be at work. Hence we find a special difficulty arising in those frequent dynamical investigations in which we deal with the interactions of salts in aqueous solution ; for though we may determine the varying total concentrations of the salts, we often find ourselves unable to ascertain what fraction of each is at any moment in the ionised or active state. Here, then, there is need of new light.

Perhaps the most generally interesting result that has followed from these dynamical studies is that the velocity of a chemical change is often accelerated by the mere presence (so it would seem) of molecules of some foreign substance which itself is quite unaffected by the change. The acceleration may be positive or negative ; that is to say, the action may be hastened or retarded ; and the effect may be in some cases so great as to render an otherwise imperceptibly slow change very rapid, or an otherwise rapid change negligibly slow. Foreign substances which act in this way are called "catalysers," and their action "catalysis." Special cases of catalysis have been known to chemists for quite a long time ; but modern dynamical work has proved that it is a much more common phenomenon than was suspected. In fact, we are inclined now to say that there is no chemical action which is not susceptible to catalytic acceleration by some agent and that there is no substance incapable of acting as a catalyser in some chemical change. There has, of course, been much speculation as to the *how* of catalysis ; but, in spite of ingenious hypotheses, applicable to particular cases, and a great accumulation of experimental evidence bearing on the question, we are still pretty ignorant. Perhaps some day we shall be wiser ; certainly catalysis is one of the problems of the future. Meanwhile, I may mention that the so-called hydrogen ions of acids and hydroxyl ions of alkalis (that is, the two ions which by their combination, form water) are among the most frequently potent catalysers, and that the enzymes or chemical ferments of physiological actions also come within the same category. This last fact speaks eloquently for the interest which attaches to the whole subject.

Leaving molecules, let me say a little about the atoms which compose them. Of these there is not an unlimited, nor even a very great, variety ; and only a few of those known occur largely as components of molecules in the laboratory of nature. But, from the standpoint of science, every species of atom, or—to put it in another way—every element, is of absolutely first rate importance ; for each differs in some respects from all others, and each can teach us lessons of its own. Moreover, it has been recognised by chemists since the eighteen-sixties that there is a definite relationship among the different kinds of atom which gives to each its own special place in a harmonious scheme, and that this scheme can not be fully understood unless every place be filled. The natural classification of the atoms (or elements) is like one of those children's picture-puzzles which consist of broken parts that have but little meaning till, by patient investigation, their mutual relations are found out, each is fitted in its place, and the picture as a whole becomes visible. Sometimes it happens with these toys that pieces are missing, and gaps must then be left which spoil the picture. So it is with the scheme of the atoms. Mendeléeff put the puzzle together, called attention to the gaps, and, reading the story from the incomplete picture, described some of the missing pieces. How these were found and fitted in, how Mendeléeff's prophetic descriptions were soon after verified by the discoveries of the elements gallium, scandium, and germanium, is an oft-told tale. So is that of the discovery in 1894 of argon by Lord Rayleigh and Sir William Ramsay, and of helium by Ramsay in the following year. But these last discoveries had not been anticipated by Mendeléeff or anyone else. For argon there seemed at first no place in the natural classification of elements: its atom seemed to stand alone, outside the picture that had become so familiar in the preceding thirty years. But helium when discovered resembled argon closely in its curious properties; and then it became apparent that there was, so to speak, a margin to the picture, hitherto unsuspected, but none the less absolutely essential to its completion; that argon and helium formed each a piece of this margin, and that other pieces must exist if only they could be found. How Ramsay searched for them and how he found them—the neon piece, the krypton piece, and the xenon piece—these form one of the most fascinating tales of modern science. The discovery of this new group of elements added to our limited list of atoms five new ones, all characterised in an unprecedented way by total inability to combine with other atoms of any kind to produce molecules; that is to say, these elements proved entirely incapable of playing any part in chemical action. We had long known atoms of different valence, or atom-fixing power, from 1 to 4, or even up to 8, and had for years speculated as to the true nature of this valence which determines the union of atoms in a molecule, and as to the causes of the variation of valence which many atoms indulge in; but we now learned that certain atoms could have the valence zero and that this fact would have to be reckoned with in any future theorising.

And then, a little later, came that marvellous rush of experimental work and startling discovery that originated in Becquerel's observation of the radio-active character of the old metallic element, uranium. Madame Curie and her husband, investigating this, discovered radium as a constant minute ingredient of uranium ores, isolated its compounds, investigated its properties, and determined its place in Mendeléeff's natural classification. The radio-activity of thorium, too, was detected and studied ; and it was found that both thorium and radium give rise to the formation of "emanations" or gases, closely resembling in their properties, and especially in their zero valence, those elements of the argon group previously discovered in the atmosphere by Ramsay. Moreover it was found that some of the active "rays" actually consist of electrons or negative electrical atoms, shot off with a velocity comparable to that of light, while others of a grosser kind consist of positively charged material atoms : and these last have been proved to be identical with the atoms of helium. Other products have been obtained in quantities very minute, it is true, but still sufficient to admit of some investigation ; and, in particular, attention has been paid to the rates of decay of their radio-activity. We owe to Rutherford and Soddy conjointly the theory of all these inter-related phenomena—the theory of the spontaneous transformations of the atom, whereby new kinds of atom, both electrical and material, are produced ; some of the latter having but a short life before they in turn undergo spontaneous disruption like their parents. Recent as this theory of successive atomic transformations is, it may be regarded as proved : proved by mathematical analysis of quantitative observations, proved by its rational explanation of a host of related phenomena, proved by its successful predictions of previously unknown facts. And perhaps the most interesting thing about it is that it confirms and tends to complete the old atomic theory. For, in spite of the etymological significance of the word atom—that which can't be cut—chemists have long been convinced that each elementary atom must have an internal structure of its own and consist of parts or sub-atoms, much as molecules consist of atoms ; and speculations have long been rife as to how many sorts of sub-atom there may be and whether indeed all atoms do not consist of the same ultimate constituents, combined in different numbers and on different patterns. Some such idea was an unavoidable outcome of the study of atomic weights and atomic properties and of the natural classification of Mendeléeff. But one thing is clear: if atoms had parts, they were still uncutable by any known method similar to those by which chemists effect disruption of molecules: if sub-atoms ever came to be discovered, it would be by processes as yet unknown. And then the new science of radio-activity arose and taught us that these processes are actually at work in nature always, but that the energy which does the work is locked up within the atom and is beyond the reach of those external influences which we are wont to control. The transmutation of elements is proved at last, but man has not learned to cause it; he has only learned that it has been going on in nature since the beginning. Perhaps, by utilising the intense energy of the natural radio-active transformations of radium or its emanation, we may succeed in influencing the life history of other, more sluggish, atoms, and thus hasten transmutations which would otherwise be so slow as to escape our observation altogether. Ramsay has done some work in this direction and has got some curious and interesting results, but it is too early to speak with certainty of their meaning. One extension of Rutherford and Soddy's theory, however, seems unavoidable. The power of spontaneous disruption, involving the creation of new atoms out of old, can hardly be the exclusive property of uranium, radium, thorium, and a few other elements of large atomic weight; it must rather be an inherent property of atoms generally. Such transformations may be either extremely slow or actually rayless, so as to escape our present methods of detection. Yet it may be that some day we shall be able to prove them—perhaps by Ramsay's method of acceleration, perhaps by some other means that has still to be discovered. Meanwhile there is much to do in the way of further investigation of those radio-active changes that have been observed already, and especially with a view to the complete knowledge of the successive products and their relations as elements to the elder ones of Mendeléeff's periodic scheme.

It was inevitable that all these new phenomena should give rise to speculative discussions concerning the true inner constitution of the elementary atoms, the nature of the positive charge, the relations between these and the negative electrons, and the actual meaning to be attached to the bonds or valencies which cause atoms to hold together in the molecule. These questions are, of course, very far from final settlement. I cannot enter into them here, and merely mention them to show how far we have been carried within the last few years by the Advancement of Science.

Let me close with a few remarks of local—Australasian—interest. The great advances that I have sketched are, of course, attributable in the main to European workers. Yet we may, I think, take some satisfaction in the fact that teachers and students of the Universities in this part of the world, or graduates who have gone Home from here, have contributed somewhat from time to time. These Australasian contributions include work on the general theory of solution, on the mobilities of ions, on electrode potentials, on conductivity in aqueous and other solutions, on the dynamics of chemical change, on gaseous ions, and on radio-active phenomena. In this last connection I would specially remind you that Professor Rutherford, who may be said to have conferred on the study of radio-activity the dignity of a special science by his theory of transformations, is a New Zealand graduate, and that my immediate predecessor in this presidential chair, Professor Bragg, gained fame for himself and for Adelaide by his brilliant researches in this field before he accepted his present appointment at Leeds.

The older Universities of Australasia are growing, and new ones are arising, as in Brisbane and Perth. Naturally and inevitably there is a tendency nowadays to ask of Universities a greatly increased attention to the more utilitarian developments of Science. It is so in England, where for instance the University of Sheffield devotes a great department to the metallurgy of iron, and that of Leeds cultivates its schools of textile fabrics, dyeing, and domestic economy. It is so in Australia, where there is a steady pressure put upon the Universities to develop increasingly on the lines of techncial schools. All this is, doubtless, as it must be ; but it is beset with a certain danger. The risk is that the whole energies of these institutions, where teachers are always too few and equipment is never too plentiful, will be directed towards the useful applications of Science, and Science itself will be neglected. This, if it occurs, will be a pitiful result, and will not tend to raise Australia among the intellectual countries of the world. Let us be a practical people and have due regard to utility ; but let us also have some means and leisure to cultivate the vastly more interesting inutilities, for thus only can we hope to increase Australasia's contribution to the true Advancement of Science.

Section A

ASTRONOMY, MATHEMATICS and PHYSICS

ADDRESS BY THE PRESIDENT:

Professor T. H. LABY, B.A.,

Professor of Physics in the Victoria College, Wellington, N.Z.

SOME RECENT ADVANCES IN PHYSICS.

SCIENCE in Australia by the departure of Professor Bragg to England lost a mathematician and physicist, and a man whom for many reasons the small band of workers in physics could ill spare. But the wider influence which Professor Bragg has is a gain to science generally.

Cambridge has recently celebrated the twenty-fifth anniversary of Sir J. J. Thomson's appointment to the Cavendish Chair of Physics, by the publication of a History of the Cavendish Laboratory. As in every case the chapters of that book have been written by distinguished physicists from personal knowledge of their period, the volume, as an exact and illuminative history of possibly England's greatest scientific centre, is worthy of the wide influence of a most inspiring investigator. All physicists will join in hoping that Sir J. J. Thomson may continue to occupy the Cavendish Chair for a future period as full of achievement as that which the History commemorates.

It is a matter of some satisfaction to find that physicists first trained in Australasian Universities are contributing to science in all parts of the world. Most of the theories and discoveries in radio-activity we owe to Professor Rutherford, formerly of Christchurch, N.Z., ; new views as to the conduction of electricity through gases to Professor Wellisch, a Sydney graduate ; important contributions to the theory of light, and high administrative work, to President MacLaurin, formerly of Auckland ; many and varied researches in ionisation to Dr. Kleeman, a South Australian ; the organisation of metallurgical research at the National Physical Laboratory, London, to Dr. Rosenhain, of Melbourne University ; the organisation of an institution for the training of those engaged in the London optical industries to Mr. Chalmers, a Sydney graduate ; a number of spectroscopic researches we owe to Professor Duffield, formerly of the University of Adelaide ; Professor

Durack (Sydney), Gray (Melbourne), Lusby (Sydney), Glasson (Adelaide), Florance (New Zealand) are all contributing to physics from various English laboratories.

It is to be hoped that in the future an increasing amount of such investigation will be carried out in Australasian laboratories, so that these laboratories will come to be generally regarded not merely as places where existing knowledge is taught, but also where there flourishes an enlightening spirit of investigation. When our laboratories come to be generally regarded in this light it can but increase their reputation in all directions, and make the community have that confidence in science which is so typical of the German people, and which many believe is intimately connected with their unprecedented industrial progress.

The History of the Earth.—The doctrine of uniformity in geology stated by Hutton in the words, "we find no vestige of a beginning and no prospect of an end," was accepted by many till Lord Kelvin surprised this school of geologists in 1868 by drawing a very decided limit to the possible age of the earth.*

Lord Kelvin assumed that in the remote past the earth was molten, that it cooled down as a whole uniformly until the crust just solidified. Then the earth's interior was at a definite temperature, which we can now roughly estimate from the known melting points of the rocks of the crust, while the surface had much the same temperature as now. The rate of cooling was determined by the thermal conductivity of the crust, *i.e.*, by the rate at which the interior heat could escape.

For such a body it becomes possible to calculate what the temperature gradient near the surface will be at any subsequent time; or conversely, if we know the temperature gradient, to calculate what time has elapsed since the crust solidified.

Lord Kelvin showed by applying Fourier's theorem that the temperature gradient at a depth x and time t is equal to

$$\theta_0 e^{-x^2/4\kappa t} / \sqrt{\pi\kappa t}$$

where θ_0 is the initial surface temperature, κ the conductivity of the solid.

In applying this to the earth we notice that x is small and t large, so that

$$d\theta/dx = \theta_0 / \sqrt{\pi\kappa t}$$

All of the quantities in this relation other than t are known.

Lord Kelvin's estimates of the antiquity of the earth varied a good deal, but 40 million years was the maximum he would admit latterly.

* By the age or antiquity of the earth I understand Lord Kelvin means the time that has elapsed since the crust solidified. The "geological age" would be less than this. The antiquity of a rock (or mineral) would only in the case of the oldest rocks be the same as the geological age. Thus the age of a mineral is a minimum estimate of the earth's age.

Sources of heat—the radio-active elements—are now known, which Lord Kelvin did not, of course, take into account. The earth can no longer be regarded as a body possessing only its sensible heat, to supply the stream continually flowing from the interior to the surface—heat which it presumably radiates into space.

The above treatment of the problem might be modified by taking into account this additional supply of heat. But the discoveries of radio-activity, which require the modification, at the same time afford, it appears to the writer, an alternative treatment of the history of the earth which is more convincing. This treatment consists in accepting the antiquity of the earth as found by Professor Strutt, using a radio-active method, and in then examining the heat of the earth in the light of that result. Every calculation of the age of the earth assumes to some degree a uniformity of present phenomena throughout the whole life of the earth, either this uniformity is assumed in the rate of deposition of sediments,[1] or for the addition of sodium to the sea,[2] or for the conduction of heat by rocks, or finally the rate of accumulation of helium in minerals or rocks.[3] Now of all these processes the last is the only one which is not altered by temperature, pressure, or other physical conditions.

Professor Strutt has concluded from a very refined determination of (1) the present rate of production of helium and (2) the total accumulated helium in thorianite that it has taken 280 million years for the helium to accumulate. As the earth is presumably older than the mineral, this is a minimum age for the earth.

The Heat of the Earth.—The question at once arises, how is it that the temperature gradient of the crust is not less than it actually is, for according to Lord Kelvin after only 40 million years the gradient would have fallen to the present value. During the remaining 240 million years it would have gone on decreasing, and at any time would be inversely proportional to the square root of the time. It becomes evident then that there is actually a need for the heat supplied by the radio-activity of the crust if all these deductions are to be reconciled.

The Heat Stream from the Interior.—The heat stream from the interior is that flowing through the Earth's surface layers. This is

$$\begin{aligned} H &= 4\pi r^2 \kappa d\theta/dr \\ &= 5{\cdot}1 \times 10^{18} \times {\cdot}004 \times 1/3200 \\ &= 6{\cdot}4 \times 10^{12}\ cal/sec. \end{aligned}$$

where r is the earth's radius, $d\theta/dr$ the temperature gradient of the crust at the earth's surface and κ its thermal conductivity. We must attempt to substitute such numerical values for the temperature gradient, and the conductivity as will give a correct result for

1. Geikie, *Brit. Ass. Rep.*, 1899.
2. Joly, *Brit. Ass. Rep.*
3. Strutt, *Proc. Roy. Soc.*, 84, 379, 1910.

the earth's whole surface. The nature of the data is indicated by the following estimates[1] :—

TEMPERATURE GRADIENT

Land Surface.		Average Temperature Gradients.	
Prestwich	1° C. per 2430 cm.	Geikie	1° C. per 3100 cm.
Kelvin	1° C. per 2750 cm.	Brit. Assn. ..	1° C. per 3240 cm.
Schardt	1° C. per 3200 cm.	C. King	1° C. per 3890 cm.

The value used above is 1° per 3200 cm.

CONDUCTIVITY

Land Surface.	Conductivity at Ordinary Temp. in Calorie Degree $^{-1}$cm.$^{-1}$ sec^{-1}
Sedimentary rocks	.0055 to .0021 mean .0041
Igneous rocks	.0053 to .0017 mean .0042

There is more uncertainty in the value of κ than in that of $d\theta/dr$. A more accurate estimate of the heat loss of the earth is desirable. Convection currents make the conduction method ordinarily inapplicable to the sea or lakes, but under special conditions, such as fresh water between 0° and 4° C., might not the method be applicable to a lake ?

Heat from Uranium and Thorium in Rocks.—Lord Kelvin supposed that this heat stream of 6×10^{12} calories per sec. came from the sensible heat of the earth's interior which is thereby cooled. That the heat of disintegration of radium might play an important part in cosmical physics was pointed out by Rutherford and Soddy[2]. The accurate determination of radium and thorium in rocks has shown there is an embarrassingly large supply of heat being continuously emitted by these substances. A number of determinations of radium in rocks have been made by Strutt and Joly, but there is need for a systematic survey.

Radium in Igneous Rocks.—

Number of Rocks.	Mean Radium Content in gm. per gm. of Rock.	Observer.
28	1.7×10^{-12}	Strutt (P.R.S. May, 1906) corrected by Eve.
4	2.16	Eve and McIntosh (P.M. Aug., 1907).
19	.79	Fletcher (P.M. July, 1909), in Joly's laboratory.
13	1.46	Farr and Florance (P.M. Nov., 1909).
mean 64	1.3	
126	7.01	Joly (Radioactivity and geology, P.M. Oct., 1909)

1. Joly, "Radio-activity and Geology."
2. *Phil. Mag.* May, 1903.

There is rather a wide difference between the mean of Joly's large number of determinations and the mean of other observations. There is clearly a discrepancy, which would probably be most quickly elucidated by the chief observers, determining the radium in specimens of the same rock carefully ground and mixed. If we give equal weight to the mean of Joly's observations 7×10^{12} and to 1.3×10^{-12} the mean of the other observers, the final average is 4.1×10^{-12} gm. Now the heat given out by radium[1] in complete radio-active equilibrium (uranium to radium F)[2] is .06 calories per sec. per gm., so that each gm. of the earth's crust on account of the radium it contains is the source of $4.1 \times 10^{-12} \times .06 = 2.5 \times 10^{-13}$ calorie per sec of heat, a source unaffected so far as experiment has shown by temperature or pressure.

Thorium in the Earth's Crust.—But the uranium radium series of radioactive elements are not the only source of such heat; thorium is also widely distributed. Fewer rocks have been examined for it than for radium, but the following results have been recorded :—

Thorium in Igneous Rocks.

Number of Rocks.	Locality.	Thorium per gm. of Rock.	Observer.
19	Transandine	$.56 \times 10^{-5}$	Fletcher, P.M. July, 1910
59	St. Gothard and Lavas	1.3 ,,	Joly, P.M. July, 1909
4	European	5. ,,	Blanc, P.M. July, 1909
Mean for 82		1.3 ,,	

The heat emitted by thorium in radio-active equilibrium is 5×10^{-9} calories per sec. per gm[3], and that by the average amount of thorium in rocks 6.5×10^{-14} cal. sec^{-1} gm.$^{-1}$

Heat due to Radium and Thorium in Rocks.—Thus the heat emitted by the uranium, radium and thorium found in surface rocks is $(24.6 \times 6.5)\ 10^{-14} = 3 \times 10^{-13}$ cal. sec^{-1} gm.$^{-1}$. Blanc[4] having found nearly four times as much thorium as our mean value, concluded that thorium contributed as much heat as uranium and radium.

Distribution of Radio-Active Elements.—If the whole mass of the earth (6×10^{27} gms.) were the source of as much radio-active heat as the surface rocks, the heat emitted would be 1.8×10^{15} calories per sec. or about 300 times the heat flowing from the interior as deduced from the conductivity and temperature gradient of the surface rocks. But if the interior of the earth gains more heat than it loses, then its temperature is rising, nor is the geological and other

1. Von Schweidler and Hess "Le Radium," Feb., 1909.
2. Boltwood, *Amer. Journ. Science.*, 1908.
3. Pegram and Webb, *Phy. Rev.*, 1908.
4. *Science Abs.*, No. 1057, 1909.

evidence that the earth was once hotter than now, the only contradiction to a "heating-up" earth.

Assuming as before that the antiquity of the earth to be at least 300 million years (t) then in that period a supply of heat of 3×10^{-13} cal. gm.$^{-1}$ sec.$^{-1}$ (h) would have raised the interior of the earth above its initial temperature. This temperature change is given by

$$s\theta=ht$$

$$\theta=3\times10^{-13}\times3\times10^{8}\times3.2\times10^{7}/.2=14{,}000^{\circ}\text{C}.$$

where s is the specific heat of the internal material. Though loss by conduction to the surface and latent heat effects are here neglected, the calculation is sufficient to show that a uniform distribution of the radio-active elements would give rise to internal temperatures too high to be reconciled with the observed temperature gradients[1]. We may safely conclude that there is very much less uranium, radium, and thorium in the inner portion of the earth than there is in the crust, and a maximum limit may be assigned to the content of radio-active elements. It would appear a minimum limit may also be set.

According to Lord Kelvin, as we have seen above, a period of cooling of more than 40 million years could not have elapsed between the solidification of the terrestrial crust and the establishment of the present temperature gradient. If, however, the antiquity of the earth is over 40 million years, then the temperature gradient has been maintained by some additional source of heat than that assumed by Kelvin and the radio-activity of the rocks is amply sufficient for the purpose if it extends to quite moderate depths. The present temperature gradient would be maintained for a very long time if the stream of heat from the interior came from the radio-activity of the rocks.

There would need to be $6\times10^{12}/.06=10^{14}$ gms. of terrestrial radium to supply the heat lost by conduction, and a layer of the earth's crust 14 km. deep, if of density 3, has a mass of 2.1×10^{25} and it would give out $2.1\times10^{25}\times3\times10^{-13}=6\times10^{12}$ cal./sec., assuming the content of radium and thorium, and therefore the heat emission, was that of the surface rocks. There is very probably at least this amount of terrestrial radio-active elements, otherwise it is not apparent why the temperature gradient of the crust has its present value, assuming the antiquity of the earth to exceed 300 million years. If it greatly exceeds that period then the present temperature gradient can depend but little on the secular cooling of the earth from a molten state.

Professor Strutt[2] has determined the minimum age of thorianite by evaluating the ratio

$$\frac{\text{the quantity of helium in the mineral at present}}{\text{the rate at which the helium is produced}}$$

1. This will be seen at once to follow from a calculation given by Strutt, *Proc. Roy. Soc.*, p. 482, 1906.
2. *Proc. Roy. Soc.*, **84**, 379, 1910.

The refinement of the experiment will be appreciated when it is recalled that the rate of production of the helium is only 4×10^{-8}cc. per gm. of thorianite per year. He found as already mentioned 280 million years for one specimen, 250 millions for another.

To deduce a minimum age for the mineral it must be assumed that :—

(1) There was no original store of helium in the mineral when it was formed.

(2) The mineral has not gained helium at any time except as it does now.

(3) That the present rate of accumulation of helium is the same as in the remote past, when possibly high pressures and temperatures pertained.

We will consider the observational basis for these assumptions :

(1 and 2) If the helium was originally present in the mineral when it was formed, or added later, then we would expect to find other minerals, in which helium is not now accumulating, containing helium, but no such minerals are known[1]. Helium is only found in appreciable quantities asssociated with thorium and uranium. The mechanism[2] of how it is continuously and unchangingly produced from these elements is known in great detail.

(3) That radio-active changes are independent of temperature and pressure has been repeatedly tested and confirmed.

Relative Motion of Earth and Ether.

All optical phenomena observed till the classic experiment of Michelson and Morley agreed with the view that the earth moved through an " absolutely " stationary ether[3]. That experiment, and others, designed to exhibit this relative motion of the earth and ether failed even to show a second order effect. Fitzgerald and Lorentz, by postulating that a body when set in motion contracts in length, were able to reconcile the absence of positive effects, with the hypothesis that the ether is stationary and undisturbed by even the earth's momentum. But the contraction hypothesis of these physicists, though it most ingeniously accounted for the null effects, where positive ones were expected, appeared neither capable of proof or of disproof, and so to many was unconvincing. Lorentz showed that the shrinkage hypothesis required that the mass of moving electric charges (β and cathode rays) should increase in a certain definite manner with their speed of translation. This has since been exactly confirmed. And so the hypothesis becomes at once one of the most remarkable and historically interesting in physics. Einstein approaching the experimental evidence from a different standpoint, postulates that it is impossible to detect uniform motion of the observer and his instruments relative to the ether.

1. The mineral beryl, it should be stated, has been found by Strutt to have an exceptional high ratio of helium to uranium, but both Strutt and Boltwood suggest explanations. *Proc. Roy. Soc.*, **84**, A 569, p. 194., July, 1910.

2. See for example Rutherford's Nobel Lecture, 1908.

3. See Bumstead, *Amer. Journ. Sci.*, Nov., 1908.

This puts absolute motion and motion relative to the ether in the same category, both as physically unrecognisable. Einstein accepts the results of such experiments as Michelson and Morley's, Rayleigh's. Brace's, Trouton and Noble's, as exhibiting an empirical principle—*the principle of relativity*, according to which it is impossible for an observer to detect his absolute motion relative to a stationary ether. Setting out with that assumption he develops a new system of dynamics, and lays down how length and time are to be measured in a moving system so that after they have been so measured no positive effects are to be expected from a convection of optical, electrical, or other apparatus in which the observer shares. It has been pointed out by Bumstead that if the principle of relativity is accepted it will occupy a position analagous to that of the second law of thermodynamics. It rests on a similar basis, in that no deviations from it have been observed. Indeed the analogy may be made more complete, for Larmor[1] has shown that the denial of the principle leads to a kind of perpetual motion, by which the kinetic energy of any body might be exhausted and the body be brought to rest with reference to the ether. There is, however, an enormous difference in the breadth of the evidence on which the two principles rest. Violations of the principle of relativity lead only to minute effects, which must be sought in difficult and recondite experiments.

H. A. Lorentz's treatment[2] of most of the problems of moving bodies, based on the fundamental equations of the electromagnetic field, has led up to the present to the same result as Einstein's principle. Lorentz's treatment makes the ether substantial and important; the other decreases the ether's importance. The principle of relativity, there can be no doubt, formulates our knowledge more clearly.

Physical Phenomena in Moving Bodies—First Order Positive Effects.—How some of the experimental results fit in with the theories mentioned above, and to what degree inconsistencies have been removed is considered below.

The aberration of light, as discovered by Bradley, in 1728, is usually explained on what is really a projectile theory of light. It is often pointed out to illustrate the theory that an observer looking through the hole made by a projectile from a stationary gun in a moving ship would not see the gun's position, but a position ahead of it. This makes the angle of aberration of light, a, equal to the ratio of the velocity of the earth, u, to velocity of light in the telescope, v, *i.e.*, $a = u/v$, when a is small.

Airy's experiment on the aberration of light, in which the telescope was filled with water in order to diminish the velocity of the light in the telescope, but with no effect on the angle of aberration, is a more general case than Bradley's. The emission

1. "Aether and Matter."
2. "The Theory of Electrons."

theory obviously fails to explain it, for v is altered while a and u are unchanged.[1]

Experimental evidence was obtained by Fizeau of the effect of a moving material medium (water) upon the velocity of light propagated in it. The light from a stationary source travelled with and against the stream of water, having a velocity u and refractive index μ. The velocity of the light in the water was increased (compared to its velocity in free space) by about half the velocity of the water. This increase is expressed by

$$u\,(1-1/\mu^2)$$

The possibility of an explanation of Airy's experiment becomes apparent, though the velocity of the light down the telescope tube is decreased by the water, the angle of aberration is unchanged, as the light disturbance drifts with the water and the earth, and to a first order of approximation the observed effects can be calculated by Huyghens' principle and Fresnel's coefficient.

Lodge's Experiment.—Now, if material media change the velocity of light in this manner, it is to be expected that the ether is entrained by moving matter. The experimental evidence is against that view, nor, as we will see, is there any satisfactory theory, which postulates such an entrainment, of the phenomena we are considering.

Lodge directly investigated the question by sending two beams of light in the equatorial crevasse in a sphere of iron capable of rotation, one beam being in the direction of rotation, the other against it. The interference bands formed on combining the beams were unaffected by the rotation of the iron. The ether, we conclude, was not entrained by the moving iron.

Fresnel Theory.—In 1818 Fresnel in a letter to Arago formulated a theory, which anticipated the increase of velocity by $u\ (1-1/\mu^2)$, which takes place in Fitzeau's experiment (see above). This coefficient $(1-1/\mu^2)$ has been deduced by Lorentz for the propagation of light in material media containing electrons[2], and assuming a stationary ether.

Thus the aberration of light in Airy's experiment, the positive effect in Fizeau's experiment are consistent with a stationary ether and electro-magnetic theory; further, Lodge's experiment affords direct evidence that moving matter does not disturb the ether.

Aberration Theories.—Stokes' Theory.—There are two important theories to explain the aberration of light from stars. Stokes[3] assumed that the earth set the ether in its immediate

1. The constant of aberration is slightly greater than can be reconciled with the velocity of light, and solar parallax, which determines u. Plummer, *Monthly Notices R.A.S.*, April, 1909.

2. Lorentz: "The Theory of Electrons," p. 182. There is a small term depending the dispersion of the medium in addition to the above.

3. *Phil. Mag.*, 27, 9, 1845.

neighbourhood in motion, and that there was no "slip" at the earth's surface. This hypothesis completely accounts for the aberration of light, provided the motion of the ether is irrotational, which is only possible if the ether is compressible.[1] The degree[2] of compression necessary, however, to account for the observed aberration is so huge that some effect on the velocity of light is to be expected. Stokes' hypothesis of no slip and Lodge's experiment are contradictory. The other theory of abberation is Fresnel's.

The Absence of Expected Second Order Effects.—Michelson and Morley's Experiment.—An immediate conclusion from the theory that the ether is stationary and the earth moves through it is that certain positive effects proportional to $u^2/v^2=\beta^2$, or of a second order of small quantities, are to be expected. Michelson and Morley were the first to seek for such a phenomenon. A beam of light was split; one-half had, for a certain orientation of the interferometer, a longitudinal path in the direction of the earth's motion, and back from a mirror to the observer; the other half of the beam had a similar path, but it was at right angles to first and to the direction of motion. The beams recombined, forming interference bands, which, however, were unaltered by changing the orientation of the interferometer. If the interferometer moved through a quiescent ether, the longitudinal path would be longer than the lateral, as the mirror is retreating from the light. The lateral path is also increased, but not so much as the other. This sets up a difference of path, which depends on the orientation of the interferometer. But actually the interference bands were independent of orientation. One-tenth of the effect to be expected could have been detected. This was the first of a series of experiments which failed to bring to light small physical effects to be expected from the convection of optical or electrical apparatus (with the earth) relative to the ether, which we concluded above is stationary.

Search for Double Refraction.—More than one point of view would indicate the possibility that the convection of transparent media through the ether would render them doubly refracting. The Fitzgerald-Lorentz shrinkage might have the same effect on the optical properties of the medium as a mechanical stress would if it produced the shrinkage. Lord Rayleigh[3] failed to find any evidence of double refraction in carbon bisulphide or glass due to the earth's motion.

Electrical Effects.—Trouton and Noble's Experiment.—The convection of the charges of an electric condenser will produce a magnetic field with a certain energy. It is to be expected that the plane of the condenser will tend to set itself in a definite direction with respect to the direction of motion. Trouton and Noble suspended a condenser, but were unable to detect any couple due to the earth's motion through space, and they could have detected the couple calculated to act on the condenser.

1. Planck.
2. Lorentz "Theory of Electrons," p. 314.
3. *Phil. Mag.*, **4**, 678 (1902).

Fitzgerald-Lorentz Hypothesis.—There is evidence of a varied nature that the ether is stationary and not entrained by moving bodies, and further evidence that positive effects to be expected from the earth's motion through that stationary ether do not exist. Taken together, these statements require material bodies to contract in length when set in motion. Stated more explicitly, the Fitzgerald-Lorentz hypothesis is that a solid body of length L when at rest if given a velocity u contracts in the direction of motion to a length $L\ (1-u^2/v^2)^{\frac{1}{2}}$ or $L\sqrt{1-\beta^2}$, v being the velocity of light. there is no change at right angles to the direction of movement. The shrinkage is very small, and the orbital velocity of the earth would only cause the very small change of 6 cms. in the earth's diameter.

Experimental Confirmation.—Lorentz has applied the contraction to electrons in motion, and predicted the effect of it on their electro-magnetic mass. An electron which is a sphere when at rest becomes an elipsoid when in motion with its short axis in the direction of motion, and the axis at right angles unchanged. Its author calls it a deformable electron, and has calculated its transverse (m_t) and longitudinal (m_l) electro-magnetic mass at different velocities. They are

$$m_t = m_o(1-\beta^2)^{-\frac{1}{2}}$$
$$m_l = m_o(1-\beta^2)^{-\frac{3}{2}}$$

where m_o is the mass of the electron for very small speeds. For the transverse mass we have :

β	0	·1	·5	·9	·99
m_t/m_o	1	1·005	1·15	2·29	7·09

and the longitudinal mass increases even more rapidly.

This variation of mass with velocity has been confirmed by the refined experiments of Bucherer[1] and Wolz[1], who used β rays from radium having velocities between ·3 and ·7 of that of light.

As stated above, Einstein has laid down how length and time are to be measured so that no positive effects are to be expected from a convection of optical, electrical, or other apparatus relative to the stationary ether. All moving bodies are subject to the Fitzgerald-Lorentz contraction in the direction of motion ; and Einstein shows that if clocks when in motion and at rest are synchronised by light signals then they may be used to measure time consistently with the principle of relativity. The moving clocks, he shows, run slower than the stationary ones. When a clock is in motion with a velocity u it beats with a period of $1/\sqrt{1-\beta^2}$ seconds, instead of the seconds it beats when at rest, where $\beta = u/v$.

1. *Ann. d. Phys.* 1909.

PAPERS READ IN SECTION A.

1.—ACTION OF THE LATEX OF EUPHORBIA PEPLUS ON THE PHOTOGRAPHIC PLATE.

By H. G. CHAPMAN, M.D., B.S., and J. M. PETRIE, D.Sc., F.I.C.

ABSTRACT.

The milky juice or latex of this plant has been employed by surgeons for the treatment of rodent ulcer. It has occurred to us to test whether the dried latex has any action on a photographic plate. A thin layer of the juice is spread on glass and is dried. A photographic plate is placed a little distance above the dried film. When the plate is developed after three to seven days an image of the film appears on the plate. If a word be written with the juice a well defined photograph of the word appears on the plate. Such an image appears when the distance between the film and the plate is not more than one centimetre. The thicker the film of dried juice the more dense is the image on the photographic plate. If tissue paper, thick paper, thin aluminium foil, or gold leaf be placed between the photographic plate and the film the image is produced in the same way and is sharply defined. If glass or mica be interposed the photographic plate is protected and no image appears. We have been unable to obtain glass or mica less than 1-100th mm. in thickness.

The film of latex may be heated to 200 C. without any diminution of its action on the photographic plate. At this temperature it commences to char and the action on the photographic plate remains powerful despite the destruction of the organic matter. When the ash becomes white the action on the photographic plate is much lessened. The photographic effect is also obtained during the passage of a dry air or of carbon dioxide, also under greatly reduced pressure.

2.—IONISATION BY IMPACT.

By PROFESSOR KERR GRANT, M.A.

ABSTRACT.

The violent impact of one solid upon another is found to cause considerable ionisation in the air in the neighbourhood. Experiments in which a leaden bullet was fired at a target lead to the following qualitative results:—

1. A definite number of ions are produced when a leaden bullet of given mass strikes an iron target with given velocity.

2. The number of ions due to impact increases with the velocity of impact, but only very slowly if the velocity exceeds a certain value.
3. The velocity, in an electric field, of the negative ions due to impact is slightly greater than that of the positive ions, the ratio of the velocities being roughly 17 to 13.
4. The ions rapidly recombine, the number falling to half its value in five seconds from the time of impact and being quite insignificant after the lapse of two minutes.
5. The effect appears to vary with the nature of the material of the target.

3.—ON A SIMPLE LABORATORY METHOD OF DETERMINING THE RATIO OF THE TWO PRINCIPAL ELASTICITIES OF AIR.

By E. F. J. LOVE, M.A., D.Sc., F.R.A.S., assisted by G. SMEAL, B.Sc.

ABSTRACT.

The method is in principle the same as Manœuvrier's, but differs altogether from it in details, being far simpler and at the same time more flexible. True adiabatic compressions are used, and the thermal difficulties of the experiment are eliminated by the use of pressure changes of the order 0·06 c.m of mercury, and consequently temperature changes of the order 0·06°C. The results, given in the paper, are claimed by the author to compare very favourably with any others obtained with simple apparatus; he proposes to adapt it to determine the ratio for other gases, especially hydrogen, for which its freedom from thermal troubles renders it particularly well adapted.

The titles of the following papers were ordered to be published :—

4.—STANDARDS OF ELECTROMOTIVE FORCE.

By R. C. SIMPSON, A.K.C., A.M.I.E.E., A.A.I.E.E.

5.—COMETS AND THEIR TAILS.

By T. COOKSEY, Ph.D., B.Sc., F.I.C.

6.—THE HARMONIC ANALYSIS OF TIDAL OBSERVATIONS.

By C. E. ADAMS, M.Sc.

7.—TIDAL PREDICTIONS.

By C. E. ADAMS, M.Sc.

8.—THE TIME CONTROL OF THE WELLINGTON TIDE GAUGE.

Bv C. E. ADAMS, M.Sc.

9.—AN INDUCTIVE METHOD OF DERIVING CERTAIN MATHEMATICAL FORMULÆ.

By H. TOMKYS.

10.—A DIRECT METHOD OF ESTABLISHING THE CONVERSE OF A PROPOSITION.

By H. TOMKYS.

11.—THE GEOGRAPHICAL POSITION, CHARACTER, AND CONTOUR OF ANTICYCLONES AS AN INDICATION OF COMING WEATHER.

By H. A. HUNT, F.R.Met.Soc.

12.—THE TRILINEAR GEOMETRY OF THE COMPLETE QUADRILATERAL.

By E. G. HOGG, M.A.

13.—ON A SYSTEM OF RELATED TRIANGLES.

By E. G. HOGG, M.A.

14.—THE SCATTERING OF CATHODE RAYS.

By J. P. V. MADSEN, B.E., D.Sc.

15.—NOTE ON THE THEORY OF THE ELECTRODELESS DISCHARGE.

By PROFESSOR POLLOCK, B.E., D.Sc.

16.—THE NATURE OF THE LIGHT EFFECT IN SELENIUM.

By O. U. VONWILLER, B.Sc.

17.—BRIEF NOTE ON THE NEW MAINKA SEISMOMETER AT RIVERVIEW COLLEGE, SYDNEY.

By Rev. E. F. PIGOT, S.J., B.A., M.B.

18.—STANDARD ASTRONOMY, ITS PRESENT POSITION AND FUTURE PROSPECTS.

By W. E. COOKE, M.A., F.R.A.S.

19.—ON THE SCATTERING OF SOUND WAVES BY A SOLID CONE.

By PROFESSOR CARSLAW, M.A., D.Sc., F.R.S.E.

REPORTS OF RESEARCH COMMITTEES

SECTION A

SOLAR PHYSICS COMMITTEE.

Resolutions carried at Brisbane, 1909 :—

(*a*) That the Australian Association for the Advancement of Science records its unanimous support to the movement for the establishment of an Observatory in Australia devoted to the study of Solar Physics, which has been so strongly advocated by the International Union for Co-operation in Solar Research, by the Royal Society, and by the British Association for the Advancement of Science, and which is essential to the scheme of solar study instituted by the International Union. The practical possibilities combined with the scientific value of solar research, make the project a matter of national as well as scientific importance.

(*b*) That a copy of the above resolution be forwarded to the Prime Minister of Australia, with an urgent appeal that steps be taken to secure the establishment of a Solar Physics Observatory in Australia.

(*c*) That a Committee be formed to aid the work of establishing such an Observatory, to consist of : Professors Bragg and Pollock, Messrs. Baracchi, Knibbs (Chairman) and Cooke, and Dr. Duffield (Secretary), with power to add to their number.

(*d*) That in view of the generous attitude of the British Association in granting £50 towards the establishment of the Observatory, a similar sum be granted to the Committee by the Association.

At the Sydney meeting, 1911, the Committee was re-appointed, with the addition of the following :—Professors Lyle, McAulay, and Chapman, Senator Keating, James Oddie, Esq.

REPORT.

The immediate object of this Committee is the establishment of a Solar Observatory which may co-operate with other great solar observatories of the world, and, by filling the last remaining gap in the chain of Observatories round the earth, *enable the sun to be kept under continuous observation for the whole of the twenty-four hours,* in accordance with the scheme of the International Solar Union. The scientific value of this work, and the practical possibilities as regards meteorological applications, have been so universally acknowledged that enumeration of them is here unnecessary.

Reasons have already been presented to this Association why it is so desirable that Australia should undertake her share in the work; they may be briefly summarised thus :—

International Reasons.

(*a*) *Australia's position in longitude* would enable her to fill a gap at present existing in the chain of Observatories round the earth.

(*b*) *Australia's position in latitude.*—No station devoted to solar research exists south of the equator, where one is required to extend and verify the work of the Smithsonian Institution's Observatory at Washington.

(*c*) *Australia's climatic conditions* would allow investigations to be made under excellent conditions at a time of year when, on account of the rainy season, work is generally impossible at other Observatories.

National Reasons.

(*a*) *The advancement of Science.*

(*b*) *The educational* advantages accruing from the study of an intellectual subject.

(*c*) *The practical* advantages which meteorology may fairly expect to gain from a proper understanding of the connection between solar and terrestrial phenomena.

The Universities throughout Australia gave their cordial support to the project by appointing their Professors of Physics to be their official representatives upon the Committee.

In accordance with the unanimous resolution of the Council of the Australasian Association to the effect that the Federal Government be strongly urged to secure the establishment of a Solar Observatory in Australia, the Committee, having met in Melbourne, formed a deputation to wait upon the Minister for Home Affairs (Mr. Mahon) of the Commonwealth Government (Fisher Ministry), whose favourable reply is given below.

Before further action could be taken by this Ministry, Mr. Deakin came into power, and to demonstrate that the movement is one which is supported most vigorously, on October 26th, 1909, a public meeting was held in the Town Hall, Melbourne, by kind permission of the Lord Mayor, which was presided over by the Governor-General, who was supported by the Governor of Victoria.

The following scientific bodies appointed representatives to attend the meeting :—

University of Melbourne—Sir John Madden, G.C.M.G., Chancellor.
University of Hobart—[1]Sir John Dodds, K.C.M.G., Chancellor.
University of Sydney—[1]Professor David, F.R.S.
University of Adelaide—Professor Henderson.
Melbourne Observatory—Mr. P. Baracchi, Government Astronomer of Victoria.
Perth Observatory—[1]Mr. W. E. Cooke, Government Astronomer of West Australia.

1. Indicates that the delegate was unable to attend the meeting.

Adelaide Observatory—Mr. Dodwell, Government Astronomer of South Australia.
Royal Society of N.S.W.—Professor Baldwin Spencer, C.M.G., F.R.S.
Royal Society of Victoria—Dr. Love.
Royal Society of South Australia—Dr. Pulleine.
N.S.W. Branch of British Astronomical Association—Mr. Merfield.
Astronomical Society of South Australia—Mr. Dodwell, Government Astronomer.

Lord Dudley, who opened the proceedings, stated that the great reason in favour of the establishment of a well-equipped Solar Observatory in the Commonwealth arose from the geographical position, which seemed to mark out Australia as most suited to fill the gap which at present existed in the chain of Observatories round the earth. It was obvious that the proper conduct of solar research depended upon a continuous series of observations being made throughout the 24 hours during which the earth rotated once about her axis, and presented different parts of her surface in succession to the sun. This could not be done from one Observatory alone, and was the chief reason for the formation of the International Union. At present the work of solar observation was being carried on in three well-defined areas. There was a great break between California and India, extending over a distance of 150 deg., or nearly half the earth's circumference, and the international importance of this project arose from the desirability of filling this gap, and thus completing the chain of solar observatories round the world. It seemed that Australia possessed one notable site-advantage over Japan for the proposed station, namely, that this country is south of the line. Observations could be made most successfully in Australia from November to May, which was just the time when observations could be least successfully made in the existing stations in the United States, Europe, and India, owing to the rainy seasons. Moreover, Australia was peculiarly favoured for this branch of research by her climatic conditions, by the abundance of her sunshine, and by the clearness of her atmosphere. It has been estimated that a minimum capital expenditure of £10,000 would be required, and that the maintenance would involve an annual expenditure of at least £1,500. No more notable monument could be raised to the memory of a great Australian by his friends and relatives than the endowment in whole or part of a Solar Observatory. It would be little short of a national misfortune, if, for the sake of a few thousand pounds, Australia failed to take the place amongst the nations of the world in scientific research for which her geographical position marked her out. This country appeared destined by nature for the work, and it was doubtful whether it could be done anywhere else so well as here. The location of the new station in Australia would mean that three out of the four necessary links in the chain of observatories would be within the Empire, and that all four—the American, the British, the Indian, and Australian—would be run by English-speaking peoples. It would also show that Australia recognised her responsibilities and her opportunities, and had taken her place amongst the nations of the world, at any rate in the realms of science.

The project was also supported by :—The Governor of Victoria, Sir John Madden, K.C.M.G. ; Sir George Reid, K.C.M.G. ; Professors David, Pollock, and Henderson, and by Mr. Baracchi, Mr. Hunt and Dr. Duffield.

A cable (supporting the project) from Sir J. J. Thomson (President of the British Association), Sir George Darwin (Vice-President of the Royal Society) and Sir Joseph Larmor (Secretary Royal Society) was received too late to be read at the meeting.

The following resolution was carried unanimously :—"That the establishment of a Solar Observatory is desirable, and that the Federal Government be strongly urged to assume the responsibility of carrying it into effect."

The above resolution was presented to the Prime Minister (Mr. Deakin), who, after the matter had been considered by the Cabinet, stated :—

"To-day the Cabinet considered the question of establishing a Solar Observatory in Australia, recognising the obligation of the Commonwealth to take its part in this great scientific work, which is of world-wide interest, and possesses also some special interest in its inferred relation to climatic changes. The Cabinet has approved of a proposal, for submission to Parliament, which will provide for the maintenance of such an observatory situated at a suitable spot in the interior of the continent.

"The idea of the Government is to maintain the institution, but the cost of construction and equipment, if fully adequate to the task of research, would probably amount to about £10,000. It is considered probable that one or more of the wealthy men of Australia might undertake this cost, in order to secure the establishment of such an institution.

"The cost of conducting the Observatory, it is calculated, will be about £1,500 per annum for the earliest years, with probably an expanding outlay as the work develops."

The reply of the Minister for Home Affairs of the first Fisher Ministry (April 1, 1909), referred to above, was that "He realised the importance of the plea for an Australian Observatory, and that the financial aid required was probably disproportionate to the value of the scientific records sought to be secured. He thought Parliament would not be less public spirited than private citizens, and would probably give pound for pound to the erection and equipment fund, and might maintain the Observatory after its establishment."

The matter has thus received the assent of the two Ministries which have controlled the affairs of the Commonwealth since this scheme was brought forward. Both have relied upon the financial assistance which might be accorded to the scheme.

It has consequently been the policy of this Committee to obtain the sum of £5,000 in money and apparatus by private donations, both in accordance with the reply of the Fisher Ministry, which indicated that the Commonwealth Parliament would give one pound for one pound as well as the annual upkeep, and in accordance with Mr. Deakin's statement in the House of Representatives, in reply to a question from Mr. Mahon, that the annual upkeep would be promised in the first place, but that "if necessary he might go further."

This Committee trusts to be enabled to offer to the Commonwealth Government the sum of £5,000 in money and apparatus towards this great Observatory. Towards this sum apparatus and funds have been forthcoming to the estimated value of £4,017, making, roughly, a total of £1,000 to be subscribed.

The Committee, in presenting this report to the Council of the Australasian Association, respectfully submits that the universal support from the scientific bodies within Australia which has been added to that of the great scientific institutions of the mother country and other nations (among others, that of the Royal Society, British Association and International Solar Union) is sufficient evidence of the responsibility which rests upon the people and Government of Australia to carry this project into complete and immediate effect.

The support accorded to this scientific movement is, it is believed, of a unique nature. More influential support within Australia or outside Australia, it would be impossible to obtain.

DONATIONS AND BEQUESTS TOWARDS SOLAR OBSERVATORY IN AUSTRALIA.

	Estimated Value.
Oddie Bequest—26-inch Reflecting Telescope, 9-inch Grubb Refractor, 8-inch Reflecting Telescope, Electrical Plant, etc. ..	£2,000
Farnham Bequest—6-inch Grubb Telescope	400
Cœlostat Body, presented by Franklin Adams, Esq.	87
Pyrheliometer, presented by James Fowler, Esq.	30
	£2,517

*F. K. McClean, Esq. ..	£500	William Oliver, Esq.	£50
Mrs. Davies Thomas ..	100	A. Gordon Laidlaw, Esq. ..	50
D. Walter Duffield, Esq ..	100	Harold Fisher, Esq.	50
Messrs. D. & J. Fowler ..	100	Messrs. Goode, Durrant & Co.	25
Messrs. Harris, Scarfe & Co.	100	Peter Waite, Esq.	25
D. A. Sutherland, Esq. ..	100	John Gordon, Esq.	25
British Association ..	50	James Pittendrigh, Esq. ..	25
Australasian Association ..	50	Mrs. Harold Fisher	25
Hon. J. J. Duncan ..	50	H. J. Preston, Esq.	25
W. G. Hawkes, Esq. ..	50		

Apparatus	£2,517
Cash	1,500
	£4,017

W. GEOFFREY DUFFIELD, Hon. Sec.,
University College, Reading, England ; and Dundrennan, Glenelg, South Australia.

* This lapsed in October, 1910, but has been renewed for another year till October, 1911

In January, 1910, the Commonwealth Government appointed a Board consisting of R. A. Macdonald (Under-Secretary for Lands, N.S.W.), R. P. Sellors (Geodetic Survey, N.S.W.), C. R. Scrivener (Commonwealth Director of Surveys), H. A. Hunt (Commonwealth Meteorologist), P. Baracchi (Government Astronomer, Victoria) to enquire and report upon the best site for an Observatory within the Federal Territory at Yass-Canberra. The Board unanimously selected and recommended a site on the summit of a hill some 2,500 feet above sea level, which, in their opinion, was probably as suitable for the purpose as any place in Australia.

The Commonwealth Government, having accepted the recommendations of this Board, instructed Mr. Barrachi to establish a temporary Observatory at the selected site and, from an astronomical point of view, to test the locality in order to determine definitely whether it answered the requirements of modern scientific research, including astrophysics. The Department of Home Affairs has prepared plans for a dome to house a 9-inch refracting telescope, and the work is now actually proceeding. The telescope is the gift of James Oddie, Esq., of Ballarat, who offered it, together with other instruments and appliances, on condition that it would be utilised as a part of the equipment of a Solar Observatory. Mr. Barrachi, under instructions from the Department of Home Affairs, took delivery of the whole of this equipment from Mr. Oddie in July, 1910, and, pending the construction of buildings at Yass-Canberra, had it housed temporarily at the Melbourne Observatory for alterations, additions and repairs. It is proposed to erect at the site this 9-inch refractor, upon which a Dallmeyer photographic lens, 6-inch aperture and 42-inch focal length is now being mounted, and for a year to make observations during one week in every six weeks, the observations to be carried out alternatively by Mr. Barrachi and his chief assistant, Mr. J. M. Baldwin.

Appended is a memorandum upon the proposed Solar Observatory in Australia issued by the Committee :—

G. H. KNIBBS,
Chairman of Committee.

MEMORANDUM UPON THE PROPOSED SOLAR OBSERVATORY IN AUSTRALIA

Issued by the Solar Physics Committee of the Australasian Association for the Advancement of Science.

Preface.

The object of this Memorandum is to draw attention to the urgency of establishing in Australia an Observatory for the study of the sun. A co-operative scheme has been initiated between the great Solar Physics Observatories of Europe, America, and India, and Australia's participation in this international work is essential to its complete success.

The study of the sun is important from two points of view—one is purely scientific, and the sun is regarded as typical of one stage in the evolution of celestial bodies ; the other takes account of his unrivalled influence upon the physical and meteorological conditions of the earth.

This Memorandum explains how an Australian Solar Observatory will fill a gap existing in the chain of Observatories round the earth, and how her position south of the equator and her unique climatic conditions make her participation in the international scheme of most urgent importance. The Australian movement has received probably as influential support as it is possible to obtain for any scientific project, among others that of the International Solar Research Union, the Royal Society, the British Association, the Australasian Association for the Advancement of Science, the Smithsonian Institution of U.S.A., and other influential scientific bodies in Europe and America, whose views are contained in these pages.

The Memorandum summarises the practical possibilities of the proposed Observatory, and the national and international advantages that would accrue from such an institution.

SOLAR RESEARCH

The Proposed Solar Observatory in Australia.

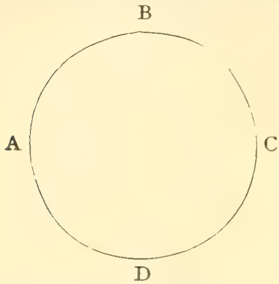
That this work is of national importance is shown by the attendance at the last Congress of the International Solar Research Union of Representatives from the Observatories and Scientific bodies of Austria, Belgium, France, Germany, Great Britain, Holland, Hungary, India, Italy, Russia, Servia, Spain, Switzerland and the United States.

Australia is not represented upon the International Committee, though her co-operation is earnestly desired for the following reasons :—

1. The Establishment of a Solar Observatory in Australia is essential for the completion of the International Scheme.

(*a*) *Because it would fill a gap at present existing in the chain of Observatories round the Earth.*

The existence of the International Union for Solar Research is due to the fact that several problems connected with the sun depend for their solution upon a continuous series of observations made throughout the 24 hours, during which period the earth rotates once about her axis, and presents different parts of her surface in succession to the sun. It has thus passed out of the scope of two or even three stations to deal with such questions—what is required are Observatories spaced regularly round the earth so that the sun may be observed at one of them when observations are unfavourable or impossible at the others. At present the stations are concentrated in three well-defined areas, which are marked A, B, C in the sketch, and which are separated by approximately 90° of longitude. The great gap between India and America, at D, could be filled by an Australian Observatory, whose erection would enable the changes in the form of sun spots, their numbers and areas, and the variations in the prominences and in the distribution of metallic vapours over the solar disc to be kept under continual observation throughout the whole of the 24 hours.



The circle represents the Equator.

A—India.
B.—England, France, Germany, Russia, &c.
C—America (Mt. Wilson, Washington, &c.)
D—Australia.

(*b*) *Because a Solar Observatory is required south of the Equator.*

If we neglect Mauritius, where solar work is confined to direct photographs of the sun's disc, no station south of the Equator contributes towards the International Scheme, though work with the spectroheliograph is required in south latitudes, and that most important branch of study—solar radiation—must eventually be undertaken in the same part of the world. For this work a fully-equipped Observatory exists at Washington, and though the Smithsonian Institution has repeatedly urged the necessity of an additional station in south latitudes, and has pointed out the benefits that may reasonably be expected from a full study of this subject, the problem is not attacked elsewhere.

(*c*) *Because Australia's Climatic Conditions are uniquely favourable.*

With her almost perpetual sunshine Australia is particularly suitable for this work, and, besides the promise that her clear skies give of excellent photographic results, the feature that makes Australian co-operation especially desirable is that observations would be possible in Australia at the time of year when they can be least successfully made at other great Observatories—Kodaikanal (India), Mt. Wilson (U.S.A.), South Kensington, &c. At the first of these the rainy season lasts from November till February, at the second from December till May, and at South Kensington work is out of the question during the English winter; consequently an Observatory in Australia, where the sunshine is practically unfailing from November to March, is essential for supplying the solar observations for this season of the year, and is necessary for the fulfilment of the scheme of international co-operation.

The comment of Sir John Eliot, K.C.I.E., F.R.S. (late Astronomer and Meteorologist to the Indian Government), when this was pointed out to him, was: "Sir, this Observatory is not only advisable, it is essential."

II. Besides the above reasons, which are of international significance, there are others which may be classified as

(*d*) *Purely Scientific Reasons.*

Apart from the educational value of astronomical research, the doctrine that all work should be relegated to the country most suitable for it, requires that advantage should be taken of the unique climatic conditions of Australia, which is unrivalled in the abundance of her sunshine and the clearness of her atmosphere. Such problems as the nature and cause of sun spots, to which the recent discovery in America of vast vortices and intense magnetic fields has added so much importance—the nature of the corona and other solar appendages—the distribution of the elements over the solar disc—the pressure of the sun's atmosphere —solar rotation—the cause of the remarkable differences between the spectra from the centre of the disc and from the limb—the connection between solar disturbances and terrestrial phenomena are all questions of world-wide interest, and it may be hoped that Australia will share in the task of elucidating them.

(*e*) *Practical Reasons—*

It would be to Australia's advantage to undertake the work. Much has been written about the connection between solar and terrestrial phenomena, between sunspots and rainfall, barometric pressure, etc., and it is the earnest hope of solar investigators that this subject may be fully dealt with at Observatories well equipped for the purpose. The Council of the Royal Society of London urges the establishment of a Solar Observatory in Australia, "especially as the subject includes the connection between solar changes and meteorological and magnetic phenomena." Moreover, the great work on solar radiation carried out in Washington by the Astrophysical Observatory of the Smithsonian Institution "was deliberately undertaken in the hope of improving weather forecasts," and for furthering this study Australia is exceptionally well placed. It is well known that the newly-established Indian Solar Observatory has been erected in the belief that it will ultimately furnish results of direct value in famine prediction, the action taken by the India Office being based upon the Indian Famine Commission Report of 1880. The Indian observations cannot, however, be linked up with those of the American Observatories until an Australian station is established, and Australia's interest in problems connected with her rainfall well fit her to join India in attempting to elucidate them.

Attention may also be drawn to the communication from the Smithsonian Institution, given on page 45, in which it is stated that "it may be fairly claimed that an Australian Solar Observatory would have a direct value for the people of Australia. Indeed, there is no branch of astronomy which more fully deserves the support of the Government because of its probable utility than the study of solar radiation in its relations to life and climate and power upon the earth." Moreover, the Australasian Association for the Advancement of Science urges that "the practical possibilities, combined with the scientific value of solar research, make the project of national as well as of international importance."

The arguments for the establishment in Australia of an Observatory devoted to Solar Physics are summarised below :—

International Reasons.

The necessity for Australian co-operation with other nations in solar work is exemplified under the following heads :—

(*a*) *Australia's position in longitude* would enable her to fill a gap at present existing in the chain of Observatories round the earth.

(*b*) *Australia's position in latitude.* No station devoted to solar research exists south of the Equator, where one is required to extend and verify the work of the Smithsonian Institution's Observatory at Washington.

(*c*) *Australia's Climatic Conditions* would allow investigations to be made under excellent conditions at a time of year when, on account of the rainy season, work is generally impossible at other Observatories.

National Reasons.

(*a*) *The Advancement of Science.*

(*b*) The *Educational* advantages accruing from the study of an intellectual subject.

(*c*) The *Practical* advantages which Meteorology may fairly expect to gain from a proper understanding of the connection between solar and terrestrial phenomena.

History of the Movement.

In April, 1907, a letter to the Adelaide papers aroused some interest in the matter, and the Premier of South Australia was asked for funds to enable the Adelaide Observatory to undertake the work. This was refused on the ground that the Observatory was about to be absorbed by the Commonwealth Government.

At the last Congress of the International Solar Research Union in Paris in May, 1907, Sir Norman Lockyer, K.C.B., F.R.S., proposed a resolution supporting the movement, and this was carried unanimously.

A copy of this resolution was forwarded by the Chairman of the International Union to the Colonial Office, whence it was referred to the Governor-General of Australia.

The Commonwealth Government, in the absence of an Astronomical Department, referred the matter to the Meteorological Department, which reported that "it is very desirable that such an Observatory should be established, etc.," and enquiries were made as to the personnel and equipment of existing State Observatories for carrying out the work. These, however, replied that they were not equipped for the purpose, and could only undertake the work if the necessary funds should be forthcoming from the Commonwealth Government.

The British Association offered its influential support, and formed a Committee to co-operate with Australian Astronomers to further the movement, with Sir David Gill, F.R.S. (retiring President of the British Association), as Chairman.

The Royal Society expressed its approval of the project and suggested that the proposed Observatory should be affiliated with the Adelaide University. But the Council of the University, though willing to undertake the work, could only do so if the funds were forthcoming from an external source.

A broader basis for this Observatory, however, lay in its being affiliated not with one University, but with *all* the Universities within the Commonwealth, the matter being one which affects the prestige of Australian Science, not the Science of any one particular State.

Upon these lines, therefore, the Australian Solar Physics Committee was formed at the meeting of the Australasian Association for the Advancement of Science in Brisbane, January, 1909, consisting of the Professors of Physics of all the Universities within the Commonwealth, and the Government Astronomer of each State (where appointed), the personnel being :—

President : G. H. Knibbs, Commonwealth Statistician ; Prof. Bragg, M.A., F.R.S., President of the Australasian Association, and Professor of Physics, University of Adelaide ; Prof. Lyle[1], M.A., D.Sc., Professor of Physics, University of Melbourne ; Prof. Pollock[1], D.Sc., Professor of Physics, University of Sydney ; Prof. McAulay[1], M.A., Professor of Physics, University of Tasmania ; Prof. Chapman[1], M.A., Professor of Engineering, University of Adelaide ; Mr. P. Barracchi, Government Astronomer of Victoria ; Mr. Dodwell, Government Astronomer of South Australia ; Mr. W. E. Cooke, M.A., Government Astronomer of Western Australia ; Senator Keating ; James Oddie, Esq. ; Hon. Sec., W. G. Duffield, D.Sc., Dundrennan, Glenelg, South Australia.

This Committee formed a deputation which waited upon the Minister for Home Affairs of the Commonwealth Government (Fisher Ministry) and presented the resolution which had been passed by the Council of the Australasian Association for the Advancement of Science. The Minister replied that " he realised the importance of the plea for an Australian Observatory, and that the financial aid required was probably disproportionate to the value of the scientific records sought to be secured. He

1. Signifies that the Member is the Official Representative of the University upon the Committee.

thought Parliament would be not less public spirited than private citizens, and would probably give pound for pound to the erection and equipment fund, and might maintain the Observatory after its establishment."

The Object of the Committee.

The Solar Physics Committee was formed to "promote in Australia the study of the sun and allied stellar and spectroscopic research."

It is of opinion that the subject requires a separate institution erected in a locality which will be favourable as regards climatic conditions, etc., in regard to which the existing State Observatories are unsuitable, and for which they have not the necessary equipment. Such a course also obviates the subject becoming a subsidiary one at an existing institution.

The Secretary acknowledges with thanks promises of sums of money amounting to a little over £1,000, which have been received since October, 1908, towards the purchase of a large spectro-heliograph, conditionally upon the remainder of the £1,500 required being promised before October, 1910. A generous offer of a telescope has been made by the Trustees of the Estate of the late Lord Farnham, whose will provided that the instrument should be devoted "to the best advancement of astronomy," and Mr. James Oddie, F.R.G.S., of Ballarat, has offered a 26-inch reflecting telescope and a 9-inch Grubb refractor, as well as some electric plant. These offers are also conditional upon a promise to house the instruments at an early date.

The Committee estimates that £10,000 will be required for the equipment, the erection of the necessary buildings, and the housing of the telescopes and apparatus that have been offered. It is further estimated that £1,500 per annum is the minimum sum required for the up-keep of the Observatory.

It is hoped that this money will be forthcoming without delay, that the chain of Observatories round the earth may no longer remain incomplete, and that Australia may take her place among the nations by establishing an Observatory for the study of the sun which will both by the encouragement of original research and by its co-operation with other nations assume an international importance.

SCIENTIFIC INSTITUTIONS SUPPORTING THE PROPOSAL.

The International Solar Research Union.—This organisation is chiefly responsible for all work connected with the sun. It has appointed Committees to undertake such special work as the choice of the necessary standards, the measurements of solar radiation, the investigation of sun spots, the organisation of eclipse expeditions, and the selection of suitable systems of research to be carried out by different observing stations.

The following bodies compose the Union :—

1. Koninklijke Akademie van Wetenschappen (Amsterdam)
2. Real Academia de Ciencias y Artes (Barcelona)
3. Deutsche Physikalische Gesellschaft (Berlin)
4. Société helvétique des Sciences Naturelles (Berne)
5. Società degli Spettroscopisti Italiani (Catania)
6. The Royal Society (London)
7. The Royal Astronomical Society (London)
8. The Solar Physics Committee (London)
9. The Astronomical and Astrophysical Society of America (Madison, Wisconsin)
10. Sociedad Española de Fisica y Quimica (Madrid)
11. Académie des Sciences (Paris)
12. Société Astronomique de France (Paris)
13. Société francaise de Physique (Paris)
14. American Physical Society (Philadelphia)
15. Académie Impériale des Sciences (St. Petersburg)
16. Kongl. Svenska Vetenskaps Akademien (Stockholm)
17. Kaiserliche Akademie der Wissenschaften (Vienna)
18. National Academy of Sciences (Washington)
19. Solar Sub-Committee of the International Meteorological Committee

At the meeting in Paris, May, 1907, the following resolution was proposed by Sir Norman Lockyer, and carried unanimously:—" That this International Congress hears with great satisfaction of the proposal to establish a Solar Physics Observatory in Australia, and expresses its decided opinion that an observing station in that part of the world would fill a gap which now exists in the system of observatories distributed over the earth, and yield contributions of great value to the study of solar phenomena."

The Royal Society.—" The Royal Society are strongly of opinion that the foundation and equipment of a Solar Observatory in Australia are desirable, or else, as an alternative, that provision for systematic solar observations, including an adequate staff, should be made at one of the existing observatories. They are of opinion that a very valuable contribution could thus be made by Australia to the International Scheme of Solar Research now in operation, especially as the subject includes the connection between Solar changes and Meteorological and Magnetic phenomena, in the systematic international observation of which Australia already takes a share."
February 10, 1908.

The British Association for the Advancement of Science, September, 1909, formed a committee to co-operate with Australian Astronomers " To aid in the establishment of a Solar Observatory in Australia," consisting of :— Sir David Gill, F.R.S. (Chairman), Professor Arthur Schuster, F.R.S., Dr. W. J. S. Lockyer, Professor H. H. Turner, F.R.S., Mr. F. K. McClean, Dr. W. G. Duffield (Hon. Secretary, Dundrennan, Glenelg, South Australia). A grant-in-aid of £50 was voted.

Smithsonian Institution.—The Secretary writes :—" Mr. Abbott, the Director of the Astrophysical Observatory here, with whom I have conferred in the matter, is of the opinion that Australia furnishes excellent sites for a Solar Observatory, because of cloudlessness. It is now known that there are rapid changes occurring on the sun, which for their proper understanding require early continuous observations to be made. Few existing observatories are situated in regions where good solar observing conditions are common, and there is abundant opportunity for valuable work on the part of the proposed Australian Observatory. Its situation is exceptionally favourable both in latitude and longitude, and therefore the more desirable, so that it may be unhesitatingly said that an Australian Solar Observatory is likely to promote knowledge in many branches of science. While of course the advantage to science is a sufficient argument among scientific men for the usefulness of such an establishment, it may be fairly claimed that such an observatory would have a direct value for the people of Australia. Indeed there is no branch of astronomy which more fully deserves the support of the Government because of its probable utility, than the study of solar radiation in its relations to life and climate and power upon the earth."

October 31, 1907.

In addition to the above institutions and to British and Colonial Observatories, the project has the support of the following:—

The Mt. Wilson Solar Observatory, California, U.S.A.
The Royal Observatory of Catania and Etna.
The Society of Italian Spectroscopists.

SEISMOLOGICAL COMMITTEE.

Originally appointed Sydney, 1887.

See also Adelaide volume, 1907, p. xxix.

Reappointed Brisbane, 1909.

"That a Committee be appointed to investigate and report on the Seismological Phenomena in Australia."

The Committee to consist of: Sir Charles Todd, K.C.M.G. (since deceased); Professor T. W. E. David, B.A., F.R.S.; Professor A. McAulay, M.A.; Mr. W. E. Cooke, F.R.A.S.; Dr. E. F. J. Love, M.A.; Mr. R. F. Griffiths; Messrs. P. Baracchi, F.R.A.S., and G. Hogben, M.A. (Secretaries).

At the Sydney meeting 1911, the Committee was reappointed with the addition of the Rev. Father E. F. Pigot, S.J.

NEW ZEALAND.

Report of G. HOGBEN, M.A.

During the past year there was an important series of earthquakes in the Western Pacific region. The origins of several of these have been approximately ascertained, as far as the imperfect data available admit of such determination. For instance, of two earthquakes recorded at most, if not all, of the Australasian stations on the 29th June, 1909, one probably had its origin beneath the surface of the ocean between the New Hebrides and the Ellice Group, and the other came from the neighbourhood of Antipodes Island. Other shocks recorded during the year came from origins intermediate in position between these two. It is suggested that the attention of the Committee should be concentrated upon the task of the definite determination of these seismic centres, and as far as possible of the nature of the movements that are taking place. For this purpose each Observatory should send to the other Observatories in the group at least as often as once a month particulars of its chief records, in the manner in which this is now being done by the Perth Observatory, and that seismograms should be sent therewith to one of the Secretaries, and on request to any other member of the Seismological Committee who is willing to work out the results. Having already determined most of the New Zealand origins and several of the other Australasian centres of disturbance, I am willing to do what can be done with whatever data may be placed at my disposal. The Secretaries should also be instructed to communicate with public officers or other residents in the various island groups with the object of obtaining records of shocks noted in the several localities. The Committee is reminded that its report presented at the Adelaide meeting in 1893 contained the record of three very considerable elevations of the land surface, namely, those that took place in the island of Tanna, New Hebrides (one in 1878, and two in 1888); and recent newspapers refer to a similar rise of the land in another portion of the same group in connection with the earthquake of the 9th November last.

The suggested investigation involves several difficulties. First, there is the well-known difficulty of identifying the phase of the waves to which any particular record relates. For distant earthquakes it is possible to distinguish series of waves, whose velocities of propagation vary considerably. But for earthquakes from nearer origins, the waves overlap on the Milne seismograms of the older type, made by instruments with the slow movement of the recording cylinder. It is in any case desirable that the seismological investigator should have a copy of the seismogram to enable him where possible to compare the times for the same phase of the waves; but even so, for comparatively near earthquakes, the task of distinguishing the phases is well nigh impossible unless the diagram is more open than is the case with the records in question. I therefore trust that in all the Observatories in which Milne instruments are installed the recommendation of the British Association will be adopted, namely, that the instruments should be fitted with the quicker-moving apparatus that more open diagrams may be secured. There still remains the difficulty, which is more serious apparently in some Observatories than in others, of the confusion caused by the appearance of what are known as air-tremors, which fog the record of the small and rapid waves of the first phase, commonly called "preliminary tremors." This difficulty could be largely overcome if the instrument could be fitted with a damping apparatus. But the momentum of the boom of the Milne instrument when disturbed is so small that any damping attachment would probably interfere seriously with its sensibility. It might be considered, therefore, that the time had arrived for the installation of instruments which are as sensitive as the Milne, but which are provided with suitable damping attachment. Any horizontal pendulum with a heavy weight attached to the boom can be so fitted with suitable damping apparatus. The British Association recommends that where possible each Observatory should be provided with a second Milne seismograph placed so as to record N-S movements, the present instruments being generally installed to record E-W movements. In the opinion of their Committee it would be of greater advantage to seismology if, instead of being provided with another Milne instrument each Observatory had for its second seismograph one of the Wiechert instruments, or else one of the Mainka-Bosch or Omori-Bosch type, with provision for damping. The latter has the advantage of comparative cheapness. The Riverview Observatory is fitted with a Wiechert Astatic pendulum and with a Mainka Bifillar Conical Pendulum; and I take this opportunity of welcoming to the ranks of seismological workers in Australasia the Rev. E. F. Pigot, S.J., Director of the Observatory.

SYDNEY OBSERVATORY.

W. C. GRAHAM, Observer.

With the exception of three instances when the clock of the Seismograph, a Milne horizontal pendulum, was stopped owing to flaws in the sensitised paper, the instrument has been continually recording during the years 1909 and 1910. The disturbances have greatly outnumbered those of the two preceding years. Whereas, during the years 1907 and 1908 ninety-six and ninety tremors respectively were recorded, in 1909 one hundred and fifty-eight, and in 1910 one hundred and sixty-three tremors were "trapped" by the Sydney Observatory Seismograph.

Classifying them according to their intensity, they are as follow :—

1909.

1	tremor	15.8 mm. in amplitude		(April 27th)	0.6%
1	,,	14.0 mm.	,,	(June 12th)	0.6%
1	,,	9.0 mm.	,,	(Dec. 9th)	0.6%
1	,,	5.2 mm.	,,	(May 30th)	0.6%
1	,,	4.0 mm.	,,	(June 3rd)	0.6%
4	,,	3 mm. and under	4mm.		2.5%
15	,,	2 mm. ,,	3 mm.		9.5%
11	,,	1 mm. ,,	2 mm.		7.0%
123	,,	under 1 mm.			78.0%
158	tremors.				100%

1910.

3	tremors	over 17 mm. in amp.		(June 16, Nov. 9, Dec. 16)	1.8%
1	,,	16.6 mm.	,,	(Nov. 26th)	0.6%
1	,,	12.0 mm.	,,	(July 29th)	0.6%
2	,,	9.0 mm. and under	10 mm.		1.2%
2	,,	8 mm. ,,	9 mm.		1.2%
0	,,	7 mm. ,,	8 mm.		0
6	,,	6 mm. ,,	7 mm.		3.6%
1	,,	5 mm. ,,	6 mm.		0.6%
2	,,	4 mm. ,,	5 mm.		1.2%
7	,,	3 mm. ,,	4 mm.		4.2%
6	,,	2 mm. ,,	3 mm.		3.6%
13	,,	1 mm. ,,	2 mm.		7.8%
122	,,	under 1 mm.			73.5%
166	tremors				100%

The tabulated records of the Seismograph are sent to Professor Milne for publication in the Annual Report of the Seismological Committee of the British Association.

MELBOURNE OBSERVATORY.

P. BARACCHI, Government Astronomer for Victoria.

Seismological records have been obtained continuously throughout the period January 1st, 1909, to December 31st, 1910, by means of a Milne Horizontal Pendulum as in previous years.

SOUTH AUSTRALIA.

G. F. DODWELL, Government Astronomer for South Australia.

A Milne Horizontal Pendulum Seismograph, recording the E-W component, has been in continuous operation at the Adelaide Observatory since June 22nd, 1909, a few days' registration only having been lost, owing to alterations in the seismograph room, failure of the light, etc. This instrument has been described in a paper on S.A. Earthquakes, read before the Association in January, 1909. Gradual changes of level, of a seasonal nature, have been recognised in the records,, and on one or two occasions the level change has been large and sudden, probably due to the heavy rains of winter affecting the foundations.

The total number of distant earthquakes, from June 22nd, 1909, to December 31st, 1910, whose maxima were of greater amplitude than 2.5 mm., was 28., four of these being in 1909 and 24 in 1910. One large earthquke in 1910 was not recorded, owing to a temporary failure of the light. Many of these earthquakes appear to have originated in the Pacific Islands.

The tabulated records of the seismograph are sent to Professor Milne for publication in the Annual Report of the Seismological Committee of the British Association.

A list of earthquakes originating in South Australia is supplied herewith.

LIST OF EARTHQUAKES ORIGINATING IN SOUTH AUSTRALIA.

Date.	Place.	Time of beginning of Shock, Adelaide S.T 9 h. 30 m., E. of G.	Apparent Direction.	Apparent Duration.	Effect. Remarks.
1909 Jan. 15	Kapunda	2.45 a.m.	W. to E.	15 secs.	Slight shock noticed by several people.
,, 24	Tothill's Belt ..	4.15 p.m.	—	15 secs.	Slight shock. Rumbling noise like distant thunder.
Feb. 11	Hallett	5.55 a.m.	N.E. to S.W.	2 secs.	Slight shock.
May 31	Port Darwin ..	6.33 a.m.	S.W. to N.E.	40 secs.	Sharp shock. Doors and windows rattled.
June 17	Blinman	6.57 p.m.	N.W. to S.E.	5 secs.	Slight. Deep rumbling. Vibration unusually sharp Barometers had previously dropped with unusual rapidity.
July 30	Wallaroo	1.45 p.m.	S.W. to N.E.	3 secs.	Sharp shock.
,, 30	Cowell	1.47 p.m.	S.W. to N.E.	8 secs.	——
Oct. 30	Port Darwin ..	7.49 p.m.	N.W. to S.E.	3 mins.	Severe shock. Doors, windows and crockery rattled.
,, 30	Katherine River	7.55 p.m.	N.W. to S.E.	2 mins.	——
1910 Feb. 7	Adelaide	4.0 p.m.	N. to S.	5 or 6 secs.	Slight. Walls of room shook. Rolling sensation experienced. Windows shaken.
,, 24	Alice Springs ..	1.35 p.m.	S.W. to N.E.	1 min.	Slight. Trembling of crockery and movable articles.
,, 24	Mt. Benstead .. (about 30 miles E.N.E. of Alice Springs.)	1.40 p.m.	—	5 mins.	Severe. Uplifting of earth's surface for about 5 mins. Earth felt as if charged with electricity.
April 2	Hornsdale ..	About midnight	N. to S.	a few secs	Fairly severe. Distinctly shook a new house.
,, 23	Marrabel	10.20 a.m.	S.W. to N.E.	20 secs.	Sharp shock. Crockery rattled and moved forward. Nothing thrown down. : 4 miles to the East plates thrown down.
,, 23	Eudunda	10.21 a.m.	Not apparent	1 sec.	Slight. Slight rattling of doors and windows.
,, 24	Beltana	8.0 p.m.	W. to E.	10 secs.	Slight. Windows rattled.
,, 24	Leigh Creek ..	8.0 p.m.	W. to E.	15 secs.	Severe shock. Buildings swayed, plaster fell, persons trying to walk rolled about as if drunk. Women fainted, No previous tremors or rumbling. Dead calm at time of shock.
,, 26	Leigh Creek ..	1.15 p.m.	W. to E.	3 secs.	Slight shock. Slight rumbling and tremor.
June 30	Booleroo Centre	6.50 p.m.	S.W. to N.E.	—	Sharp. Crockery rattled.
,, 30	Melrose	6.54 p.m.	N.W. to S.W.(?)	15 to 20sec.	Slight. Crockery slightly shaken ; rumbling noise.
Sept. 16	Hornsdale ..	2.0 a.m.	N. to S.	5 secs.	Sharp shock. No effects shown. Heavy storm during shock.
Oct. 22	Leigh Creek ..	7.35 p.m.	—	—	Buildings shook.
,, 22	Blinman	7.35 p.m.	S.E. to N.W.	15 to 20sec.	Severe shock.
,, 25	Willochra	6.10 a.m.	—	30 secs.	Not severe. Shook walls of houses.
Dec. 12	Sutherlands ..	3.0 a.m.	—	—	—

RIVERVIEW COLLEGE OBSERVATORY, SYDNEY, N.S.W.

Rev. E. F. PIGOT, S.J., Director.

The Seismological branch of the College Observatory begun here some few years ago was opened in March, 1909, and since the following month the seismometers Nos. 1 and 2 (see attached sheet) have been recording continuously, while the pair of Strasburg Pendulums (No. 3) have been in operation since their erection last June. The two former instruments have been briefly described in a paper read before the Royal Society of New South Wales, December, 1909 ; a description of the latter (with lantern illustrations of details, as in the former case) formed the subject of a short communication to Section A of the A.A.A.S., meeting in Sydney.

The accompanying sheet is explanatory to the Riverview "Seismological Bulletins," which are published at intervals, giving quantitative analyses of the disturbances of true seismic origin recorded here. A detailed study of the records with reference to other lines of research—*e.g.*, periodic bradyseismic tilt movements, the meteorological significance of certain forms of microseismic waves, etc.—has been also in progress for some time, the results of which will be published later.

Riverview College Observatory.

$\phi = 33° \ 49' \ 49''$ S.
$\lambda = 10^{h.} \ 4^{m} \ 38^{s.}$ E.
$h = 41.9$ metres.

Seismological Bulletins Notation Employed, Instruments, Reductions, etc.

Notation.—That of the Göttingen Geophysical Institute (slightly modified).

The following abbreviations are employed :—

A.—Character of the Earthquake.

I. = perceptible ; II. = striking ; III. = very striking.
d (= *terræ motus domesticus*) = local.
v (= ,, ,, *vicinus*) = near (less than 1000 km.)
r (= ,, ,, *remotus*) = distant (1000 to 5000 km.)
u (= ,, ,, *ultimus*) = very distant (over 5000 km.)

B.—Phases.

P (= *undæ primæ*) = 1st prelim. tremors (commencement).
S (= ,, *secundæ*) = 2nd ,, ,, (,,).
L (= ,, *longæ*) = "principal phase," long waves, Rayleigh waves (commencement).
M (= ,, *maximæ*) = maximum amplitude of L waves.
C (= *coda*) = a prominent wave among the "after-tremors" (Nachlaufer).
F (= *finis*) = last perceptible movement (non-microseismic).
PR_1, PR_2, ... SR_1, SR_2, ... = 1st, 2nd . . . . . reflected waves of P and S.
PS = so-called "Wechselwellen"—*i.e.*, waves whose longitudinal character has been altered by reflection to transversal.
$M_{rI.}$ = L waves which have traversed the major arc.
$M_{rII.}$ = ,, ,, ,, ,, minor ,, $+2\pi R$.

C.—WAVE-ELEMENTS, UNITS, ETC.

T = complete Period of earth-particle (in seconds).
A = Amplitude ,, ,, measured from median position, in microns, μ ; ($1\mu = \frac{1}{1000}$ mm.).
Δg = maximum acceleration of earth-particle (in milligals)—
1 milligal = $\frac{1}{1000}$ Gal (C. G. S. unit of acceleration).
= 10^{-3} cm/sec.^{2} (or approximately, $g \times 10^{-6}$, since 1 gal = $\frac{g}{980}$ nearly).
i (= *impetus*) = abrupt commencement, clearly defined.
e (= *emersio*) = gradual ,, not clearly defined.
E′ = *stylus-displacement* for 1″ of tilt (inclination), in mm.
E, N, Z = EW, NS, and Vertical components of earth-oscillation, respectively
Ep. = approximate distance from Epicentre (or epicentral area), in km.
E. Q. = earthquake.

N.B.—Phase-symbols, numerical values, etc., in brackets ( ) are to be considered as *probable* only.

INSTRUMENTS.

No. 1 Wiechert 1000 kilo. Horizontal-Seismometer (" Astatic Pendulum ") 2 Components—EW and NS. (G. Bartels, Göttingen).
No. 2 Wiechert 80 kilo. Vertical-Seismometer. (Spindler & Hoyer, Göttingen).
[Nos. 1 and 2 in use since March and April, 1909, respectively. No. 3 to be erected immediately (April, 1910.)]
No. 3 Mainka 500 kilo. Horizontal-Seismometer (" Bifilar Conical Pendulum "), 2 Components—EW and NS. (J. & A. Bosch, Strassburg.)

Working-Constants (re-determined at short intervals) : last determination:—

No. 1 —EW	$T_0 = 8.7$s.	V = 207	ϵ = 5.8.
No. 1 —NS	$T_0 = 8.5$s.	V = 217	ϵ = 4.7.
No. 2	$T_0 = 3.5$s.	V = 57.5	ϵ = 2.6.

The determination of Constants, calculation of A, Δg, Ep., etc., are carried out strictly according to accepted methods. For A, a graphic method (Dr. L. Geiger, 1908) is employed, and for Ep. (in most cases) the " Laufzeiten " of Dr. Zoeppritz.

SITE.—The Seismological-cellar (half underground) is situated in a secluded portion of the College Grounds, remote from any artificial source of vibration therein, 5 km. distant from the city of Sydney, and 3 km. from the nearest railway. It is about 300 m. from the shore of one of the numerous indentations of Sydney Harbour, at a height of about 25 m. above mean sea-level. The seismometers are mounted on massive concrete piers, with rock-foundation. A gap of several centimeters surrounds the piers of Nos. 1 and 3 to the full depth.

GEOLOGICAL STRUCTURE.—The foundation is solid Triassic " Hawkesbury Sandstone," a formation of remarkably uniform character. The sandstone has a dip of about 1° westwards, and a thickness of about 270 m. Weathering renders the stone soft to a depth of a metre or two from the surface. Under the Hawkesbury Sandstone there are about 600 m. of Triassic " Narrabeen Beds " (sandstone and shale), and probably at least 1500 m. of Permo-carboniferous rocks, the whole thickness being approximately in horizontal layers.

Section B

CHEMISTRY, METALLURGY and MINERALOGY

ADDRESS BY THE PRESIDENT:

Professor BERTRAM D. STEELE, D.Sc.

Professor of Chemistry in the University of Queensland, Brisbane.

THE subject that I have chosen for the annual address this year has been selected in the belief that a useful purpose would be served by calling attention to the manner in which our conventional views are influenced by the fact that the majority of the chemical reactions which we study take place in aqueous solution.

There is an opinion, never perhaps formulated, but very often unconsciously held, that " wet-way analysis " is perhaps the most important branch of chemistry. Perhaps in the minds of some students the idea may have become developed that it *is* chemistry—an idea which might certainly be expected occasionally from the fact that it is frequently the only branch of chemistry that is taught in some of our institutions.

A few examples will illustrate the results of our concentration of effort and instruction on wet-way reactions.

Thus barium sulphate is regarded as one of the most insoluble of substances, and its chemistry is usually dismissed with the statement of this fact. But whilst this is true of water as solvent, it dissolves freely in concentrated sulphuric acid. Again, we classify substances as crystalloids and colloids solely on the information derived from the study of aqueous solutions ; but as a matter of fact sodium chloride, a typical crystalloid, may and does behave as a colloid when in solution in benzol. It is true that chemists are beginning to recognise that we must rather speak of a crystalloid or colloid state of matter than of crystalloid and colloid substances. As another example, we may consider the fact that in a standard English treatise ammonia is spoken of as a strongly basic substance, having a pungent alkaline taste, etc, a statement which is certainly true of an aqueous solution of ammonia, but not of the pure substance, the behaviour of which in the absence of water is entirely different, though no less interesting and important.

I propose to-day very briefly to put before you some of the results of investigations on the solvent action of inorganic substances other than water, and to point out as far as may be possible the similarities and dissimilarities in their general behaviour.

Of the large number of solvents that have been investigated, mention may be made of the following:—Water, alcohols, acetone and ether, the halogen hydrides, sulphuretted hydrogen, ammonia and certain organic amines, hydrogen cyanide and the alkyl cyanides, bromine, sulphur dioxide, nitrogen peroxide, nitric acid, some of the trihalides and oxyhalides of phosphorus, arsenic and antimony, etc. etc.

Exhaustive investigations have been carried out with only a few of these, and I propose to discuss briefly the behaviour of solutions in water, ammonia, sulphur dioxide, and the halogen hydrides.

Solutions in any solvent may be classified as conducting and non-conducting, according as they do or do not permit of the easy passage of a current of electricity. A corresponding classification of solutes into electrolytes and non-electrolytes has been made and based again solely on the results of the study of aqueous solutions. To the former class belong the acids, bases and salts, and to the latter substances such as sugar, the alcohols, ethers and other non-saline solutes.

It is worth pointing out that no metallic salt is known which dissolves in sulphuretted hydrogen or in any of the halogen hydrides, and that in all of these solvents substances like ether, alcohols, ketones, etc., dissolve more or less freely with the formation of conducting solutions, and might therefore have been regarded as electrolytes had these solutions been studied before those in water.

The selective action of solvent towards solute in forming a conducting solution is a fact which speedily becomes apparent when a number of solvents are considered. Take, for example, the following figures, which represent the conductivities of equivalent solutions of potassium iodide and of hydrogen chloride in the same series of solvents:—

SOLUTE.	SOLVENT.			
	Water.	Methyl Alcohol.	Acetone.	Sulphur Dioxide.
Potassium Iodide ..	143	98	154	45
Hydrogen Chloride ..	360	133	2.21	extremely small.

The lack of any regularity in these figures is very striking, and the consideration of a larger number of instances would convince us that it would be more correct to speak of conducting solutions than of conducting solvents, as is so frequently done.

That attention has in the past been devoted mainly to the solvent is evidenced by the large amount of work which has been done in the effort to correlate the formation of a conducting solution with certain of the physical properties of the *solvent*. Of these properties there is one, and only one, the magnitude of which appears to vary with the 'ionising' power of the solvent. This is the dielectric constant, and its possible relation to the power of a solvent to take part in the formation of a conducting solution was pointed out by Nernst and by Thompson, and has been thoroughly investigated by Walden.

Consideration of the foregoing facts has led to the suggestion that the necessary antecedent to the formation of a conducting solution is the formation of a compound between solvent and solute. I think that there is not yet sufficient evidence to settle the question here set forth, but the following considerations indicate clearly that such compound formation cannot be the only necessary antecedent.

(1) Hydrogen bromide alone and water alone do not form conducting solutions in liquefied sulphur dioxide, but mixed solutions of these two substances in this solvent do conduct fairly well. This can be explained by compound formation between the water and the hydrogen bromide with formation of an oxonium compound, but cannot be explained by compound formation of either solute with the solvent.

(2) It might be argued on the last quoted results that the conductivity of a solution of hydrogen bromide in water was to be associated with the prior formation of an oxonium compound, and this is probably correct; but if this were the only necessary condition we should expect to get a much more highly conducting solution of hydrogen bromide in acetone, since there is evidence that a much more stable compound should result in the case of the last named pair of substances. This expectation is not realised.

(3) Hydrated salts are not all soluble in water, as for example, $Ca\ SO_4\ 2H_2O$, which is very sparingly soluble; many other salts which at the temperature of solution do not yield hydrates are freely soluble and form highly conducting solutions.

A similar lack of parallel between compound formation and solution formation is instanced by the extreme solubility of silver iodide and chloride in liquefied ammonia, and the extreme insolubility of calcium chloride, although all three substances readily form addition compounds with ammonia. Moreover, although large numbers of metallic salts are known with each of the solvents —water, ammonia, sulphur dioxide, and the hydrides of chlorine, bromine and iodine—it is probable that the majority of them do not dissolve in the appropriate solvent; and it is therefore certain that the formation of a compound between a solid substance and a liquid which can function as a solvent does not alone justify the anticipation of a solution being formed, much less a conducting solution.

The detailed study of a few solvents has brought out many striking analogies in the mechanism of electrolysis in these solvents.

Only three solvents have been examined in any detail from this point of view, namely—water, ammonia and sulphur dioxide, and we will consider very briefly the behaviour of solutions in each of these solvents.

Taking first the case of a solution in water, it is well known that the following changes occur during electrolysis:—

(*a*) At the Cathode

(1) If the solute is a salt of an alkali, as, for example, potassium iodide, hydrogen is liberated and an alkaline hydroxide is formed.

(2) If a salt of a heavy metal, the metal is deposited on the cathode.

(*b*) At the Anode:

(1) If the solute is a halogen salt the halogen may be liberated, or the anode may be dissolved; or,

(2) If the solute is an alkali or any one of certain oxygen salts, oxygen may be liberated.

The liberation of the hydrogen and oxygen is interpreted by chemists as affording evidence of the occurrence of these two substances in the ionic condition in the solution, and their actual concentration has been measured with a considerable degree of accuracy.

The formation of a caustic potash at the cathode is explained as follows:—Water is ionised to form $H^{\cdot}$ and OH'. The $H^{\cdot}$ are discharged and escape and the OH' accumulate and partner the $K^{\cdot}$ which are constantly arriving in the neighbourhood of the cathode.

Compare this with the behaviour of a solution of potassium iodide in ammonia when such a solution is ionised. In this case it is found that—

(*a*) at the cathode

(1) hydrogen is liberated and

(2) potassamide ($K\,NH_2$) is formed;

(*b*) at the anode, iodine derivatives of ammonia are formed.

If these results are interpreted analogously to the corresponding results in water, we must conclude that ammonia is ionised to form $H^{\cdot}$ and NH_2', and that the latter accumulate in the neighbourhood of the cathode and partner the $K^{\cdot}$ which are constantly arriving under the directive influence of the current.

This would lead to the conclusion that a metallic amide in ammonia solution would correspond to a metallic hydroxide in aqueous solution, a conclusion which has been verified in many ways. Thus a solution of phenolphthalein in dry ammonia is colourless, and is not turned red by an alkali, but is so turned by an amide of one of the alkali metals.

Similarly an ammonium salt is found to behave as an acid—a fact which is explained at once if we consider the relation between the ammonium salt $NH_4\,Br$, and the hypothetical oxonium salt $OH_3\,Br$, which is probably formed when hydrogen bromide is dissolved in water.

A large number of reactions occur in liquefied ammonia in which the grouping NH_2 plays a part analogous to that played by the OH group in aqueous solution. As for example, in neutralisation—

$$KNH_2 + NH_4Cl = KCl + 2NH_3$$

compare $KOH + (OH_3Cl) = KCl + 2H_2O$

in water solution.

Or in hydrolysis, as

$$BCl_3 + 6NH_3 = 3NH_4Cl + B(NH_2)_3$$

compare $BCl_3 + 6H_2O = (3HCl + 3H_2O) + B(OH)_3$.

If now we consider the electrolysis of potassium iodide in sulphur dioxide we shall find a striking similarity of behaviour to that already described for water and for ammonia.

When such a solution is electrolysed it has been found that

(*a*) at the cathode

(1) sulphur is liberated and (2) potassium sulphite is formed ;

(*b*) at the anode, iodine is liberated, or if the anode consists of zinc or iron this may pass into solution as an iodide.

The behaviour at the cathode is consistent with the supposition that the sulphur dioxide ionises into sulphur cations $S^{\cdot\cdot\cdot\cdot}$ and sulphite ions $2\,SO_3''$. The sulphur ions are discharged just as the hydrogen ions are in the cases already discussed and just as the hydroxyl and amido ions accumulate in those cases, so here the sulphite ions accumulate and combine with the potassium ions K' as they arrive at the cathode under the directive action of the current, being precipitated on the cathode as a crystalline deposit of potassium sulphite.

The solvent action of the iodine ion as it arrives at the anode is precisely analogous to the corresponding action of certain anions on certain anodes in aqueous solution.

In the case of solutions in sulphur dioxide the sulphites are analogous to hydroxides in water solution and to amides in ammonia solution, but with the difference that the potassium sulphite happens to be insoluble in sulphur dioxide.

The consideration of the quantitative relations that have been disclosed during the many investigations that have been undertaken on molecular conductivity on hydrolysis and allied phenomena leads to the conclusion that the ionic theory is the basis of which the foregoing analogies have been discussed in its present form is inadequate to express every aspect of the quantitative behaviour of conducting solutions ; but it appears to me that this theory will require rather to be modified and extended than to be discarded.

PAPERS READ IN SECTION B

1.—THE CORROSION OF IRON AND STEEL.

By C. E. FAWSITT, D.Sc., Ph.D., Professor of Chemistry in the University of Sydney.

FROM time to time the corrosion of iron and steel is a problem brought prominently before the public as some new specific case of corrosion arises, with its serious, or possibly serious, consequences.

A considerable amount of work has been recently done on corrosion, and it appears not inopportune to review the present position of the corrosion of iron and steel.

By corrosion of a metal is meant a wearing away of the metal, whether the metal is transformed by oxygen and water into oxide or is dissolved by some other substance such as an acid.

In considering any kind of corrosion, it is important at first to distinguish between the behaviour of a metal in the initial stages of corrosion and its behaviour when the corrosion over long periods of time is considered. The initial stages of corrosion represent largely the "tendency" of the metal to corrode. The tendency of the metal to corrode is an important point to note in connection with its actual corrosion as it is measured over long periods. It should be pointed out at the outset that the tendency of a metal to oxidise and its tendency to dissolve are very similar things. The tendency to oxidise may be judged by the amount of heat given out when the substance oxidises. The tendency to dissolve is shown either in the heat given out by the solution of an equivalent weight of the metal, or by the potential of the metal when placed in a solution of one of its salts. In the light of such measurements it is interesting to note that there is a very close analogy between the tendency to oxidise and the tendency to dissolve.

Tendency to dissolve or oxidise is only one of many factors in corrosion. Iron has less tendency to dissolve or to oxidise than zinc or aluminium, and yet it will rust on until it is completely oxidised, while zinc or aluminium are preserved indefinitely in the air.

In considering the corrosion of a metal it has been noticed that the relative rate at which two metals are dissolved by an acid is not a measure of the relative rate at which water and oxygen act on the metal. Iron and many other metals dissolve in hydrochloric acid evolving hydrogen. The hydrogen is evolved in bubbles from the surface of the metal. This is a different process from the action of oxygen and water on a metal when hydrogen is not evolved.

The corrosion of iron by its transformation into rust is a more important phase of its corrosion and a more usual phase than its corrosion by the direct action of acids. This paper deals with the corrosion of iron when it forms rust under the influence of oxygen and water and small amounts of other substances which accelerate or diminish the rate of corrosion.

Although opinion with regard to the rusting process is not unanimous, the author considers that certain facts connected with the rusting of iron have been established experimentally.[1]

(1) It is not possible for iron to rust (*i.e.*, form ferric hydrate) by the action of oxygen or water alone on iron.

(2) Both of these acting together are necessary for rusting to take place.

(3) Presence of Carbon dioxide is not necessary for rusting to take place.

It has been suggested in the past by some chemists that rusting cannot take place by water and oxygen acting on iron unless carbonic acid or some other acid is present. It is not supposed that the ion HCO'_3 has any specific action, but that the carbon dioxide acts directly according to the equation

$$Fe+H_2O+2CO_2+O=Fe\ H_2(CO_3)_2.$$

This view is considered by its adherents to receive support from the fact that iron will not rust in water containing a sufficient amount of free alkali.

The author considers that carbonic acid (carbon dioxide in water) need not, on the evidence, be considered as anything more than an added substance increasing the concentration of hydrogen ion. Water and oxygen alone have been shown by Cushman, Dunstan, and others[2] to be sufficient for the rusting of iron or steel. It is found also that a small concentration of free alkali or any concentration of sodium carbonate does not prevent corrosion as it should do if carbon dioxide is necessary for corrosion, as free carbon dioxide is removed from acting on iron by such solutions.

The following theory seems to be the one which will account most readily for the observed facts :—

If a piece of pure iron is placed in pure water an immeasurably small amount of the iron dissolves. It dissolves as Fe^{++} ion, and the iron rod becomes charged negatively to the same extent. In behaving like this iron acts like other metals. Every metal has a solution pressure or driving force which tends to make the metal go into the ionic condition.

Hydrogen behaves also in some respects like a metal, but it has a smaller solution pressure than iron ; iron therefore displaces hydrogen from solutions.

There is a small concentration of hydrogen ion in water—one gram of hydrogen ion in 10^7 litres. When the ion forms

1. Cushman and Gardner, " Corrosion of Iron and Steel," 1910.
2. See Cushman and Gardner ; " Corrosion of Iron and Steel."

ferrous ion, the hydrogen ion separates out to a certain small extent as hydrogen on the plate ; it is not separated in sufficient quantity to form hydrogen gas bubbles, and remains as a layer on on the surface of the iron.

If the iron differs in its physical or chemical composition from one place to another, the layer of hydrogen will not be evenly distributed over the surface ; the hydrogen will then appear at a point where there is no iron going into solution, and a current *tends* to flow.

What now is the effect of oxygen under these conditions ? The oxygen oxidises the layer of polarising hydrogen on the iron, which then dissolves further in the water. According to this view of the action of oxygen, the corrosion of iron would probably be hastened by contact with other more electro-negative metals, which indeed is found by the author to be the case.

After ferrous ion has been formed in solution it is oxidised by oxygen to ferric ion, and in this way ferric hydrate (rust) is produced.

EFFECT OF OTHER CONDITIONS ON CORROSION.

(1) *Addition of Carbon-dioxide.*—It would be expected that as this substance when dissolved in water increases the concentration of the H ion it would assist corrosion. It may be calculated that the amount of hydrogen ion in a specimen of water which contains sufficient carbon dioxide to be in equilibrium with the carbon dioxide in the air is ten times as much as exists in absolutely pure water.

Experiment shows that in many cases carbon dioxide accelerates corrosion. Other things being equal, carbon dioxide does accelerate corrosion ; if in any case presence of carbon dioxide should not assist corrosion, then there must be some other disturbing element present.

(2) *Addition of other Acids.*—Other acids besides carbonic acid also accelerate this corrosion of iron, the acceleration being in general greater the stronger and more concentrated the acid.

(3) *Addition of Alkalies.*—As might be expected, free alkali prevents corrosion if present in sufficient quantity. Alkaline carbonates do not prevent corrosion ; indeed they usually accelerate it.

(4) *Presence of Neutral Salts.*—Neutral salts, such as common salt, sometimes appear to accelerate the corrosion process, but not always. Very little is definitely known of the action of salts on corrosion. They make the water a better conductor. Arsenic in water prevents corrosion. Bichromates also prevent corrosion.

(5) *Temperature Effect.*—Rise of temperature accelerates most chemical reactions, but in cases where one of the reacting substances is a gas, there will be less gas present in solution the higher the temperature, and this decreases the rate of corrosion.

It appears from recent work[1] that 80° C. is the temperature of maximum corrosion.

(6) *Surface Effect.*—It has been shown[2] that a rough surface tends to dissolve more than a smooth surface. This will, of course, only have an effect on the initial rate of corrosion.

(7) *Physical Condition of the Metal.*—A metal if slowly cooled is to a large extent in an annealed condition. The annealed condition corresponds to the crystalline state of the metal. The effect of working the metal is to break down the crystalline structure to some extent and to produce the ammorphous form. The author has already shown that the tendency of a hammered metal to dissolve is greater than that of the annealed metal by 10 millivolts in certain cases.

Iron is subjected to a good deal of straining in rolling or hammering processes, and differs in hardness between one place and another in an especial degree. This circumstance must, therefore, assist greatly the corrosion of iron.

(8) As influencing corrosion exceptionally there is to be considered *the chemical condition of the metal.*

It is well known that metals which are impure usually dissolve more easily than pure metals. Pure iron will not rust[3]. Iron in its commercial forms, however, may be described as being the most impure of all metals in their commercial varieties, and oxidises with great readiness.

Carbon.—Iron always contains carbon. This is present in all ordinary steels in the combined form cementite (Fe_3C.), which contains about 7 per cent. of carbon. The cementite is often intimately mixed with the pure iron to form other constituents such as the eutectics pearlite and sorbite with .9 per cent. of carbon ; in these eutectics the iron particles are, of course, quite distinct from the cementite particles, and at present, from the corrosion standpoint it is probably more correct to look on steels as a mixture of iron and cementite. A number of steels all in the annealed condition, containing varying amounts of carbon up to 0.9 per cent. were tested for their solution pressure by the E.M.F. method,[4] and were found all to give the same value. This showed the presence of some pure iron in all cases, which was giving the value of the potential obtained.

Actual corrosion experiments on steels with varying percentages of carbon do not in general show that the presence of carbide has a pronouncedly bad or good effect.[5]

At my suggestion Mr. G. J. Burrows, B.Sc., tested some steels in a corrosive water containing sodium chloride, sodium bicarbonate, and magnesium sulphate. There were seven steels tested with the following percentages of carbon : 0.18, 0.23, 0.40, 0.62,

1 Hehn & Bauer ; *Mitt. Kgl., Material-Prufungsamt*, 1910.
2 Fawsitt ; *Journ. Soc. Chem. Ind.*, 1906, 25, 1133.
3 Lambert and Thomson ; *Proc. Chem. Soc.*, 26, 290.
4 See *Journ. Soc. Chem. Ind.*, 1906, vol. 25, 1133.
5 See Cushman and Gardner, "The Corrosion of Iron and Steel," p. 76.

0.80, 0.90, 1.18. After five weeks all the steels had corroded to about the same extent. After about six months the steels with the higher percentage of carbon had corroded considerably less than those with the lower percentages of carbon.

It is not possible at present, however, to lay down any general rule regulating the manner in which corrosion depends on the percentage of carbon in steel.

Carbon in some varieties of cast iron is present as graphite. Free carbon would be expected to accelerate the solution of the iron in cast iron, and doubtless does so. Corroded cast iron pipes are always found to have most of the iron oxidised or dissolved away while the graphite remains. There is an impression that cast iron often lasts better than steel or malleable iron. This is probably because—

(1) Structures of cast iron are usually much thicker than those of other forms of iron.
(2) Cast iron structures have usually a uniform skin of magnetic oxide on them.
(3) Cast iron often contains phosphorus.

Magnetic Oxide of Iron.—This, if completely covering iron, protects it from corrosion. However, it is easily chipped off in patches, and the uncovered iron will then corrode more rapidly than before, owing to contact with the more electro-negative iron oxide.

Slag or Cinder.—Slag is present chiefly in wrought iron. Experience does not point to this being an objectionable constituent.

Manganese, Nickel, Silicon.—The effect of *manganese* or *nickel* in such large proportions as 10 per cent. protects iron from corrosion, but in small quantities it is doubtful how these substances act. The effect of *silicon* is also doubtful, being not very pronounced.

Phosphorus.—Phosphorus usually acts so as to hinder corrosion.

Arsenic (1%).—Arsenic also hinders corrosion.

Sulphur.—Sulphur is undoubtedly a bad constituent, as it accelerates corrosion.

Occluded Gases.—Gases, in particular hydrogen, exist in small quantities in iron. A small quantity of hydrogen, which is scarcely detectable by analytical means, has probably a very pronounced effect on iron. The hydrogen may come in during manufacture, or it may be formed in pickling the iron in the acid. Iron which has been cleaned by acid is more oxidisable than without this treatment.[1] Hydrogen accelerates corrosion of iron because it is electro-negative to iron.

Among accidental circumstances that effect corrosion must be mentioned the electric currents which flow to earth in modern cities. It appears[2] that current flowing *from* iron pipes to earth

1 Cushman and Gardner, *op. cit.*, p. 69.
2 Buyers; *Trans. Amer. Elec. Soc.*, 1908, 13, 19.

accelerates corrosion. This is what one would expect. There is no corrosion where a current flows *to* a pipe, as from tram lines. Another accidental case of corrosion is that due to particles of dirt, especially oil, getting into water, and thus on to the surface of iron, giving rise to an unusual amount of electrolytic action.

The corrosion of different forms of iron and steel appears as somewhat irregular, and varies according to the conditions to which the iron is exposed. It is usually possible to repeat a corrosion experiment with precisely the same result if the conditions are the same, but if any of the conditions are not the same, and vary in what appear to be quite trivial particulars, then widely different results are often obtained. Messrs. Hehn & Bauer (see above) find for instance that cast iron and malleable iron are equally corroded in distilled water if this is at rest. If the water is kept in motion then the cast iron is most corroded. On the other hand, there is no difference between the irons as regards corrosion in moving salt water. It is due to facts like these that uncertainty may be said to exist as regards corrosion of iron.

Iron corrosion has points of similarity with the corrosion of other metals, but it is to be looked on as exceptional among metals for the following reasons :—

(1) Iron is more heterogeneous, physically and chemically, than any other metal used commercially. It contains many impurities. It occludes gases (especially hydrogen) in an especial degree.

(2) The rust which forms from iron is not an adherent coating, and does not protect the metal from further corrosion.

(3) Ferrous compounds, which are formed as intermediate products in rusting, are powerful catalytic agents on certain reactions, and possibly on part of the rusting process.

(4) The property of being made passive, while it does not appear at present to bulk largely in corrosion problems, makes iron stand out from the metals as exceptional.

2.—THE UTILISATION OF GASES IN MODERN INDUSTRIAL LIFE

By GEORGE HARKER, D.Sc., Sydney

I HAVE chosen as the subject of my paper the utilisation of Gases in Modern Life, because of the rapidly extending application of these light and invisible substances to every department of human activity. It would not be possible within the compass of a short paper to deal with all the uses to which gases are nowadays put, even had I the necessary knowledge, so many and varied are their applications, and I shall content myself with describing the most important.

Putting on one side the use of air as a means of sustaining life and the processes of combustion, since these can hardly be considered as human applications, the uses of gases for illuminating purposes comes first in importance, both on the score of its world-wide application and the amount of money involved. The capital invested in public gas-light companies in Great Britain alone exceeds 130 million pounds sterling, while the amount of coal consumed annually for gas-making purposes in the same country is not less than fifteen million tons. The cost of producing gas is now much less than formerly. By employing gas-fired furnaces and sloping retorts the working charges of handling and carbonising coal have been reduced as low as 1½d per ton. The practically universal introduction of incandescent mantles for illumination and of gas stoves for cooking has relegated the illuminating power of the gas to a position of smaller importance, and the efforts of gas engineers are being more and more directed towards increasing the calorific value.

Before leaving the subject of gas for illuminating purposes; mention should be made of the extensive use of acetylene and the so-called air-gas for small installations where coal-gas would be both expensive and troublesome. In the United States it is interesting to note that many gas-light companies retort no coal but manufacture carburetted water-gas. The latter is much cheaper than coal-gas, but its use would not be permitted in England owing to the high percentage of carbonic oxide which it contains.

After illumination, the next most important use for gas is for power and heating purposes. The history of gas engines is interesting. Patents for various forms of machines working with gas were taken out over and over again during the last hundred and twenty years, but it was only after the introduction of the Otto engine, some thirty years ago, that gas engines became commercially successful. At the present day they are numbered by thousands, the English firm of Crossley Bros. having alone manufactured over 70,000 engines.

Owing to convenience of supply coal-gas is frequently employed for small plants, but the cheapest and most generally used source of power is producer gas, made by passing air and steam alternately through incandescent coal or coke contained in vessels called "producers." The gas, which consists mainly of carbonic oxide, hydrogen and nitrogen, passes on its way to the engine through a scrubber which removes dust and tarry matters.

In the Mond producer, which has been specially designed to deal with bituminous coal and low-grade fuels, such as peat, and also to collect as much as possible of the nitrogen of the fuel in the form of ammonia, a very large quantity of steam is used. Mond gas contains 80-85 per cent. of the total heat energy of the fuel, while at the same time in its manufacture an amount of sulphate of ammonia is produced which may, even with low grades of fuel, be worth as much as the fuel itself. The calorific value of the gas is about 150 b.t.u. per c. ft. as made from slack, and consequently by using Mond gas and gas engines at least double the power can be obtained from the same quantity of fuel as when using high-class steam engines.

Mond gas is now being supplied over a considerable area in South Staffordshire, England. The gas is delivered at a pressure of 5 lb. per square inch, the diameter of the trunk mains is 36 inches, and the longest distance to which it is carried 8 miles. It is supplied at a price of 1½d to 2½d per 1000 cubic feet, and there are over one hundred consumers. The capacity of the plant at this central station is about one million tons of coal per annum.

The Mond gas producer is chiefly of use for large installations ; for the far more numerous but smaller plants suction gas producers are employed, burning a better class of fuel.

I cannot leave the subject of producer gas without touching upon its use for fuel purposes. It contains more of the original energy of the fuel than any other gas, and is now largely used for heating purposes. The chief advantages over direct coal firing are that a higher temperature and more exact regulation of air are attainable, the furnace temperature is under absolute control, no smoke is produced, labour costs are reduced, a saving in weight of fuel is readily obtained by efficient gas firing, and it is generally possible to use a cheaper fuel.

The next subject I propose to deal with is refrigeration, where we meet with another important and interesting use for gases, and more especially for the three gases—ammonia, sulphur-dioxide, and carbonic acid.

The first form of machine used commercially was one invented by Dr. Gorrie, of New Orleans, in 1845, in which compressed air was employed, although Perkins had taken out a patent for an ammonia machine as early as 1834. Air machines, owing to the difficulty of rapid exchange of heat, are very inefficient, and the vapour compression machines, viz., those employing as working substance a gas which by compression can be reduced to liquid form have now almost entirely displaced all other forms of refrigerating machines.

The first vapour compression machine to be used commercially was one employing sulphuric ether as working substance, and was introduced by James Harrison, of Geelong. The author of the book in which this statement occurs remarks :—"It is certainly interesting to find a colonial engineer taking this important step in the development of the process, and it is appropriate, for certainly no parts of the world have profited more from mechanical refrigeration than have the Australian colonies."

On its introduction by Harrison, the ether machine quickly came into general use, but is now obsolete on account of serious drawbacks in comparison with other vapour compression machines. These use either ammonia, carbonic acid, or sulphuric dioxide. As regards efficiency—*i.e.*, cold produced for energy supplied—

ammonia comes first and carbonic acid last. Carbonic acid machines, however, have the advantage of being much more compact, since they work at higher pressures, and carbonic acid has the further advantage over ammonia and sulphuric dioxide that it has no offensive odour and is not corrosive ; consequently, for refrigerating on ships carbonic acid machines are now displacing the more efficient ones using ammonia.

Refrigerating machines are now being employed for a variety of purposes, amongst which may be mentioned the cooling of wort in breweries, the preservation of food on land and sea, ice-making, butter-making, and the manufacture of explosives and chemicals. The Americans have gone further, and in some towns, notably at Louisville, cold is supplied from a central station to the houses and shops of consumers. Liquid ammonia is sent out under pressure in mains buried in the streets, and is admitted as wanted to refrigerating coils on the premises of each consumer. The latter can obtain any amount of refrigeration he pleases by regulating the amount of ammonia admitted to his evaporating coils. The gaseous ammonia returns to the generating station through a second main.

Another important use for gases is in connection with processes of disinfection.

For houses, ships and other enclosed spaces, sulphur dioxide and formalin vapour are most commonly employed, and enormous quantities of formalin are now being used for disinfection purposes. For ship use, the method I have brought forward of carrying formalin vapour in a current of cooled and cleaned flue gas to the various parts of the ship will, I hope, be of some service. In orchards extensive use is made of prussic acid generated from cyanide and sulphuric acid, and this gas is now largely used for destroying vermin in houses, and moths and other insects in flour mills, etc.

While on the subject of disinfection the employment of gases for fire extinction can be touched upon.

Liquid carbonic acid is now being largely used by the fire brigades all over the world. The pressure of the gas in the cylinders forces the water to the seat of the fire and at the same time charges it with gas which materially assists in keeping away the air from the burning material.

Carbonic acid gas is also used for ship fires ; but for this purpose the gas itself is projected into the burning hold. Owing to the large quantity of gas required to effectively deal with a fire in the hold of a ship the application of carbonic acid has very distinct limitations, and I venture to believe that the method I have introduced—which consists of displacing the air in the hold by means of cleaned and cooled flue gas, taken from the funnel of the ship itself, will prove of real service.

Another quite recent application of gases is that dealing with the cutting and welding of metals, in which use is made of the high temperature produced by the combustion of various gases with oxygen. The temperature obtained varies with the gas employed, and until recently the hottest blow-pipe flame was the oxy-hydrogen, which gives a temperature of about 4000°F. It has been found, however, that a much more intense heat is obtainable by the combustion of acetylene, and with the oxy-acetylene blow-pipe a temperature of 6300° F. is reached. Quite a new field has been opened up in the working of metals by the development of the oxy-acetylene blow-pipe, since metals such as iron and steel can be fused with the greatest facility.

Instead of using rivets, metal joints are now often made by fusing the ends of the metal together ; cracks in metal castings and in working machinery are being repaired by cutting out the cracks and then filling them up with metal fused from a stick of the same by the oxy-acetylene blow-pipe, the whole process resembling soldering. Damaged boilers and steam pipes are now being repaired *in situ.*

The oxy-acetylene blow-pipe is also being extensively used for cutting metal, in which case an excess of oxygen is supplied to the blow-pipe, so that not only is the metal melted, but at the high temperature of the flame a considerable portion of it is actually burnt by the oxygen. It is indeed a wonderful sight to see a thick plate of steel cut through by an oxy-acetylene flame with the greatest ease.

I have not time to dwell upon the many other important applications of gases in modern life, such us the utilization of hydrogen gas for filling the envelopes of air-ships and in the manufacture of filament lamps ; the use of oxygen and nitrous oxide gases in medicine, and of carbonic acid gas for aerating water ; but I hope I have already said enough to impress upon my audience, if they were not already aware of it, the very important functions filled by gases in the industrial life of the present day.

In my work during the last few years I have been brought into contact in several ways with problems concerning the utilisation of gases, and have always found the subject interesting, and before actually closing this paper I should like to mention one or two minor uses to which, I think, gases might be put, although such matter really falls outside the scope of the paper.

While investigating the use of flue gas for fire-extinction purposes I carried out some experiments to determine the best means of displacing the air from a closed space by means of this gas. Into a vessel of known capacity an equal volume of flue gas was passed and the percentage of oxygen in the residual atmosphere was determined. Knowing the content of the flue gas in oxygen I was able to ascertain just how much air had been driven out of the vessel and how much remained mixed with flue gas. My experiments, performed on a small scale in glass jars, gave results which were borne out accurately when applied to ships' holds, and it struck me at the time that the method would be of some value in deciding ventilation questions.

For this purpose oxygen gas could be conveniently employed since it has practically the same density as air, and would behave, so far as ventilation is concerned, just as if it were air, while at the same time providing a means of accurately determining air displacements. With a small model the ventilating arrangements of any building for instance could be tested by admitting a known quantity of oxygen gas and determining the amount of original air displaced from its various portions.

Another use for gases which will probably receive more attention in the future relates to the application for destruction purposes of the force liberated by many gases and vapours on explosion with air. We are all aware of the destruction wrought in coal mines by gas explosions, and that on innumerable occasions dwelling-houses and factories have been shattered by the same means. I think that this explosive force might be turned to account in this country to aid in the destruction of rabbits and their burrows by displacing the air in the burrows by an explosive mixture of, say, petrol and air, and then firing the mixture. I have got as far in the matter as to interest a friend to construct a machine, but we have not yet had an opportunity of testing it. It is true that at the present time various inflammable vapours, such as carbon bi-sulphide are charged into the burrows and sometimes ignited, but it seems to me that if the matter were pursued further and as much as possible of the air of the burrows displaced by an explosive mixture much more effective results would be obtained than has been the case hitherto.

3.—THE ANALYSIS OF LIQUEFIED AMMONIA.

By W. HEBER GREEN and B. D. STEELE, Melbourne.

Abstract.

THE authors point out that the impurities present may be of three kinds :—

(1) Permanent Gases.
(2) Non-gaseous soluble substances.
(3) Insoluble impurities held in suspension.

The first kind may be readily determined by the ordinary method of absorbing the ammonia in water and collecting the permanent gases in suitable measuring tubes.

The second kind are usually estimated by the so-called " evaporation test," but the results so obtained are only approximate, and give no guarantee as to the absolute purity of the liquefied ammonia. For making this absolute determination the authors have devised a method which consists of absorbing a known amount of the ammonia in a weight quantity of sulphuric

acid, and estimating its purity by titration of the unneutralised sulphuric acid. The original sulphuric acid was standardised by carrying out a similar experiment with carefully purified and dried ammonia.

The third kind of impurity can be readily detected by the cloudiness or otherwise of the liquefied ammonia, and was absent in the samples examined.

Using the methods above indicated, an examination was made of the "anhydrous liquefied ammonia" used at the various refrigerating works in Melbourne, complaints having been made as to its inefficiency as a refrigerating agent. Analysis of the dissolved permanent gases showed these to be present in quantities comparing well with the best liquefied ammonia used in America, and to consist essentially of atmospheric air, the space above the liquid in the bottle examined being occupied by almost pure nitrogen, and the gas dissolved in the liquid itself contained about 27 per cent. of oxygen. No hydrogen was present.

Including these dissolved gases the ammonia in several bottles contained at least 99·97 per cent. of pure anhydrous ammonia, whereas the ammonia drawn off from one refrigerating plant contained from 1·0 to 1·5 per cent. of impurities.

The authors commented on the purity of the material supplied, and indicated how the ammonia in a working plant could be kept up to a reasonable standard as required for efficient working, without unnecessary loss.

4.—KETONES OF THE HIGHER FATTY ACIDS.

By PROFESSOR T. H. EASTERFIELD and MISS C. M. TAYLOR, M.A., Wellington, N.Z.

ABSTRACT.

THE usual method for the preparation of ketones of fatty acids consists in the heating of the barium salt of the corresponding acid, or in the case of acids of high molecular weight, in the action of phosphoric anhydride on the acid. A new method, which gives a greatly increased yield, and which is particularly applicable to acids of high molecular weight, consists in the heating of the acid with metallic iron. During the reaction carbon dioxide and water are evolved, and from the residue the ketone may be extracted by a suitable solvent. By this method the ketones of palmitic, stearic, cerotic, montanic and melissic acids have been prepared. From stearic acid as high a yield as 80 per cent. of stearone has been obtained. The oximes, secondary alcohols and their acetates derived from cerotone, mantanone and melissone have been prepared. The method of heating iron with acids has also been applied to the preparation of the ketones of unsaturated acids of high molecular weight, a class of compounds hitherto undescribed. Oleone, elaidons and brassidon and their derivatives have been thus prepared and their properties described.

5.—THE ESTIMATION OF FAT, WITH AN IMPROVED METHOD FOR THE DETERMINATION OF FATTY ACIDS AND CHOLESTEROL IN TISSUES.

By E. C. GREY, B.Sc., Acting Assistant Lecturer and Demonstrator in Physiology in the University of Sydney.

THE gradual discovery of the phosphorised and nitrogenous fatty substances, spoken of collectively as lipoids, has of recent years very considerably modified our conceptions of the nature of the fats which build up the tissues of our bodies, and although to the physiological chemist these conceptions are tolerably familiar, they do not seem yet to have been much recognised or utilised by those who are devoted to applied science. For this reason one sees still employed the old methods of ether extraction. Two assumptions are involved in this method, firstly, that ether is capable of dissolving all the fat from tissues, either vegetable or animal, and secondly that whatever does dissolve in ether is indeed to be considered fat. As a matter of fact both these assumptions are incorrect.

Dealing firstly with the question: Does ether extract all the fat from tissues? If the tissue is moist, the extraction is very laborious and incomplete. After 200 hours' extraction with Soxhlet apparatus, Dormeyer was able by his method [1] to demonstrate that 8·5 per cent. of the fat still remained unextracted. To overcome the difficulty, Voit [2] extracted the tissue with ether in Soxhlet apparatus after he had previously dehydrated it with alcohol. Under these circumstances, if care were taken to exclude moisture, he found that only a trace of fat remained after 24 hours' extraction. This result, however, would not have been so favourable if he had used other tissues than those which he employed. Moreover, this author found it necessary to work with very small amounts of material, so that the constants of the fat could not readily be determined.

A method of extraction is therefore desirable which yields the fats in sufficient amount to permit of purification and examination. Kumagawa and Suto (3) have recently examined at some length the solvent powers of ether, petroleum spirit, benzene, ethyl alcohol, etc., and have agreed in the opinion formed by most workers of recent years that ethyl alcohol is the best fat-extracting solvent for tissues. In many cases, however, the alcohol cannot dissolve all the fatty material and the alcohol extraction must be followed or preceded by treatment with ether.

According to the method of Rosenfeld [4] treatment with hot alcohol, followed by chloroform and petrol spirit gives also good results, leading in many cases to complete extraction. For a summary of these methods the reader is referred to Glikin's paper[5] and also to his article on fats.[6]

The second question concerns the nature of the material which is extracted by any of these processes. During the early part of the operation it is very probable that pure fats will be extracted if the organ is rich in such, but later it will invariably be found that the extract contains phosphorus and possibly also nitrogen, which indicates that lipoids are being dissolved, but it is impossible to draw any line of distinction. In some cases lipoids will be extracted from the first. Moreover, although these bodies are sometimes themselves insoluble in ether, they invariably dissolve when the ether contains fats or other lipoid material.

It is obviously of importance that these lipoid bodies should not be regarded simply as impurities, for they have an invaluable function in metabolism, and in judging of the nutritive value of foodstuffs their importance should be recognised.

With regard to the separation of lipoids from true fats, no satisfactory method has been yet suggested. The best procedure is that of Zuelzer[7]. The fatty extract is dissolved in the smallest quantity of ether, and acetone is added in excess, the acetone-ether solution then contains the fat, and the lipoid material is precipitated.

The writer has found that with Zuelzer's method as much as 25 per cent. of lipoid may remain with the fat. Many lipoids are undoubtedly soluble in acetone.

The Determination of Fatty Acids.—For the reasons given above, most workers prefer to estimate not the fat but the fatty acid. It is quite unnecessary to extract the fat for this purpose—on the contrary, such a procedure is obviously inaccurate. The material is mixed with 40 per cent. KOH and saponified directly. This method was first used by Liebermann [8] and has since been modified by Kumagawa and Suto,[3] Hartley,[9] Mottram,[10] and others. Their method is briefly as follows :—The tissue is saponified for varying times with 20-30 per cent. alcoholic potash or dissolved by adding KOH and then saponified by adding alcohol and boiling as before. The alcohol is removed, the soap and unsaponified material dissolved in water, HCl is then added and the liberated fatty acids and unsaponifiable material dissolved with ether. Mottram's treatment is then as follows :—The ether solution of fatty acid and unsaponifiable material obtained above is mixed with an approximately equal volume of dilute NaOH and the soap solution is separated in this way from the ether solution, the operation being repeated till all the fatty acid is removed. The ether solution then contains only unsaponifiable material. In this way one avoids the emulsions which so interfere with such separations.

But to carry out the method as described by Mottram, one employs only small amounts of material ; the method is not applicable for obtaining large quantities of fatty acid.

The writer[11] has set himself the problem of determining the quantities of various fatty acids in certain tissues, and it became of importance to find a method by which it would be possible to combine accuracy with the obtaining of a sufficient amount of fatty acids to permit of their individual recognition. It is always desirable to employ a method which is applicable to large as well as small quantities of material. For this reason it may not perhaps be out of place to describe an improved method by which this end may be achieved.

The material under investigation was highly rich in lipoid and practically devoid of free fat. Saponification thus required at least ten hours and it was customary to extend this time to twenty hours. Saponification is complete when the ether extract of unsaponified material does not contain phosphorus. With ordinary animal or vegetable tissues such a lengthy saponification would not be required. The remainder of the procedure would, however, be the same in all cases.

Details of the improved method for the determination of fatty acids and cholesterol in animal or vegetable tissues :—

1. A suitable quantity of the material (50-100 gms.) is dissolved by adding KOH or NaOH with or without a small quantity of water. When quite fluid (this state may be accelerated by placing in steam bath or steriliser for half an hour), alcohol is added to make the solution of KOH about 20 per cent. and the saponification continued with reflux condenser. The alcohol is then partly removed by distillation.
2. The saponified mass is now poured into a porcelain dish and mixed with $NaHCO_3$. The mass is thoroughly dried and may then be powdered and transferred to a bottle when it can be repeatedly extracted with anhydrous ether. To render the ether perfectly anhydrous the addition of freshly burned Na_2CO_3 is recommended.
3. The ether extracts are united and evaporated. The extract from animal tissue should be quite white and consists of cholesterol.
4. The powder now free from cholesterol is dissolved in hot water, acid is added in excess and the fatty acids collected on filter paper and dissolved in ether, or they may be dissolved directly from the soap solution by adding first ether and then hydrochloric acid. An aliquot portion of the ether solution is evaporated to determine the percentage of total fatty acids.

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6.—THE ESSENTIAL OIL OBTAINED FROM THE "*NATIVE SASSAFRAS*" OF VICTORIA.

By MARGARET SCOTT, B.Sc., communicated by DR. HEBER GREEN, Melbourne.

Athersperma moschatum (miscalled "native sassafras", for it has no connection with the *Sassafras officinalis* of the B.P.) grows luxuriantly in gullies among the ranges round Healesville and Warburton. The oil from the leaves and bark was distilled by Bosisto and exhibited at the Philadelphia Exhibition in 1876, but has not apparently been further examined, although decoctions of the leaves and bark have some medicinal repute locally.

For purposes of this research several sacks of leaves were obtained and subjected to steady distillation in specially designed stills, the yield of essential oil being about 2 per cent. This oil is slightly heavier than water, and has a characteristic smell and a pungent taste. Chemically, it was at once found to differ from the official sassafras oil in not containing saffrol, and from eucalyptus in being free from cineol After a very tedious and careful fractional distillation its main ingredients have been separated and identified, and of these the chief is methyleugenol, a simple derivative of eugenol, from which synthetic vanillin is made in such large quantities.

Two other ingredients present, in smaller quantities, are pinene (similar to that present in some turpentines and eucalyptus oils) and ordinary camphor.

Still other substances are indicated, but their examination is not as yet complete.

It is proposed that this paper will be the forerunner of a series of such investigations to be carried out at the Melbourne University on the native plants of Victoria.

7.—SOME REMARKABLE ESSENTIAL OILS FROM THE AUSTRALIAN MYRTACEÆ.

By HENRY G. SMITH, F.C.S., Assistant Curator and Economic Chemist, Technological Museum, Sydney.

AUSTRALIA is exceedingly rich in plants belonging to the Myrtaceæ, and not less than three-fourths of the whole vegetation of the continent are of this natural order. The leaves of the greater number of the species of the various genera yield an essential oil when distilled with steam, either in larger or smaller amounts. Broadly speaking, there appears to be a similarity in the constitution of the oils of the individual species of each genus, although this rule cannot be carried too far, as there are numerous exceptions, often of a most remarkable character, as the various types of eucalyptus oils verify. Varied as these products often are, yet, so far as work has proceeded in the elucidation of the constitution of the essential oils of the various Australian Myrtaceous plants, it has been well demonstrated that the same species will always give a product practically constant in constituents, which only vary slightly in amount at any time. It is thus seen that the influences which have brought about distinctive characters in the external features of the several plants, have also exerted corresponding influences on the constitution of their various chemical products.

The Australian Myrtaceous plants are evergreen, so that the particular constituents which characterise the oils of individual species are continually in a state of formation. With the Eucalypts particularly it can be demonstrated that in the very earliest seedling leaves the characteristic oil constituent of that species is formed. This can be well shown with the odoriferous constituents such as citronellal, in the seedlings of *E. citriodora*, or of geranyl-acetate in the corresponding young seedling leaves of *E. Macarthuri*. The formation of these odoriferous constituents, characteristic of the species, is thus brought about very early in the life history of the plant, and remains persistent throughout its whole growth. One would naturally expect, therefore, to find a certain constancy in the molecular arrangement of the constituents of the essential oils, corresponding to the constancy of botanical features which identify the plant. That there is often a close relationship between the constitution of the essential oil and the morphological characters of the plant is now certain, and is well shown by the three types of leaf venation in the genus Eucalyptus, each type being indicative of the predominance of a particular oil constituent. It is thus seen that the chemical characters of any particular species should be of a fairly constant nature, and in practice this is found to be the case, so that when once the constituents of the chemical products of any Myrtaceous plant have been accurately determined, a basis has been established for their possible commercial utilisation, if this is promising.

Myrtaceous plants generally, and the Eucalypts in particular, are as a rule very tenacious of life, and under ordinary conditions are difficult to destroy by merely cutting them back, as they soon shoot out again with an abundance of new growth. The oil from this new growth is in agreement with that from older trees, and is often obtainable in greater quantity, so that if a plantation was established, a supply of a particular product would be assured. By the indiscriminate waste of naturally growing material the supply will in time become exhausted, particularly in cases where the land is cleared for agriculture, so that the question of cultivation naturally demands consideration.

It seems beyond question that the products from systematically cultivated Myrtaceous plants could be produced at a price with which the suppliers from naturally growing trees could in many instances hardly hope to compete. Unfortunately, the idea of cultivating natural Australian plants is one that the average Australian takes little interest in. The country is so vast, and so sparsely populated, and has such an abundance of vegetable growth, that he is content to destroy the indigenous trees rather than to cultivate them. The subsequent shortage of supplies in any direction does not seem to trouble him, and he is content if Nature only continues to be good to him. Numerous instances might, of course, be given in support of this statement, and the wattle bark and cedar industries are cases in point. It is with the object of pointing out the chemical peculiarities, together with some of the commercial possibilities of the products obtainable from a few of the wonderful Myrtaceous plants of Australia, that this paper has been prepared. The cultivation of some of these species is also suggested, and in such a manner that when ready the material could be collected by machinery, and distilled in correspondingly large stills, so that their several oils might be produced in such quantities and at such a reasonable price as to successfully compete with similar material from other sources. The success obtained with the cultivation of Eucalyptus trees in America, and also in Africa, demonstrates the possibility of their successful cultivation here also.

The oils considered in this paper have been arranged under the following heads :—

1. Geraniol and geranyl-acetate oils.
2. Citral oils.
3. Citronellal oils.
4. Eucalyptol (Cineol) oils.
5. Phellandrene oils.
6. Pinene oils.
7. Methyl-eugenol oils.

1.—*Geraniol and geranyl-acetate Oils.*

In this group the products of the following Myrtaceous plants are worthy of consideration :

(*a*) *Darwinia fasicularis.*
(*b*) *Eucalyptus Macarthuri.*

The first of these is a small shrub growing plentifully on the shores of Port Jackson, and extending over a considerable area. It has been found some distance north of Manly, and as far as the Blue Mountains. It seems to like the dry, sandy soil of the Hawkesbury series, and is able to withstand the most extreme drought. The leaves are small and slender, and when the terminal branchlets are steam-distilled, from 0·3 to 0·4 per cent. of an aromatic oil is obtained, which consists very largely of the acetic acid ester of Geraniol. The amount of ester has so far been determined to vary between 57 and 65 per cent., according to the time of year. Free geraniol to the extent of about 13 per cent. is also present. The announcement of this geraniol-bearing oil to the Royal Society of New South Wales (December, 1899) was probably the first instance of the known occurrence of this valuable constituent in plants belonging to the Myrtaceæ, but it is now known to occur in quantity, not only in this Natural Order but in certain of the Coniferæ also. The oil of this Darwinia is so closely related in chemical constituents to that of *Eucalyptus Macarthuri* that the consideration of the products of both trees may be taken together.

(*b*) *Eucalyptus Macarthuri* grows plentifully in the Wingello district of this State, and is also a common tree in the neighbourhood of Bowral. It grows in proximity to Paddy's River as a fine foliaceous tree, and is there known as "Paddy's River Box." The oil distilled from its leaves has no resemblance to ordinary Eucalyptus oil, as it consists very largely of the acetic acid ester of geraniol, free geraniol being also present. It is thus closely related to the oil of *D. fascicularis.* The amount of ester varies between 60 and 75 per cent. in the leaves of old trees, the free geraniol diminishing in amount as the ester increases. Free geraniol to the extent of 12 per cent. has been found. All the determinations which have been so far made show the ratio $\frac{\text{combined geraniol}}{\text{total geraniol}}$ to be between $\frac{80}{100}$ and $\frac{90}{100}$ so that the increase of ester is largely at the expense of the free geraniol. The following results show this clearly:—One sample of oil containing 74·9 per cent. of original ester was acetylised, and the total ester then formed was 82·6 per cent., indicating only about 6 per cent. of free alcohol to be present. Another sample containing 65·8 per cent. of naturally formed geranyl-acetate showed total ester on acetylising to be 80·5 per cent., or nearly 12 per cent. of alcohol.

Neither Eucalyptol nor Phellandrene occur in the oil of this Eucalyptus, so that sophistication with other Eucalyptus oils could be easily detected. A minimum content of 60 per cent. ester could, however, be taken as a standard, because no natural oil has yet been determined with less than that amount of ester, but perhaps a better standard would be the total amount of ester formed on acetylising.

The following constants are those of a fair sample of the crude oil of this species of Eucalyptus:—

Specific gravity at 15°C.	= 0·9174
Optical rotation a_D	= + 0·69°
Original ester	= 68·4%
Ester after acetylising	= 81·02%
Refractive index at 22°C.	= 1·4712

Soluble in $1\frac{1}{4}$ volumes 70% alcohol by weight.

Messrs. Schimmel & Co. have determined the ester values in two consignments of this oil with the following results:—

(1) Ester content before acetylising, 63·7; after, 85·2%
(2) ,, ,, ,, ,, 71·68; after, 80·5%

No. 2 was rectified in vacuo and on acetylising it gave 82.2 per cent. ester.

It may thus be assumed that natural oils of this species of Eucalyptus should always show about 80 per cent. of ester after acetylising, but sufficient work has not yet been done to enable this minimum to be fixed with certainty.

The most valuable constituent in the oils of these two plants is, of course, geranyl-acetate, and as this has a considerable value (about 30s. per pound when pure), it is worthy of consideration, whether the systematic cultivation of these plants could not be made a successful commercial proposition. In no other plant, so far known, has an oil so rich in geranyl-acetate been found. The oil can be distilled from the leaves of either plant very easily, so that no difficulty whatever should be experienced in this respect.

As with most species of Eucalyptus the vitality of this tree is most marked, and no ordinary cutting seems to seriously affect the life of the plant. Some time back, in a paddock at Bowral, I saw numerous clumps of "sucker" growth of *E. Macarthuri* springing from the stumps of trees which had previously been felled. I was informed that they were repeatedly eaten down by stock, and yet continued to thrive. The yield of oil, too, in this young growth is greater in amount than with the leaves of older trees, and the ester content is larger also. Oil was distilled from "suckers" obtained for me from Paddy's River, by Mr. W. F. Farrell, who collected them in March, from the stumps of trees felled the previous year. The growth of "suckers" was most vigorous and dense. The yield of oil was 0·23 per cent., and the amount of ester 77·5 per cent.; this result is exceedingly satisfactory and promising. It is probable that the month of January will be found to be the best time of the year in which to collect the seed.

But little is known at present about the propagation of *Darwinia fascicularis*, but pruning seems to have little effect upon it, except to cause the growth to be thicker and more foliaceous.

From the knowledge so far gained, it seems reasonable to suppose that with the systematic cultivation of either one or both of these Myrtaceous plants, Australia could secure the greater portion of the trade in this class of essential oils. The world's demand for geraniol perfumery oils is now somewhat considerable, and their use might be expected to increase considerably if they were less costly: a result to be secured with the distillation of these Australian plants. The output of geranium oils is given by Schimmel and Co. for the year 1909 as about 125,000 pounds.

2.—*Citral Oils.*

Two Australian oils belonging to this group are here considered:—

(*a*) *Backhousia citriodora.*
(*b*) *Eucalyptus Staigeriana.*

(*a*) *Backhousia citriodora*, the "Sweet Verbena Tree," is a medium-sized tree growing in the Moreton Bay district, and on the North Coast Railway in Queensland, and was plentiful between Brisbane and Gympie. The essential oil obtained from its leaves by steam distillation is of considerable commercial importance, and is richer in Citral than any other known essential oil. The yield also is large, so that one cannot see why this tree should not by systematic cultivation be made the means of supplying the world with this useful product, and could probably be made to largely take the place of Lemon-grass oils. There is no reason to suppose that the oil from the young plants of this species would differ, either in composition or yield, from that obtained from older trees, and in this respect it should follow the general rule with Myrtaceous plants, so that a supply of oil might be assured at a very early stage in the life of the tree. Citral is the aldehyde of the alcohol geraniol. It was first isolated from the oil of *Backhousia citriodora*, and was named citral because the constituent of lemon oil, to which the odour is due, was found to be identical with it.[1] Besides its other uses, citral is the principal constituent in the manufacture of Ionone, the artificial violet perfume.

As there was some uncertainty as to the exact amount of oil yielded by the leaves of this tree, material was obtained from Eumundi, Queensland, and forwarded in the month of May. The branchlets were collected exactly as would be done commercially, for oil distillation. The material was sent by sea, but it had only partly dried by the time it reached the Museum, as it had been packed in bags. The amount of oil obtained was equal to 1·415 per cent. Schimmel & Co.[2] give the yield as 4 per cent., but this result was probably not founded on the distillation of terminal branchlets.

The first investigation into the composition of the oil of this tree is recorded in Schimmel's Berichte (loc. cit.), and it is there shown to consist almost entirely of citral, and to have a specific gravity 0·9. An analysis of a sample of the oil was carried out by the chemists of the Imperial Institute, London.[3] Another analysis later still was undertaken in London by J. C. Umney and C. F. Bennett.[4] To these may now be added the results of my own investigation. These results show that constancy of results is to be expected with the products of perfumery species belonging to the Myrtaceæ.

	Sp. Gravity.	Optical Rotation. a_D.	Refractive Index.	Citral per cent.	Solubility in Alcohol.
Imperial Institute ..	0.8903 at 21°C.	nil.	1.494 at 22°C.	93.5	2.25 vols. 70%
Umney & Bennett ..	0.895 to 0.896	nil or slightly lævo	1.4889	94-95	2½ to 3 vols. 70%
Technological Museum Sydney	0.8979 at 23°C.	nil	1.4886	94	1 vol. 70% by weight

1 For history of citral, see Tiemann; *Berichte*, 31, p. 3278.
2 Report of April, 1888, p. 20: Oct., 1888, p. 17.
3 *Queenslander*, Jan. 7, 1905.
4 *Chemist and Druggist*, 1906, 68, 738.

The authorities of the Imperial Institute report from enquiries they had made, that the value of the oil in London is judged to be from 7d. to 9½d. per ounce, and that if the high percentage of citral was maintained, probably the higher price mentioned could be secured. If the leaves of this tree alone are used for distillation, the results can be relied upon, and judging from the price obtainable for Eucalyptus oils yielding even a less amount of oil than does this tree, it can be readily seen how profitable its production should be, as it is not more difficult to distil the oil from the leaves of this plant than from those of other eucalyptus trees. The amount of lemon-grass oil exported from the Malabar Coast of India is about 3000 cases annually, each of two gallons. Here again the demand might be expected to increase if a cheaper article were produced.

(*b*) *Eucalyptus Staigeriana.*—This small tree, the "Lemon-scented Ironbark," is, so far as known, restricted to certain parts of Queensland. The material, 78 lb. of leaves and terminal branchlets, from which the Museum results were obtained, was sent from the Palmer River, in that State, and was obtained through the kindness of Mr. J. L. Adams, of Cooktown. As it had to come such a great distance it was naturally quite dry, so that the yield of oil may be considered a maximum one. The yield was equal to 2·484 per cent., a result agreeing with that previously given,[1] where this tree is stated to yield 2¾ per cent. of an oil having a specific gravity 0·901. An investigation of the oil of *E. Staigeriana* was carried out by Schimmel & Co.[2] It is there stated to have a specific gravity 0·880 and the boiling point from 170° to 230° C. There is no evidence to show how long the oil had been distilled before investigation, as in both the above cases the specific gravity is higher than that of the Museum sample, and oils of this class are very liable to change on keeping.

The oil is a remarkable one to be derived from the Eucalypts, as when rectified it has a strong resemblance to lemon oil, although the crude oil is a little more aromatic. It is very probable that when the oil is properly prepared by steam rectification or other methods, it will be much utilised as a flavouring agent for culinary and other purposes, and thus largely take the place of lemon oil in many directions. It could be prepared very much more cheaply than is possible with lemon oil, the yield being so great. If the tree was systematically cultivated, an oil could be easily produced at about 1s. or 1s. 6d. per pound, containing 16 per cent. of citral, and even at that price it should pay very well, judging from the present cost of producing other Eucalyptus oils.

The Museum results of the investigation of the crude oil of this tree were published in the Pharmaceutical Journal, May 19, 1906, so that only the more salient points will be given here. The

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[1] See Christy's *New Commercial Plants and Drugs*, 9, 14-15; also *Abst. Journ. Soc. Chem. Ind.* 1886, p. 436.

[2] Semi-Annual Report, April, 1888.

specific gravity at 16°C. was 0·8708; rotation, a_D—43·1°; refractive index, 1·4871, and it commenced to distil at about 175°C. The principal constituent was found to be lævo-rotatory limonene, the rotation thus being in the opposite direction to that of the limonene in lemon oil; the amount of citral was 16 per cent. which is considerably more than occurs in lemon oil. When the oil was rectified by steam distillation the distilled product was but slightly coloured, had a pleasant lemon oil odour, and in specific gravity and other characters closely approached those of ordinary lemon oil, always with the exception that the limonene is lævo-rotatory instead of dextro-rotatory. The specific gravity of the steam-distilled product (77 per cent.) at $\frac{23^{\circ}C}{15}$=0·859; rotation a_D—51·5°; refractive index at 22°C.=1·4771; citral, 16·5 per cent. by the sodium bisulphite method. (The quantitative determination of the citral by this process acts very satisfactory, and the readings were quite sharp.) The solubility in alcohol is very good, 1 volume being soluble in 6 volumes 80 per cent. alcohol by weight.

Numerous friends kindly undertook to test the comparative value of the essence made with the rectified oil of *E. Staigeriana*, against the best lemon essence obtainable, the identity of the Eucalyptus product being unknown to them at the time. For flavouring puddings, jellies, and similar articles many reported in favour of the Eucalyptus essence, while others failed to detect any difference. As a flavouring agent for lemonade it is perhaps equal to any essence obtainable, and this is also the case with lemon syrup. Aerated lemonades made with it were found very satisfactory. The crude oil does not answer so satisfactorily, because the geranyl-acetate present gives to the gas a slight aromatic odour, but when the crude oil is rectified this odour cannot be detected. The residue left on rectifying the oil should also be a valuable product when properly prepared, owing to the geranyl-acetate and geraniol it contains.

The world's demand for lemon oil is very considerable, the yearly export from Sicily alone being about 1,500,000 lb. at a wholesale value of, say, about 3 lire per lb. The commercial possibilities for the oil of *Eucalyptus Staigeriana* are thus most promising, and the cultivation of the plant is worthy of every consideration. Another Myrtaceous plant, *Leptospermum Liversidgei*, also yields an oil rich in citral.[1]

3.—*Citronellal Oils.*

The only Australian Myrtaceous plant so far known which yields an oil containing the aldehyde Citronellal in quantity is *Eucalyptus citriodora*. This tree grows plentifully in the neighbourhood of Gladstone, in Queensland, and is there worked for its oil by distillation. It has been cultivated in several of the other States, in India, and other places. The oil distilled from

1 See *Proc. Roy. Soc. N.S.W.*, 1905, p. 124.

the leaves of this tree is richer in the aldehyde citronellal than that of any other known plant, and its physical and chemical characters are remarkably constant, no matter where the trees are grown. This is, of course, only what is to be expected with identical species of Myrtaceous plants. The yield of oil varies from 0·6 to 0·9 per cent., and this result has been obtained commercially from many tons of leaves and terminal branchlets. The oil is distinctly aromatic, has a pleasant citronellal-like odour, and is much used as a perfume for soap, for which purpose it is admirably suited. A sample of oil freshly distilled in Queensland was analysed early in 1910 and gave—

Specific gravity at 21°C.	= 0·8652.
Optical rotation a_D	=+1·7°
Refractive index at 22°C.	= 1·4542.
Aldehydes	= 92%.

Soluble in 1¾ volumes 70% alcohol by weight.

This agrees very well with the results obtained with the oil of a cultivated tree grown at Sydney. Eucalyptol and phellandrene are both absent in the oil of this species.

The trade in the grass citronella oils is an extensive one, and in 1909 the exports of this oil from Ceylon were about 1,110,000 lb. the value being about one shilling per lb. The oil of *E. citriodora* when distilled from material collected from large trees, as at present, cannot be produced at so low a price, but by systematic cultivation there seems no reason why this should not be done, and if the industry were on a sufficiently extensive scale the oil might be prepared at a considerably cheaper rate than is possible at the present time. With an equal competition in price there seems no reason why much of the trade in citronella oils should not be appropriated by Australia, and distilled from the leaves of this species of Eucalyptus.

4.—*Eucalyptol* (*Cineol*) *Oils.*

Eucalyptus oils richest in Eucalyptol are in most countries official, and to pass the tests demanded by their pharmacopœias it is necessary that more than half the whole oil should consist of that constituent. It is not appropriate here to consider the relative medicinal value of the various constituents found in Eucalyptus oils so far as experiments have gone, but it is very probable that Eucalyptol will be found eventually not to be the most efficacious in this direction. From a commercial point of view it is sufficient that Eucalyptol Eucalyptus oils are demanded for pharmaceutical purposes, and as the world's requirements for eucalyptus oil of this class are now somewhat considerable, the production to meet this demand is one of some importance. Eucalyptol is perhaps the most frequent constituent in the oils of the Eucalypts and Melaleucas, but varies in quantity in the oils of the various species, so that only those species can be utilised which produce the richest Eucalyptol oils and yield them in greatest abundance. The competition amongst suppliers has, during recent years, become very keen, and consequently the price has been reduced to the lowest, commensurate with a sufficient profit on working expenses.

The first Eucalyptus tree supplying a Eucalyptol oil commercially was *E. globulus*, and the good favour that this oil then obtained has remained with it even up to the present time. This appreciation is, perhaps, more largely due to the name than to any intrinsic merit the oil may have above that of other species in the same class. The "Mallee" Eucalyptol oils, such as *E. dumosa*, and *E. oleosa*, then came into use, because the yield was greater than with *E. globulus*, and as these species grow as shrubs the material was easier to collect, and consequently the oil could be produced at a cheaper rate. Many of the "Mallee" oils, although rich in Eucalyptol, often contain a small amount of the aromatic aldehyde aromadendral, which constituent appears to be absent in the oil of *E. globulus*, *E. Smithii* and other similar species, and consequently the odour of the various eucalyptol oils is not always identical. *E. polybractea*, another "mallee," yields one of the richest Eucalyptol oils, and in great quantity, but it also contains a small amount of aromadendral. This constituent, however, can be largely left in the leaf by a proper system of distillation, the product then being, when rectified, one of the very best of the Eucalyptol class of oils. As this is the principal species occurring over many square miles of country in the Wyalong district of this State, there is available at once what may be considered a permanent plantation. The reason this species has not yet been more systematically worked is that it grows far away from the coast, and the cost of transit and other incidental expenses have so far operated adversely.

Probably the Eucalyptus species yielding the best and richest Eucalyptol oil yet known is *E. Smithii*. The yield is great, and such objectionable constituents as the aldehydes, esters, sesquiterpenes, etc., are at a minimum; the rectified oil consists almost entirely of Eucalyptol, the remainder being largely pinene. *E. Smithii* has, since the discovery of the value of its oil, been largely worked, but the species usually grows as a big tree, and mostly in mountainous country, consequently the material is quite as difficult to collect as is that of *E. globulus*, but it yields twice the amount of oil obtainable from the latter species. If *E. Smithii* were systematically cultivated for its oil, an article could be produced, which as a pharmaceutical Eucalyptus oil, and as a source of Eucalyptol itself, would be superior, perhaps, to that obtainable from any other species, as it could then be supplied so cheaply. When the time arrives for Eucalyptus species to be systematically cultivated in Australia for their economic products, then *E. Smithii* would probably answer all demands for a Eucalyptol oil better than any other Eucalypt. Other species yielding Eucalyptol oils in great quantity are *E. cordata* of Tasmania, and *E. pulverulenta* of this State. These two oils, however, contain rather a large amount of ester, and the lower boiling aldehydes are pronounced, necessitating careful rectification. *E. Morrisii*, the "Grey Mallee" of New South Wales, also yields a large quantity of a Eucalyptol oil, which is also of good quality.[1]

In this connection certain oils obtainable from Melaleucas or "Tea Trees" might be mentioned, which yield very rich cineol (Eucalyptol) oils, especially *M. trichostachya*,[2] a species found over a great extent of country in New South Wales and Queensland, which yields a water white oil, very rich in Cineol, and up to 2·6 per cent. in amount from commercially collected material. It does not correspond to "Cajuput" although distilled from a Melaleuca, but approaches more closely to the better pharmaceutical Eucalyptus oils.

5.—*Phellandrene Oils.*

So far as at present known the commercial Phellandrene oils obtainable from the Myrtaceæ are restricted to that group of Eucalyptus known vernacularly as "Peppermints." The leaves of these species are characterised by a special venation, and they often yield a large amount of oil. The name "Peppermint" was originally given to these trees, owing to the presence in their oils of a small quantity of ketone (Piperitone) which has a marked peppermint odour and taste. The terpene phellandrene in Eucalyptus oils is always lævorotatory, and in the species at the extreme end of the group, as *E. dives* and *E. radiata*, forms the greater portion of the oil. Eucalyptol is usually present in the oils of this group, but often in such a small amount that it is difficult to detect; in the oil of *E. amygdalina*, however, it is present in greater quantity, often up to 30 per cent. Until very recently the phellandrene Eucalyptus oils were looked upon with great disfavour, and were distinctly prohibited for pharmaceutical purposes. The discovery by Mr. Lavers that a small quantity of phellandrene Eucalyptus oil was an excellent means for separating metallic sulphides from the gangue in tailings and other similar material, has caused a great demand for these oils to arise, which demand will probably increase considerably in the near future. It would not be surprising if the amount required increased to 20 tons or more per month, and the question then arises, can the supply of this quantity be assured? I am conviced that New South Wales could alone supply that amount of phellandrene oils continuously. Fortunately, the species which yield these oils occur in great quantity over a large portion of the highlands of this State, and in localities where the land is not likely for many years to be required for agricultural purposes, as it is often comparatively of little use for anything else except growing Eucalyptus trees. The species belonging to this group, when cut back, quickly supply a fresh dense growth, which in a year or two is ready to be again gathered, so that the continuous supply of material is assured. Although the phellandrene oils are obtainable from natural growth in such large

1 For further information regarding these species, see "Research on the Eucalypts," Sydney, 1902.
2 *Proc. Roy. Soc., N.S.W.*, Dec., 1910.

quantities, yet, the question of cultivation might even here be worthy of consideration, because the concentrated growth of the species required would give greater facility for collection and distillation, and consequently the oil might be supplied at even a cheaper rate than at present.

The supply of Phellandrene oils will naturally be drawn from those plants yielding it in greatest abundance. The species which yields the largest amount of oil is the type *E. amygdalina*, from which often more than 4 per cent. is obtained, but the oil of this species contains about 25 to 30 per cent. of Eucalyptol, and at certain times of the year the amount of phellandrene is small. Both *E. dives*, the "Broad leaf Peppermint," and *E. radiata*, the "White Top Peppermint," yield oils consisting almost entirely of phellandrene, as does also *E. delegatensis*, and if that constituent is required to be present in greatest amount these species are the best to exploit. The yield of oil from commercially collected material of *E. dives* is about 2½ to 3 per cent., and that from *E. radiata* 2 to 2½ per cent. There is not much difference in the physical properties of the oils of these two species, as is seen from the following :—

	Sp. Gr. at 15°C.	Specific Rotation [a] D.	Refractive Index at at 16°C.
E. dives	0·8713 to 0·888	—62·68 to —72·45	1.4894
E. radiata	0·8695 to 0·8814	—74·48 to —89·4	1.4863

From these results it would be easy to formulate a standard to govern purity and so prevent sophistication.

6.—*Pinene Oils.*

The high price lately ruling for turpentine leads one to consider whether it might not be possible to prepare that substance from Australian material. The work lately completed at the Museum on the "Pines of Australia" (Sydney, 1910) has demonstrated that turpentine, identical in composition with that of America or of Europe, can be prepared from only one Australian plant belonging to the Coniferæ. The oleo-resinous exudation of *Agathis robusta*, the "Kauri Tree" of Queensland, yields a turpentine identical with the American, but the tree hardly occurs in sufficient abundance to enable an industry to be established without it is cutlivated. It may be well to point out, however, that there are two species of Eucalyptus growing in this State, from the leaves of which a turpentine identical in composition with the commercial article can be distilled. The dextrorotatory form is obtained from E. *dextropinea*, and the lævorotatory from *E. lævopinea*. Unfortunately the yield of oil from both these species is, in comparison with the phellandrene oils, somewhat small, about 0·8 per cent. in the former and about 0·7 per cent. in the latter. Both trees belong to the "Stringybark" group, and grow to a large size, so that to make the distillation of turpentine from them in any way commercially possible, it would be necessary to cultivate them. Whether the article could then be produced to compete with ordinary turpentine at its present price is a question which yet remains to be settled, but the problem is one certainly worthy of serious investigation.[1]

7.—*Methyl-eugenol Oils.*

An example of a Myrtaceous oil of this class, and one worthy of consideration, is that of *Melaleuca bracteata*. This is a small tree or shrub growing in the Warialda and other districts of this State, the Museum material being obtained from Oakey Creek. Its botanical features have no marked characteristics by which its remarkable chemical constituents might be suggested, as it closely approaches in some respects *M. styphelioides*, and has been previously associated with that plant and also with *M. genistifolia*. It has, however, a remarkably hard and close bark, which seems to separate it at once from the other Melaleucas. A paper on this species was read before the Royal Society N.S.W., Dec., 1910, where the full results of the botanical and chemical investigations are recorded. The constiutents of the oil of this species are quite foreign to those generally found in Melaleuca oils. The principal constituent is methyl-eugenol, of which the oil largely consists. This substance was recently shewn to be the chief odoriferous constituent in the timber of "Huon Pine," of Tasmania, *Dacrydium Franklini*,[2] but for any possible commercial use to which, in the future, this constituent may be put the supplies could probably be obtained from this species of Melaleuca more cheaply and in larger quantity than from any other source.

Although perhaps at present there is no great demand for methyl-eugenol, yet synthetic chemistry moves along so rapidly that at any time a request for it might arise, so that it is well to be informed from what source it is obtainable. It would not be possible to prepare it from Eugenol, in the ordinary way, to compete with the product from this Melaleuca, so that when the demand does arise Australia is ready to supply it.

Eugenol is present in small quantity in the oil of *M. bracteata*, as is also free cinnamic acid and cinnamic aldehyde. An ester of cinnamic acid is also present, but no acid of the fatty series could be detected, nor was any low boiling alcohol found. The slight lævorotation of the oil was due to the presence of lævorotatory phellandrene. Cineol (Eucalyptol) was quite absent.

Three samples of oil were investigated from material collected at various times of the year. These gave the following results:—Specific gravity at 18°C. = 1·032 to 1·0358; optical rotation a_D,

1 For further results, see papers in *Proc. Roy. Soc., N.S.W.*, Oct., 1898, and Nov., 1911.
2 "Research on the Pines of Australia," June, 1910, p. 406.

up to—3·1° ; refractive index, 1·5325 to 1·535 ; saponification number up to 20·8, with S.N. for free acid up to 1·26 ; soluble in ¾ volume 70 per cent. alcohol by weight.

The yield of oil obtained commercially would be about 1 per cent., and as this is heavier than water it would be necessary, of course, to separate it from the bottom of the receiver. From the above results it may be assumed that when the whole of the oils of the Melaleucas shall have been investigated they will be found to be as diverse in composition as are the oils of the Eucalypts.

I wish to express my thanks to my colleague, Mr. R. T. Baker, F.L.S., the Curator, for botanical assistance.

8.—ON "RED RAIN" DUST.

By THOS. STEEL, F.L.S., Sydney.

In 1898 I communicated to this Association[1] an account of an examination of a sample of dust which fell in Victoria in December, 1896. On the morning of October 11th, 1909, a similar dust-shower occurred over Sydney and surrounding districts, the fall being subsequent to a period of strong westerly winds. Although a fair amount of rain fell just before that carrying the dust, the latter was brought down by a moderate shower, immediately after which the weather became fine, so that much of the dust remained, adhering to railings, roofs, leaves of plants, footpaths, etc., where it quickly dried. On the morning of the fall I was able to gather a fair quantity of the dust from flat skylight windows and from gutters on the roofs of buildings at Pyrmont, a suburb of Sydney. The dust which was deposited on the flat skylight windows had to a large extent accumulated in a line along the lower edge of the glass, and by scraping this off into a sheet of paper a very clean sample, quite free from soot and other contamination, was obtained for analysis. The dust was examined by boiling with hydrochloric acid, the solution being treated in the manner usual in such analyses. The results obtained were :—

Sample dried at 110°C.—

Organic matter, etc.*	8·37
Sand and insoluble	69·11
Soluble silica	·10
Ferric oxide	5·05
Ferrous oxide	·52
Alumina	14·76
Lime	·56
Magnesia	·95
Sulphuric anhydride	·14
Phosphoric oxide	·22
Not determined	·22
	100·00
* Containing nitrogen	·17
Moisture in air-dried sample	5·87

1 This Journal, VII., 1898, p. 334.

In composition and appearance this dust closely resembles that which fell in Victoria in 1898, both being doubtless derived from the dry interior of the continent. Neither of these dusts contained any magnetic particles.

An analysis of the Sydney dust by Mr. L. Cohen, published in the *Sydney Daily Telegraph* newspaper, Nov. 1st, 1909, shows the very large proportion of 14·69 (when calculated to dryness) of ferric oxide, no ferrous oxide, and considerably less alumina than I find to be present in my sample. So great a proportion of iron oxide may perhaps be due to contamination with rust from the iron roof on which Mr. Cohen's sample was collected.

A rough idea of the amount of dust which fell may be gathered from the weight collected by me from one of the skylight windows. To all appearances the greater part of the dust which fell on the window remained adhering to the edge of the glass, though probably some was washed away. The window in question had an area of about 68 square feet, and the weight of air-dried dust collected therefrom was about 6 grams. This is equivalent to about $8\frac{1}{2}$ lb. per acre, or nearly $2\frac{1}{2}$ tons per square mile.

Leaves of trees and various plants were coated with the dust, which collected along the veins and edges in such situations as would retain adhering water. As the water evaporated, the dust remained and was in evidence for several days until washed off by subsequent rain. Although the dust is spoken of as red, it is really of a pale buff or clay colour, which becomes somewhat red on moistening.

Some time after the publication of my paper on the Victorian dust of 1896, Dr. T. L. Phipson, of London, published two papers detailing the results of his examination of a small sample from the same fall, given to him by Captain C. J. Gray, who personally collected it.[1] Dr. Phipson claims to have detected nickel in the dust, which he estimates at about 1 per cent., and in his first paper he concludes that "it is partly, if not wholly, of cosmic origin, and not merely desert sand uplifted by the wind, nor volcanic dust ; it would appear to be the mineral dust left in the higher regions of the air by the explosion of meteors or shooting stars." In his second paper, however, after examining a further sample weighing about half a gram, given him by Captain Gray, Dr. Phipson altogether ignores his first conclusion, and says : "I am decidedly of opinion, after due discussion of this subject, that this dust brought down in the rain is of volcanic origin."

Working on much larger quantities than Dr. Phipson had at his disposal I have been unable, by ordinary chemical tests, to confirm his detection of nickel, the presence of which, in any case, is by no means a reliable indication of cosmic origin. I see nothing in the character of the dust or in the circumstances attending its fall to lead to any other conclusion than that it consists of ordinary soil, raised and carried by wind from the interior of Australia.

(1) *Chemical News.*, lxxxiii., pp. 159, 253. 1901.

Professor Liversidge, in 1902, published a most comprehensive and valuable paper on "Meteoric Dusts,"[1] on p. 283 of which he shows that the presence of nickel and cobalt in such dusts has no particular significance as an indication of cosmic origin.

A paper by T. L. Patterson, entitled "Recent Dust Showers"[2] gives an interesting account of dusts collected by melting surface snow, and of certain curious fused spherules, some of which consist of silicates and others of magnetic oxide of iron, which occur in the smoke emitted by factory chimneys, and which were found by Mr. Patterson in the dust recovered from snow collected in the vicinity of a manufacturing town. Both kinds of spherules occur freely in the flue dust of factories burning coal, and when found in atmospheric dust those of magnetic iron oxide might, without this knowledge, be readily attributed to a cosmic source.[3]

In 1901 Professor Hartley and H. Ramage published an account of a careful spectroscopic examination of a large number of dusts from various sources,[4] having special reference to the presence of small amounts of nickel and the rarer elements. One of the most striking features of this research was the demonstration of the constant presence of minute quantities of nickel and other rare metals in dusts from the most varied terrestrial sources. The composition of the sooty particles which form a conspicuous constituent of much of the atmospheric dust of our cities is fully dealt with by Professor E. Knecht in a paper published in 1905.[5]

I exhibit samples of the Victorian and Sydney dusts and of leaves incrusted with the latter, also volcanic dusts from eruptions of Mounts Pelée and Vesuvius.

9.—NOTE ON THE FREEZING POINT OF MILK.

By J. B. HENDERSON, Brisbane.

Since reading a paper before this Section of the Australasian Association for the Advancement of Science at its meeting in Brisbane (1909), the determination of the Freezing Point of all doubtful samples of milk has been continued in the Government Chemical Laboratory, Brisbane.

The reading of that paper resulted in such a large number on enquiries from all quarters that I thought a note on the results of another two years' experience with the method might be acceptable to public analysts.

1 *Proc. Royal Soc. N.S.W.*, XXXVI., 241, 1902, and *Chem. News*, LXXXVIII., 16 etc., 1903.
2 *Illustrated Science Monthly*, July, 1884.
3 See also *Brit. Assoc. Adv. Science Reports*, various volumes, 1881 to 1889, under "Meteoric Dust."
4 *Chemical News*, LXXXIII., 157, 1901.
5 *Chem. News*, XCI., 259, 1905.

As recorded in my previous paper, I find that the added water indicated by the Freezing Point is on the average well above that calculated from the 8·5 per cent. Solids Not Fat standard, still further emphasising the fact that the 8·5 per cent. Solid Not Fat legal minimum standard is by no means too high.

During the year 1909 every milk sample containing less than 8·5 per cent. of Solids Not Fat was found by the determination of the Freezing Point to have been watered, and last year the same result was obtained, except in two cases. These cases I thought of sufficient interest to bring before this meeting. The following results were obtained on analysis :—

	(*a*) 19th August, 1910. (4 cows.)	(*b*) 16th September, 1910. (? Cows)
Total Solids	11·62%	11·6%
Fat	4·00%	3·3%
Solids Not Fat	7·62%	8·3%
Ash	0·64%	0·68%
Nitrogen	0·487%	0·474%
Freezing Point	—0·565°C.	—0·55°C.

But for the determination of the Freezing Point there is little doubt that both of these samples would have been adjudged watered. As it was, the Freezing Point showed them to be genuine, and the dairymen were warned to raise the quality of the milk to at least the legal minimum by better attention to their herds.

Not only is the determination of the Freezing Point useful in distinguishing between naturally poor milks and watered milks, but I trust that its use will soon lead to the prosecution of those who add water to a naturally rich milk, but do not add sufficient water to bring the milk below the legal minimum standards. The average composition of the milk of one herd in Brisbane, the result being the mean of 104 samples, is—Fat 4·5 per cent. and Solids Not Fat 9·2 per cent. Such a milk could have 7·5 per cent. of water added, and yet pass the ordinary 3 per cent. Fat and 8·5 per cent. Solids Not Fat standard. The determination of the Freezing Point would, of course, at once show the addition of water even to such rich milk.

Section C

GEOLOGY

ADDRESS BY THE PRESIDENT:

Professor P. MARSHALL, M.A., D.Sc., F.G.S.

Professor of Geology in the University of Otago, Dunedin, N.Z.

My first duty is to thank you for the honour you have conferred upon me in appointing me to the important position of President of the Geology Section of this Association. Before trenching on the subject to which I specially desire to direct your attention, I cannot fail to refer to the work of one of our members who at previous conferences has added much to the enjoyment of our meetings. Professor David, it is well known, has wrung from the frozen South some of her most guarded secrets, and it is a matter of keen regret to all of us that circumstances have not permitted him to be present at this Association to give us first hand some statements of the experiences that he has been determined and plucky enough to survive, and some details of those discoveries he has made under the hard taskmaster, Jack Frost. We would willingly forego much of our other interesting matter could we but hear something of the geology of these cold, stark lands from these brave pioneers, whose deeds will for ever redound to the glory of Sydney and her University.

The honour of occupying the position of President carries with it certain responsibilities, and chief amongst these is the choice of a subject for a Presidential Address. It is of course a truism that the selected subject should be one of a sufficiently general nature to arouse the interest of those from all portions of the widespread Australasian area. At the same time it is obviously desirable that the address should deal with some branch of the subject of which your President possesses some special knowledge.

This involves me in considerable difficulty, for I can lay claim to no special knowledge, except in so far as our Science applies to New Zealand. But this land of fierce geological controversy is so small and so remote from you that I cannot expect you to have any particular interest in its detailed geology. New Zealand has in the past been made to hide its geological nature and literature behind a misty veil of sesquipedalian nomenclature of Polynesian origin. There is, however, one geological feature in which we have a common interest. The Pacific Ocean washes your shores as well as ours. Its secrets are as alluring to you as to us, and I feel that I need crave no special indulgence in asking you to consider shortly what is the true structural boundary of this profound ocean basin.

Our knowledge of this the greatest of the earth's features is still slight indeed. Its vastness must stimulate the imagination of all. No one can help wondering whether it has always been so immense. We cannot fail to question whether our distant lands have not in the past joined hands and pressed forward into the confines of this watery waste.

It is well known that the Pacific Ocean is, generally speaking, of great and uniform depth. Its floor is almost everywhere between 2,000 and 3,000 fathoms below the surface of the water, and the few scattered islands that rise above the troubled waves are either mere volcanic peaks or structures due to the activity of coral-making organisms.

Many speculations have been indulged in to account for this most mighty of all physical features of the earth's surface. They have been based in some cases upon cosmical speculations, for Professor Pickering has lately suggested that the ocean basin is the scar left by the moon, which Darwin has shown was derived from the earth.[1] Jeans and Sollas have regarded this basin as actually inherent in the pear-shaped form that the earth assumed in cooling. On the other hand, Suess regards the immense depression as a subsidence area which has been in existence since the Triassic Period. He thinks that it marks a region where the crust of the earth has fallen in owing to lack of support afforded by a shrinking nucleus.

Other authorities have taken less extreme views of its antiquity, and these are typified by Captain Hutton, who would construct a land bridge across the ocean between New Zealand and South America at no distant period in the past in order to explain the resemblances between the flora and fauna of tropical South America and those of New Zealand.

Great as are the differences of opinion in regard to the age and the permanence of this great basin, those in regard to its structure are at least equally great. They are mainly founded upon the positions of the groups of minute islands with which the surface of the ocean is dusted. It is well known that the islands of several groups have a definite linear arrangement, and this has naturally suggested that they are nothing more than the emerged summits of mountain ranges. The linear arrangement of different groups is usually more or less parallel, and the further generalisation has somewhat naturally followed that they constitute parallel ranges of a mountain chain in which the dominant trend is W.N.W. to E.S.E.

In making such statements little account has been taken of the soundings in the surrounding ocean. It is also noteworthy that too much importance should not be attached to the arrange-

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[1] Pickering: *Journ. Geol.*, XV., 1907, p. 23; Sollas: "Age of the Earth," p. ; Suess: "The Face of the Earth," II., p. 553.

ment of volcanic mountains. If, for example, the level of the North Island of New Zealand were lowered by 7,000 feet, Ruapehu, Ngauruhoe and Egmont alone would extend above the surface of the ocean. The line connecting their summits is almost at right angles to the true structural axis of the island.

Using the arrangement of the island groups as a basis, Dana, Gregory and Suess have all made statements as to the direction of structural lines in the Pacific. The opinions of these authors need brief recapitulation. Thus Dana makes the following statements :—[1] See Map Plate.

1. Over the Pacific area there are no prominent north-south courses in its ranges.

2. Ranges in the Pacific Ocean trend not far from N.W. by W. One transverse range crosses the middle South Pacific—the New Zealand—commencing in New Zealand and islands south of it with the course N.35° E. continuing through the islands and the Tonga group, the latter trending N. 22° E., and this is the nearest north-south line in the ocean except towards its western border.

3. Oceanic ranges are seldom straight, but, instead, change gradually in trend through a large curve or a series of curves.

4. There are parallelisms between the trend of the New Zealand range and that of the east coast of North America, and also between the trend of the foot of the New Zealand boot, with the Louisiade group and New Guinea group further west.

Later Dana defined four mountain chains in the Pacific.[2] Three of these belong to the north-westerly system and one to the north-easterly system.

1. Hawaiian chain, Hawaii to Kauai to 175° E. A total length of 1,500 miles.

2. Polynesian chain sweeps through the centre of the ocean with a length of 5,500 miles It consists of a series of parallel ranges, with a mean trend north west by north. Paumotu, Tahiti, Rurutu and Hervey (Cook) Islands are parallel lines in the east of the chain. Samoa, Gilbert, Radack, and Ralick to Wake's Island are others in the western parts.

3. Australasian chain (*a*) New Hebrides, Solomon, New Ireland and Admiralty Island, 2,000 miles ; (*b*) North of New Guinea, Louisiade, New Caledonia, and the foot of the New Zealand boot.

4. New Zealand chain, Macquarie to Vavau Island, 2,500 miles. This transverse chain is at right angles to the Polynesian system, where they meet. It is nearly central to the ocean. The New Zealand chain has great significance.

J. W. Gregory[3] has described the groups of Islands as arranged in festoons, and of these he distinguishes five.

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1 Dana, E. S. : "Characteristics of Volcanoes," 1890, p. 361.
2 Dana, E. S. :" Manual of Geology," 4th edition, 1895, p. 37.
3 J. W. Gregory : "Geography, Structural, Physical, and Comparative," 1908, p. 275.

1. Australasian festoon. New Zealand, Norfolk Island, New Caledonia, New Hebrides, Solomon Islands, and New Guinea.

2. Micronesian festoon. This is concentric with the Australasian festoon, and includes the Caroline, Marshall, Gilbert and Ellice Islands, Fiji, Samoa and Tonga.

3. Pelew-Ladrone festoon, Pelew, Ladrone, Volcano.

4. North Pacific chain, Hawaiian Islands, Ocean Island.

5. South Pacific chain, a long series of islands which branch from the Micronesian festoon at Samoa and extend eastward across the southern Pacific through the following groups: Paumotu, Society, Marquesas, Cook.

In the last volume of the "Face of the Earth," p. 301, Suess has discussed the arrangement of the Pacific Islands and discovers the following main features:—

(1) First Australian arc, with two branches:
  (*a*) New Guinea, Louisiade, New Caledonia and New Zealand. Ancient rocks are found in these islands.
  (*b*) New Mecklenberg, Solomon, New Hebrides. Along this line again ancient rocks are found.

(2) Second Australian arc: Caroline, Radack, Gilbert, Ellice and Fiji groups of islands.

(3) Third Australian arc: Tonga, Kermadec, north-east of New Zealand.

In this great work no arrangement of the islands of the eastern portion of the area is described.

It is noticeable that Dana and Suess agree in the main especially in regard to the position of the arcs nearest to Australia and of the New Zealand line running to the north-east.

Suess invests the north of New Zealand with great structural importance. It is the point whence the two Australian arcs and the Polynesian arc whirl. This contrasts markedly with Dana's statements, for he aligns his New Zealand range almost at right angles to his Polynesian chain, which includes its constituent ranges in the N.N.W. direction, practically all the island groups of the Pacific. Suess admits that our knowledge of the eastern island groups of the Pacific is at present so imperfect that any statements made in regard to them would be no more than vague speculation.

The authors quoted appear to have based their opinions almost solely on the mere position of the islands and island groups. This seems a lamentably insufficient basis for generalisations, when one reflects on the value of the data that are deemed necessary for any generalisations in regard to prominent elevations among land surfaces. It is well known that the elevation of the land joining the highest summits and the direction of lines of folding are taken as necessary criteria in such cases. Subsidiary but still considerable importance would be attached to the nature of the rocks of which these elevated areas might be composed. In the case under consideration it appears to me that use may be made of these matters, at any rate to some extent. It is, of course, true that the elevations on the sea floor between the separated islands are still but imperfectly known, though soundings have now revealed some of their more important features. It is also true that the majority of the islands contain no folded rock series and are formed mainly of volcanic material or of limestone, which is but slightly tilted. So far as the nature of the rocks is concerned, their mineralogical and chemical composition is becoming fairly well known, at any rate in the western portions of the area.

Any conclusion that may be arrived at after consideration of these various matters must certainly be less problematical than those which are based solely on the positions of the islands.

Two years ago[1] I endeavoured to point out some of the main features of the ocean floor as shown by soundings. The same features have also been shown by Murray and by Murray and Lee. Inspection of these maps shows that there is a continuous area of relatively shallow water extending from New Zealand through the Kermadecs and Tonga groups and thence through the Fiji Islands, afterwards striking west, afterwards turning again to the north, and passing through the New Hebrides. North of this group the soundings are extremely few, and our opinions of the nature of the sea floor is conjectural only.

This shallow ridge separates the Gazelle Basin from the main basin of the Pacific, and it is noteworthy that one of Suess' lines of elevation that whirl from the north of New Zealand must pass through the centre of this well-sounded deep basin. Westward of the Gazelle Basin there are two other ridges that separate it from the deep water of the Thomson Basin of the Tasman Sea. Obviously then all the sea floor west of the New Zealand, Tonga, Fiji, New Hebrides line is greatly varied, alternately sinking to great depths and anon rising almost to the surface of the ocean. On the other side of this line the deep water extends over wide areas. A mere consideration of the soundings appears, then, to suggest that the line mentioned is the true border of the Pacific basin at the present day, and this statement in no way involves any theories as to the antiquity of the great basin.

It is perhaps necessary to explain what one means by the statement that the island line so often referred to is the real margin of the Pacific basin. By this statement it is intended to convey the meaning that any movement of elevation or depression, or any rock movements that have affected that portion of the earth's crust that lies to the west of this line, may have left all that which lies to the east entirely unaffected. In other words, the structural margin is supposed to mark the limit of that portion of the area that according to geological ideas may in the past have formed an eastern extension of the Australian continent.

In this matter a recital of observed rock foldings will help us but little. It is only in New Zealand, Fiji and the New Hebrides that they have been observed. In all of these cases they are parallel to the line of elevation here described, a result that at least

1 *Proc. A.A.A.S.*, Brisbane, vol. XII., p. 432.

strongly suggests that this line of elevation is also a structural line. New Zealand, from the importance that has been attached to it by Suess and Dana, deserves special consideration in this matter.

It is well known that in the south the prominent line of folding from Oamaru to Nugget Point is directed almost at right angles to the coast line, that is nearly E.S.E. It is believed that this line of fold bends gradually round to the direction of the backbone, N.N.E., which is its direction at Mt. Cook. Complete observations are wanting to establish this supposed gradual bend on a basis of fact, though there is no reason to doubt it. Eastwards of Dunedin there is no known continuation of this line of folding which ends abruptly on the sea coast, showing in its transverse section a conformable series of sandstones and schists all much folded, and the latter in some places contorted, the whole folded area being 150 miles across. It is, however, significant that the Bounty Islands, 400 miles to the south-east, are formed of granite.

Similarly, near the East Cape, the direction of strike of the Triassic (?) sandstones that form the western side of the range would carry them out to sea, but there is no indication of the continuation of this line of folds, for the floor of the ocean drops quite abruptly and is soon over 700 fathoms beneath the sea level.

The rocks that are probably of equivalent age in the Coromandel Peninsula appear to strike nearly due north. Still further north the strike of the rocks" shows little connection with the general trend of the North Auckland Peninsula."

In these two regions of S.E. and N.W. folding in the south and of elongation in the same direction in the extreme north, Gregory has sought to discover a series of folds older than the main series of the Southern Alps.[1] This opinion is evidently based on impressions only, for in the south, Jurassic and Triassic rocks are highly involved in these folds which are the older series of Gregory. This is also the case in the north, and here it is certainly not yet shown that the rock folds are directed N.W. and S.E.[2] It therefore appears that the coast of New Zealand does not conform to Suess's statements as to the structure of the coastlines of the Pacific Ocean, which reads as follows : " With the exception of a part of the coast of Central America in Guatemala, where the bending cordillera of the Antilles has sunk in the whole border of the Pacific Ocean wherever it is known in any detail is formed of mountain chains folded towards the ocean in such a manner that their outer folds either form the boundary of the mainland itself or lie in front of it as peninsulas and island chains."

The continuation of the north-east structural line which is here suggested as the true boundary of the Pacific basin is found in the Kermadecs and the Tonga group. The former consist entirely of volcanic material, though blocks of granite derived apparently from a breccia are found in some number in Sunday Island. The Tonga Islands are formed of volcanic material in the western

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1 Gregory, J. W.: *Loc. Cit.*, p. 190.

2 Clarke, E. de C., *N.Z. Geo. Surv.*, *Bull.* 8, p. 42

members of the group and of raised limestone in the east, but this is lying almost horizontally. Here and at the Kermadecs there is a trench of great depth in close proximity to the island chain on its eastern side. It has in the past been generally thought that this trench should rightly be classed as a "graben" or trough fault, as it was described by Jensen[1] and Krummel.[2] Suess, however, distinguishes it as a fore-deep. He emphasises the difference of structure of the two sides of the trench. He says: "With one or two exceptions all marine abysses that sink below a depth of 7,000 metres are fore-deeps in a tectonic sense, and indicate the subsidence of the foreland beneath the folded mountains."[3]; and on a later page, "The fore-deeps are not synclines in the tectonic sense of the word, for one side belongs to the foreland, the other to the folded mountains." In this particular case it must be remembered that all statements about folded mountains are conjectures, for all the exposed sediments—and they are certainly not older than the tertiary—are not folded. Again, apart from the difference in the slope of the two sides of the trench, there is no evidence of a difference of structure. It is well known that in the island of Niue on the foreland side there is a series of raised and terraced limestones quite similar to those of the Eastern Tonga Islands, though the distance that separates them is less than 250 miles. Whatever the true structure of the Kermadec and Tonga regions may be—analogous to the East Cape region of New Zealand or not—the linear arrangement of the islands strongly suggests that they mark a result of the same earth forces to which the lineal form of New Zealand is due.

As this line of shallow soundings is followed north of the Tonga group it is found to trend sharply to the west, when it widens out and on its broad surface is found the Fiji group. For our knowledge of the structure of these islands we are mainly indebted to Woolnough.[4] Consisting as this group does mainly of lavas and tuffs, there are but few structural matters of importance. An older series of rocks but little exposed strikes N.N.W. to S.S.E. The Tertiary rocks are almost flat, though found at times at an elevation of 4,000 feet.

Another sharp curve, first west and then north, in the line of shallow soundings, brings us to the New Hebrides. Here Mawson has described tertiary limestones highly inclined with a very variable strike, though on the whole N.W. to S.E. He regards the structure as due to pressure and overthrusting from the east and subsequently to a down throw on the eastern side.[5] The evidence in favour of this view is, however, somewhat fragmentary. So little is known of the soundings to the north of the New Hebrides and of the structure of the Solomon Islands that it can only be said that the arrangement of the islands supports the view that

1 Jensen, H. I.: *Proc. Linn. Soc. N.S.W.*, 1906, p. 141.
2 Krummel, O.: "Handbuch der Oceanographie," 1907, p. 126.
3 Suess, E.: "The Face of the Earth," vol. IV., 1909, p. 295 and p. 627.
4 Woolnough, W. G.: A contribution to the Geology of Viti Levu, Fiji, *Proc. Linn. Soc. N.S.W.* 1907, p. 431.
5 Mawson, D.: "The Geology of the New Hebrides," *Proc. Linn. Soc. N.S.W.*, 1905, p. 400.

the structural line is continued through the Solomon Islands to the New Ireland and Admiralty Islands.

The rocks of the islands situated along the line mentioned are sufficiently similar to support the idea of its tectonic continuity. On the western side of the structural axis of the North Island of New Zealand the volcanic rocks are andesites, generally of somewhat basic types. Those of the Kermadecs are also almost exclusively andesites, but somewhat more basic. The rocks of the Tonga group, so far as known, are also andesites, and this series with basalts are practically the only types in the Fiji Islands, and similar rocks occur again in the New Hebrides and in the Solomon Islands. There is then a remarkable absence of acid and of alkaline rock types in these island groups situated along the line that has been so frequently mentioned.

At the present time there is a tendency to refer to the andesitic rocks as the "Pacific type" because of their frequent occurrence in the Pacific area. It has, however, been pointed out by Becke[1] that the rocks of the Pacific type are connected with foldings by tangential pressure. If this statement be accepted, additional weight is given to the suggestion that the line that passes through the island groups mentioned is one of structural significance.

The importance of this is realised when it is pointed out that in all the island groups lying to the east of this line only basic and alkaline rocks are known. These types have been shown to exist side by side by Lacroix in Tahiti, by Weber in Samoa, by Wichman in Hawaii, by Velain in Easter Island, by Marshall in Raratonga, Aitutaki, Raiatea and Huaheine. Such rocks are by Becke supposed to be associated with inbreaks due to radial contraction, and if this is true it emphasises the structural difference between the islands on the line referred to and the isolated island groups of the Pacific basin. However, if this view is adopted difficulties will be encountered in explaining the occurrence of the alkaline and basic types at Dunedin and Auckland, in New Zealand, though it is true that the abrupt truncation of the folded range at the former place supports the idea of crustal fracture there. Lacroix has lately, in discussing the occurrence of alkaline rocks in the Pacific area, suggested in regard to the andesitic or Pacific type that "au moins faut-il parler non d'un facies Pacifique mais d'un facies circum-Pacifique."[2]

From time to time biologists have considered the distribution of plants and animals in the Pacific region, and have arrived at certain conclusions in regard to land extensions at different periods in the past. It is, however, unfortunately true that biologists are not a present in agreement as to the extent and nature of these earlier land connections. Such speculations have been in great part confined to the problems encountered in the far South, and they have varied from Wallace's belief, that no changes need have taken place in the past to account for the present distribution to Forbes's construction of an immense continental area in high

1 Becke, F.: *Min. petr. Mitth.*, 1903, XXII., p. 209.
2 Lacroix, A.: *Comptes Rendus*, 151, p. 127, 1910.

southern latitudes. Hutton believed that New Zealand and South America were connected by continuous land across the central Pacific, but Hedley has more recently compared the fauna of several groups of Pacific Islands and has concluded that "no sign of an American migration can be traced in the Central Pacific."[1]

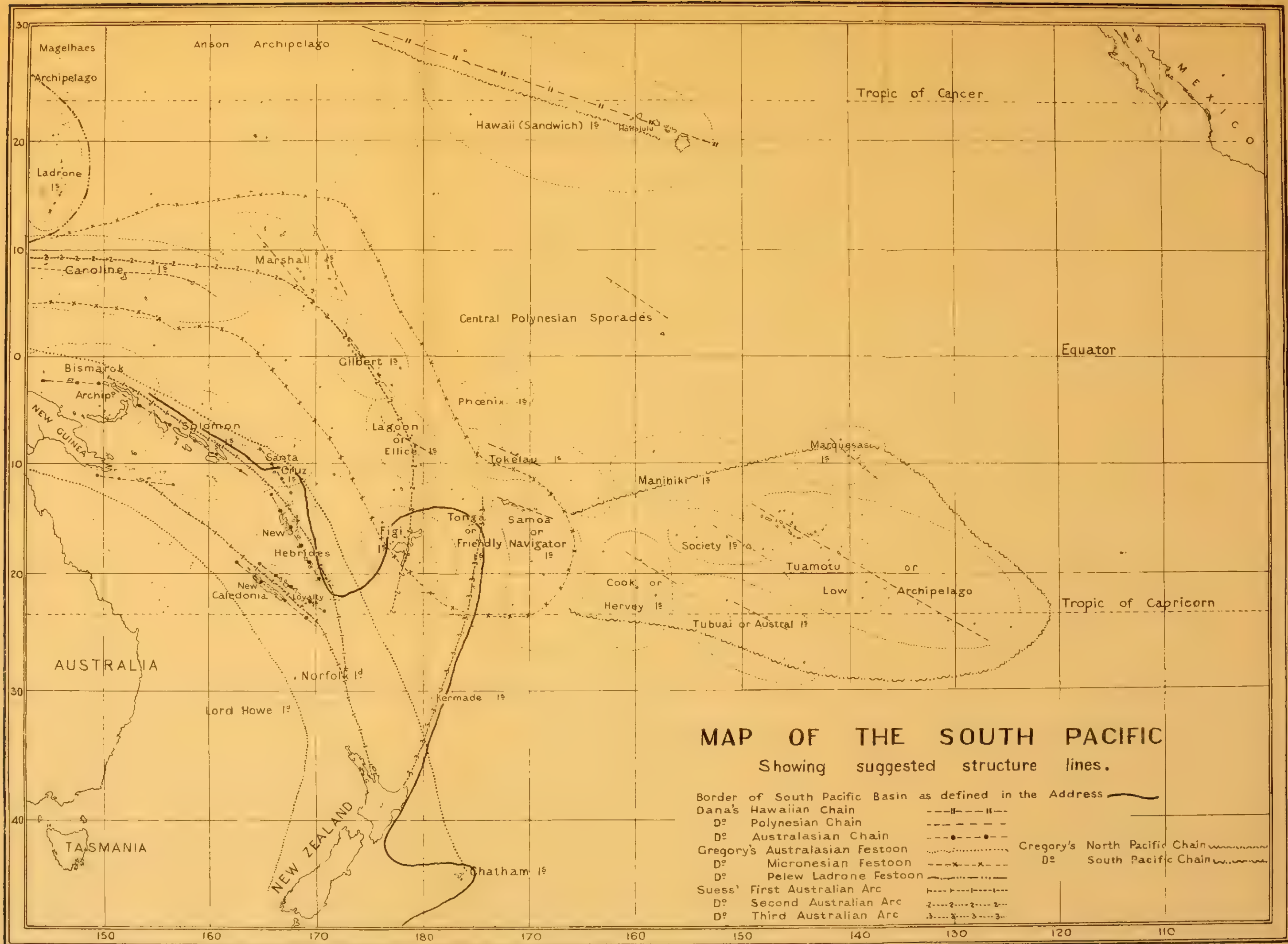
However, he was satisfied that biological evidence showed that a former continental area had connected New Zealand, New Caledonia, New Hebrides, Solomon Islands, and New Guinea, with a peninsula directed south eastward to Fiji. The Tonga Islands and the Kermadecs are not included in this continent. In the latter group the flora is closely related to that of New Zealand, no less than 74 of the plants being found in the larger land. Cheeseman,[2] however, considers that it is unlikely that a land connection ever existed between New Zealand and the Kermadec Islands; the resemblance between the faunas is ascribed by him to the strong currents which have transported many Kauri logs from New Zealand to the Islands. This opinion is apparently shared by Oliver. The former extension of New Zealand to the Kermadecs and Tonga, and thence westwards to Fiji is, however, strongly advocated by Speight.[3] The latest researches on the Kermadec fishes and echinoderms by Waite and Benham show rather unexpected alliances with Australian forms.

It appears, then, that this line through New Zealand, Kermadec, Tonga, Fiji, New Hebrides, Solomon, New Ireland, and Admiralty Islands, which certainly has petrographical features in common, has also much structural resemblance throughout. With the possible exception of Tonga, there is strong biological evidence of land connection between them in the past and of prolonged, perhaps aboriginal, separation from the Eastern Pacific Islands.

If this string of islands were ever connected, there remains the question as to the date when this portion of the Pacific occupied such a much more elevated position. The complete absence of older fossiliferous rocks or even older sediments in all the islands, except New Caledonia, which lies somewhat to the west, makes it impossible to answer this question definitely. It is, however, known that in the majority of the Island groups there are tertiary limestones now occupying elevated positions, 4,000 feet in New Zealand, 1,000 feet in Tonga, 4,000 feet in Fiji, 3,000 feet in the New Hebrides, and 1,000 feet in the Solomon Islands.

In Fiji, Woolnough states that elevation has been continuous from middle tertiary times to the present day. In New Zealand there appears to have been a great elevation at the close of the tertiary and early part of the quaternary, when all the present drowned valleys on the coast line were formed by ordinary sub-aerial erosion. It appears worthy of further investigation to inquire whether there is absolutely no trace of a similar elevation in the other island groups. If in the future it

1 Hedley, C.: "A Zoogeographical Scheme for the Mid-Pacific," *Proc. Linn. Soc. N.S.W*, 1899, p. 404.
2 Cheeseman, T.: "On the Flora of the Kermadec Islands," *Trans. N.Z. Inst.*, XX., 1887, p. 163.
3 Speight, R.: *Trans. N.Z. Inst.*, XLII., 1909, p. 241.


MAP OF THE SOUTH PACIFIC
Showing suggested structure lines.
Border of South Pacific Basin as defined in the Address
Dana's Hawaiian Chain
D° Polynesian Chain
D° Australasian Chain
Gregory's Australasian Festoon
D° Micronesian Festoon
D° Pelew Ladrone Festoon
Suess' First Australian Arc
D° Second Australian Arc
D° Third Australian Arc
Gregory's North Pacific Chain
D° South Pacific Chain
Magelhaes Archipelago
Anson Archipelago
Tropic of Cancer
Hawaii (Sandwich) Is
Honolulu
MEXICO
Ladrone Is
Caroline Is
Marshall Is
Central Polynesian Sporades
Equator
Bismarck Archip°
Gilbert Is
Phœnix Is
NEW GUINEA
Solomon Is
Lagoon or Ellice Is
Tokelau Is
Santa Cruz Is
Manihiki Is
Marquesas Is
New Hebrides
Figi Is
Tonga or Friendly Is
Samoa or Navigator Is
Society Is
Tuamotu or Low Archipelago
New Caledonia
Loyalty
Cook or Hervey Is
Tubuai or Austral Is
Tropic of Capricorn
AUSTRALIA
Norfolk Id
Lord Howe Id
Kermade Is
NEW ZEALAND
TASMANIA
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is definitely proved that no such elevation took place, then the land connection must have been in the late Mesozoic, for there is, I believe, in New Zealand a complete stratigraphical conformable sequence from rocks that contain Cretaceous fossils to the youngest tertiary sediments. Careful work in connection with Messrs. R. Speight and C. A. Cotton in the typical district of North Canterbury has made us of one mind in this matter, and has caused us, at first with diffidence, but afterwards as work progressed with confidence, to oppose the views of Haast, Hutton, Hector, and Park. At first sight this may appear a conflict against the united opinion of older geologists, who have devoted much time to the elucidation of New Zealand geology. Such is, however, not really the case, for although each observer has broken up the series that we believe to be conformable into several divisions, yet each observer has put these divisional planes at a different horizon in the series from all of the others. We are therefore more in agreement with each of the geologists mentioned than is any one of them with the others.

If our view of the New Zealand Stratigraphy is adopted, the northward extension of New Zealand must have been in the late Mesozoic or in the Pleistocene. Would the former sufficiently account for the present distribution of flora and fauna? I think not, for it is well known that the Cainozoic flora of New Zealand is quite fundamentally different from that of the present day.

We are compelled, then, to believe that this continental expansion took place in quite late geological times. It is for biologists to say whether the great differences between the islands in faunal and floral characters could have been developed within that time. But in making any statements about this matter a liberal allowance must be made for latitudinal effect and for local climatic peculiarities as well as soil.

Within New Zealand itself the flora of Mt. Egmont differs as much from that of Cape Farewell as does the flora of the Bluff from the Auckland Islands or the North Cape from that of the Kermadecs.

This somewhat random discussion ends with little more certainty than that with which it began. It appears, however, that—

1. Bathymetrical, structural and petrographical characteristics support the idea that the real boundary of the south-west Pacific passes through New Zealand, Kermadec, Tonga, Fiji, New Hebrides, Solomon, and on to the Admiralty Islands.

2. That this practically coincides with biological knowledge as to plant and animal distribution within the area.

3. That the land connection or approximation took place in the late Mesozoic or in the Pleistocene, probably in both.

4. That the eastern Pacific islands are different in structure, nature and origin from the lands on the line of islands mentioned, and that they have derived their fauna and flora by chance migrants from them.

EXPLANATION OF MAP.

PLATE I.

Map of South Pacific, showing structure lines suggested by various authors.

PAPERS READ IN SECTION C

1.—A PRESENT REVIEW OF THE TERTIARIES OF AUSTRALIA.

By G. B. PRITCHARD.

2.—A PRELIMINARY ACCOUNT OF THE GEOLOGY OF NUNDLE DISTRICT, NEAR TAMWORTH, N.S.W.

By W .N. BENSON, B.Sc.

PART 1.—THE GEOLOGY OF NUNDLE.

NUNDLE lies near the head of the Peel River, 37 miles south-south-east of Tamworth, and towards the southern end of the great serpentine belt of New South Wales. Though of considerable geological interest and complexity, it has so far escaped detailed study. [15 19 35]

The Devonian System forms the foundation of the whole district and is of very great thickness. It is most convenient to divide it into three sections, which, commencing with the oldest, are respectively the Woolomin Series, the Bowling Alley Series, and the Nundle Series. The Woolomin Series forms the eastern portion of the area studied. It consists of steeply-dipping slaty rocks, usually inclined to the east, and striking on the average about 20° west of north. Sometimes rather tuffaceous bands appear and also andesites, but whether these are interbedded flows or intrusive is not yet quite certain. The most remarkable feature is the occurrence of several parallel bands of red jasper, which are continuous over long distances, but are not as a rule much above 100 feet in thickness. Towards the southern end of the area the series passes up into felspathic quartzites and pinkish felspathic sandstones, and in places is conglomeratic. The series must be several thousand feet in thickness, though it is probable repetition of the beds by overthrust faulting may have occurred. Their lithological uniformity, however, prevents this being readily recognisable. It has been suggested[8] that this series has been thrust over the one succeeding it on the west, and there is considerable evidence in support of the hypothesis. The Bowling Alley Series is also of great thickness, and here there is sufficient variety in the formation to allow it to be ascertained that there is little probability of extensive repetition by faulting in the series. Minor repetitions, however, may be fairly common. The strike of the beds is parallel to that of the Woolomin Series, but the dip is predominantly to the west, being nearly vertical in the eastern portion. The order of deposition appears to have as follows :—A thin layer of banded radiolarian chert, on which lies a huge thickness (1000 feet or more) of coarse, grey-blue andesitic tuff, since silicified, containing angular fragments up to half an inch in diameter, and rarely casts of radiolaria. Above this is an horizon in which coral limestone is frequently developed, containing a Middle Devonian fauna. The following forms determined by Mr. W. S. Dun were collected from this horizon: *Favosites multitabulata*, *F. salebrosa*, and a dendroid species; *Diphiphyllum porteri*, *Heliolites porosa*; *Alveolites*; *Litophyllum Konincki*, ; *Atrypa*.

This calcareous belt is made up of brecciated red marble, white marble, silicified blue limestone, or very impure tuffaceous limestone. Frequently its place is occupied by a black, seemingly vesicular, rock in the cavities of which coral fossils may occur. Microscopically the rock suggests a rapidly-chilled lava flow, and is full of skeleton crystals of magnetite and other minerals. The calcareous rocks are not confined to this one horizon, but may occur both above and below it. There are also occasionally thin limestone lenses in the banded cherts. The upper portion of the Bowling Alley Series is made up of a succession of tuffs and radiolarian cherts, with slate layers and shale bands in which *Lepidendron australe* occurs. They pass without unconformity upwards into the Nundle Series. In these, however, the dips are less steep, and sometimes the beds are almost horizontal. The series is composed of a succession of fine-grained andesitic tuffs and soft laminated clay-shales and mudstones. In places these may become cherty; elsewhere there are bands of conglomerate containing granitic pebbles, and frequently there are thin limestone lenses.

During the Devonian period of sedimentation volcanic activity was pronounced; vast quantities of ash were ejected, and probably lava flows were frequent. The products of this activity must be in the aggregate over a thousand feet in thickness. In chemical nature it is chiefly andesitic, though occasionally felsitic. During the close of the Devonian period orogenetic movements began, accompanied by great earth folding, the axis of the folding being about N. 20° W. and S. 20°E., and the force was directed from the east. It is probable that in this folding the Woolomin Series was repeated by isoclinal folding and thrust up over the Bowling Alley Series. Along this strike fault plane ultrabasic rocks were intruded; they thus occur at an almost definite horizon in the sedimentary series, but at the same time there are a few minor intrusions both in the Woolomin and Bowling Alley Series. Near Hanging Rock the serpentines leave the junction line of Woolomin and Bowling Alley Series and intrude the lower portion of the latter. The rocks developed are olivine and pyroxene serpentines of various types, which may have become silicified or carbonated, and more or less saussuritised gabbros. Following this intrusion came the diabases. These form exceedingly irregular masses, and within the area studied are confined to the Bowling Alley Series. They vary considerably in texture and grain size and contain pegmatoid veins. Pyrites is a common accessory. Closely connected with these intrusions was the formation of the numerous quartz veins, which contained originally most of the gold in the district. With these there is sometimes scheelite or axinite. It is not certain how far this silcification of the country is responsible for the formation by replacement of the red jasper bands.

After this came the great Carboniferous (?) period of granitic intrusion. A large portion of the area studied is underlain by a batholith of micaceous granodiorite, which is exposed in Duncan's Creek on the east and near Mt. Ephraim on the south. Associated with it are a large number of porphyry apophyses, which extend up into the Bowling Alley and Nundle Series. There is a great variety of these, including quartz, felspar, or hornblende porphyries and granophyres. It seems not unreasonable to regard the serpentines, gabbros, diabases and granodiorites as a differentiation series.

The wide flats on the Peel River, where it bends to the west to meet Hyde's Creek, are composed probably of Permo-Carboniferous rocks overlain by alluvial. Stonier[22] reports the occurrence of *Glossopteris* and other Permo-Carboniferous leaves in a shaft on these flats, and marine fossils occur by Reichels' homestead on the eastern side. The rock is an arenaceous limestone and contains *Deltopecten*, *Martiniopsis*, and obscure casts suggesting *Astartila*, *Edmondia*, *Mourlonia* and *Ptycomphalina*. This area is doubtless portion of a sheet once continuous over the whole district which has been faulted down into the Devonian beds.

According to Mr. Andrews, a peneplain was developed in Tertiary times, and, consequent on its elevation, considerable dissection ensued, and the valleys cut attained considerable size.[2 3 4] In this district they had not progressed beyond the canyon stage, when a depression of the area brought about heavy silting. The valleys became filled with coarse gravel, sandstone, and in places soft shales, which contain leaf impressions. Mr. Deane has examined specimens, and reports that the material is very imperfect. There are fragments suggesting the *Cinnamomum* type, *Sterculia*, *Flindersia*, *Clerodendron tomentosum*, *Ficus scabra*. There are no leaves which can be referred to *Eucalyptus*. He adds :—

> "I do not think these fossil leaves can lead to any deductions as to age. They are quite of the same character as the Brush vegetation of our coast, a type which has existed in Eastern Australia from the Miocene, if not from an earlier, period. Of course the climate must have been a much moister one, owing partly to the absence of a parched interior enabling a luxuriant vegetation, now restricted to patches of the coast, to spread over the tableland and down the western slopes."

The deposits are often of great thickness ; those of Yellow Rock Hill, near Nundle, are 350 feet thick.

This sedimentation was followed by the outpouring of basic rock, which flooded over the undissected parts of the peneplain, and flowed down the valleys, covering the gravels, etc. Several flows occurred, and between these there are occasionally layers of gravel. While the rocks correspond in the main to the plateau-basalt physiography,[14] no evidence has been seen of the fissure eruption, but five distinct necks have been noted. Petrologically these rocks vary considerably ; they include fine and coarse grained olivine basalts, doleritic types, and rarely scoriaceous basalt. Associated with these is a nepheline basanite, typically developed on Square Top, near Nundle. The relation of these to the normal basalt has not yet been determined. It may be mentioned, however, that there is a series of nepheline rocks extending from Nundle southwards to the Mount Royal Range, and these appear to be intimately associated with the normal tertiary basalt. The writer has in preparation a note descriptive of these.

Following on the basaltic eruption there have been periods of uplift and dissection producing the present physiography, which has been briefly described by Mr. E. C. Andrews. Want of space forbids a discussion of many interesting points in this connection.

During the grading of the Peel River at least two sets of gravels have been produced, sometimes giving rise to terracing on a small scale.

Economic Notes.—Gold was first found in this district in 1852, and since then about £750,000 worth has been obtained. It occurs in many ways :—(*a*) In quartz veins near the boundaries of the diabases ; (*b*) in quartz veins in slate away from the diabases ; (*c*) as impregnations in slate in wide low-grade channels with rich quartz stringers ; (*d*) as impregnations in carbonated serpentine ; (*e*) in tertiary drift, mined by hydraulic sluicing ; (*f*) in high-level river gravels ; (*g*) in the present river gravels, won by dredging.

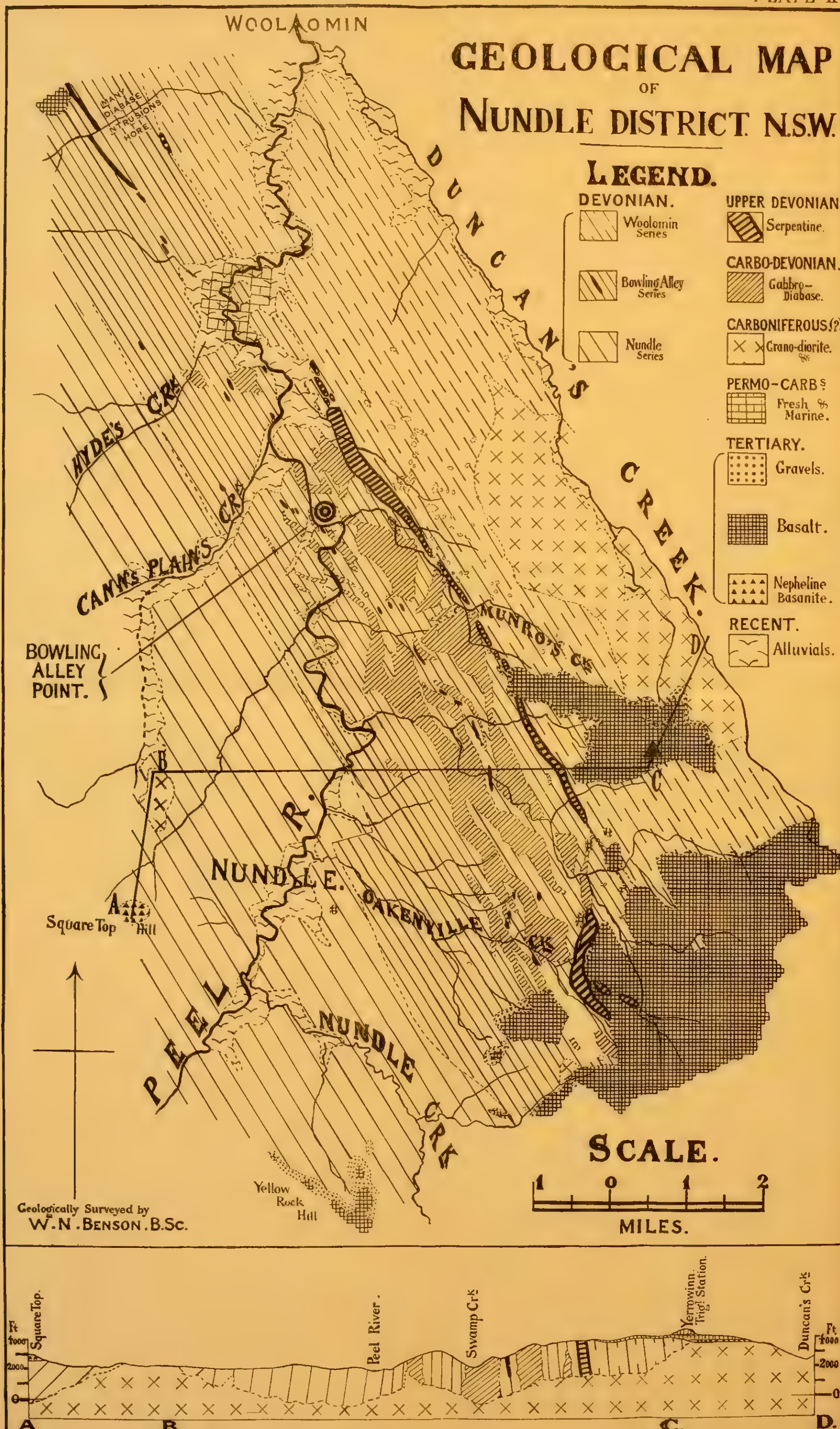
Scheelite occurs in small quantities in most of the modes of occurrence noted for gold, but of these the first two only seem to have yielded payable amounts. In the slate it forms lenticular bunches. Stibnite occurs near Nundle seemingly in a brecciated fissure vein in slate, parallel to the strike. Chromite forms large segregations in the serpentine, but for the most part is of low grade. The white marble does not form deposits large enough to work for statutory marble, and is difficult of access, the red marble is in greater quantity, is easy of access, and takes a good polish. Zircons and sapphires have been found in the interbasaltic layers, but not of large size.

The map (Plate II.) has been drafted from a plane-table survey by the writer. The smallness of the scale has prevented the showing of much detail that might well have been added. The many intrusions of porphyry are shown to occur chiefly in the Woolomin Series, but the largest of them is at B on the section line, in the Nundle Series. The limestones of the Bowling Alley Series are shown as solid black patches. The intrusions or flows of andesite in the sedimentary series have not been indicated, nor have the layers of andesitic tuff. The epochs of intrusion stated for the plutonic must be taken chiefly as indicating the relative order of their intrusion ; the serpentine may be early carboniferous, and the gabbro diabase consequently rather more recent than indicated. The occurrence of serpentines as erratics in the glacial permo-carboniferous age proves that these cannot post date the carboniferous. Particularly with regard to the age of the granodiorites there is much uncertainty. That they are not remarkably acid would suggest their correlation with the carboniferous granites of New England,[3] a suggestion supported by their low erosion relief. On the other hand, the nearest granites are those of Moonbi, which are stated to be mesozoic. The Duncan Creek rocks are not, however, sphene-bearing to any marked degree, as are those of Moonbi, as far as has been ascertained. A section along a line further south than A.B.C.D. would show a much smaller angle of dip for part of the Nundle series.

Part II.—Abstract.

Suess has shown that ultrabasic rocks in general form sills in dislocated mountains, and have been intruded into bedding or fault planes during the period of crust movement. Attention is here drawn to the fact that ultrabasic rocks in Eastern Australia and Tasmania occur in sill-like masses in folded rocks, and have their maximum extension in a direction lying between north and north-west. (See fig. 1.) As far as is at present known the only exception

Fig. 1.
Diagram showing Distribution of Ultrabasic Rocks in Eastern Australia.


GEOLOGICAL MAP
OF
NUNDLE DISTRICT N.S.W.
LEGEND.
DEVONIAN.
Woolomin Series
Bowling Alley Series
Nundle Series
UPPER DEVONIAN.
Serpentine.
CARBO-DEVONIAN.
Gabbro-Diabase.
CARBONIFEROUS(?)
Grano-diorite. &c
PERMO-CARBS.
Fresh & Marine.
TERTIARY.
Gravels.
Basalt.
Nepheline Basanite.
RECENT.
Alluvials.
WOOLAOMIN
MANY DIABASE INTRUSIONS HERE
DUNCAN'S CREEK.
HYDE'S CRK
CANN'S PLAINS CRK
BOWLING ALLEY POINT.
MUNRO'S CK
R.
NUNDLE.
OAKENVILLE CK
PEEL
NUNDLE CRK
Square Top Hill
Yellow Rock Hill
A
B
C
D
SCALE.
1 0 1 2
MILES.
Geologically Surveyed by
W. N. BENSON. B.Sc.
Square Top.
Peel River.
Swamp Crk
Yerrowinn. Trig! Station.
Duncan's Crk
Ft
4000
2000
0
A.
B.
C.
D.

is the serpentine belt of Port Macquarie, New South Wales, which runs in a north-easterly direction. Little is known as to the period of intrusion of these rocks. The Tasmanian occurrences are stated to be Devonian in age, the Nundle belt is probably late Devonian or early Carboniferous. Of the rest no more can be said than that, with one exception, none of them have been proved to be of an age not comparable with that of the Nundle and Tasmanian rocks. The exception is the serpentine of Dolodrook, near Mt. Wellington, in Victoria, which is Ordovician or older. Should it be shown eventually that the Eastern Australian and Tasmanian ultrabasic rocks are in the main coeval, it would indicate that at the time of their intrusion, probably near the close of the Devonian period, the whole area over which they extend was being folded as a geological unit, about an axis running approximate by north-north-west, and south-south-east. The evidence at Nundle suggests that the thrust was directed from the east.

(Postscript added 3rd June, 1911.)

Since the above paper was written further study has been made of the Nundle-Bingara serpentine belt, about its northern portion, the Bingara district. While the sequence of events deducted from a study of the Nundle is fully confirmed, it seems that the period of folding associated with the intrusion of the ultrabasic magma was most probable in late carboniferous times. The periods of diabase intrusion and of silicification must accordingly be advanced, though both antedate the permo-carboniferous. That the thrust was from east to west is sufficiently clear.

Further work is now in progress.

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PLATE II.

GEOGRAPHICAL SKETCH MAP OT THE NUNDLE DISTRICT.

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3. THE GEOLOGY OF THE YASS DISTRICT.

By A. J. SHEARSBY, F.R.M.S.

PLATES III.

THE area under consideration embraces the country traversed by the Southern Railway from Gunning on the east to Bowning on the west, a distance of about 26 miles, with a breadth of about 12 miles. As it is mostly of a mountainous nature, it presents great difficulties to the geologist who single-handed attempts to solve the problems with which the district abounds.

The country at Gunning consists of shales highly folded and faulted by intrusions of quartz porphyry and granite. These shales are apparently barren of fossil remains. Their relation to the other sedimentary beds to the west points to them being Upper Silurian, probably a little older than the Bango and Yass Beds.

To the west of Gunning the country passed over is chiefly granite, to about the 173 mile peg, two miles on the Yass side of Oolong railway platform. This granite decomposes into a very fertile soil. Many imposing perched blocks of denudation are to be seen from the railway line near the 170 mile peg.

At the 173 mile peg the granite gives way to about eight miles of shales, mudstones, and quartz beds, most of which are of a very barren nature, both as regards plant food and fossils. For eight miles the train travels over these sedimentary beds, the *Jerrawa Shales*. They are folded and contorted so much that the same beds are continually being exposed, forming an isoclinal fold.

At about 181½ miles the Jerrawa shales are replaced by quartz porphyry. Near the 183 mile peg it will be noticed that the porphyry is distinctly columnar.

At Coolalie (184 miles) the country is more or less level, and the bed rock is covered by recent deposits, so that no change is observable from the railway. The beds here are, however, silurian sediments, consisting of limestone, shales and sandstones, and are best studied a mile or so to the north near Bango homestead—the *Bango Beds*. Towards Yass the cuttings show quartz porphyry similar to that last mentioned, and would lead one to believe that the two were a continuous sheet. The Bango Beds, however, separate them. Yass Junction (189 miles) is on porphyry, but this gives way to sedimentaries a quarter of a mile to the west. These are a continuation of the *Yass Beds* of Jenkins.[1] The railway cuts these at right angles and enters porphyry again near the 190 mile peg. The width of this strip of porphyry is only about a mile.

Silurian sediments are again encountered to Bowning (196 miles). These beds form the *Hume Beds* of Jenkins,[2] and the Bowning Beds of Mitchell.[3] They are replaced by porphyry about two miles beyond Bowning.

Gunning Shales.—These extend in a southerly direction through Gundaroo, on the Yass River, towards Queanbeyan. To the north they extend beyond Dalton. They are pierced here and there by granite and porphyry hills. This part of the section has not been thoroughly examined, but no fossils have been found, although some areas were examined minutely. At Nelanglo Creek near Gundaroo, peculiar markings were found, but their organic origin is doubtful. That the Gunning shales differ from the Jerrawa shales in mineral constituents is evident from the fact that they weather into a much more fertile soil than is met with in the latter.

Intrusions.—The shales have in many instances been metamorphosed into slates by intrusions of quartz porphyry and granite. Appearances point to the porphyry being the earlier instrusion, as in places the granite has forced its way through both porphyry and slates, the result being that the porphyry has been crushed and altered. An interesting example of this double intrusion of the shales is to be seen in a creek to the north of the Gunning railway station. In the bed of this creek, about half a mile above where the Dalton road crosses it, the grey shales are noticed to abruptly give place to a peculiar white rock. The transition is very sharp. Closer examination reveals the intrusive nature of the white rock, little tongues of which penetrate the slate, the junction of the two showing a distinct contact selvage. This intrusive rock is without doubt a quartz porphyry crushed and metamorphosed by the more recent grey hornblendic granite, which is found at the same spot intruding both the porphyry and the slates. It is very extensive, outcrops of large area being found many miles from Gunning in all directions.

Tertiary Deposits.—At Dalton, about four miles north of Oolong, an interesting Tertiary deposit is found lying on the almost vertical edges of the Gunning shales. (Pl. III. Fig. 1). It occurs in the village of Dalton, on Wm. Brown's portion 35, and consists of a very compact conglomerate of quartz pebbles and sand, highly silicified. The bedding planes are highly fossiliferous, well-preserved specimens of Miocene leaves occurring in abundance. Unfortunately, the deposit, which is apparently only a few acres in extent, has suffered greatly

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1 C. Jenkins: "Geology of Yass Plains," *Proc. Linn. Soc. N.S.W.*, Vol. III., 1878.
2 C. Jenkins: *Op. cit.*
3 J. Mitchell: "Notes on Geology of Bowning," *Proc. Linn. Soc. N.S.W.*, Vol. I, 1887; "The Geological Sequence of the Bowning Beds, N.S.W.," *Rept. Austral. Assoc. Adv. Science*, Vol. I., 1888 (1889).

at the hands of thoughtless visitors, and good specimens which were exposed to view have been defaced or removed. The owner of the property has wisely prohibited the removal of any more specimens. Good examples of the leaves from this spot are in the Yass Mechanics' Institute and the Mining and Geological Museum, Sydney.

Jerrawa Shales.—The barren character of the Jerrawa shales has already been commented on. To say, however, that all the sedimentary rocks to the west of the Gunning-Oolong granite are barren would not, strictly speaking, be true, as the shales between the granite and Jerrawa Creek give some good farming and grazing land. The character of the soil in this part of the section is very similar to and may prove to be part of the Gunning shales. The typical barren Jerrawa shales cross the railway line near where the Jerrawa Creek crosses, and continue in a course a little W. of N. for many miles. In a southerly direction they are found near Queanbeyan, to the east of the Yass-Canberra Federal City area. The width of this belt of country is variable, but in the vicinity of Yass it is about six miles.

Intrusions of porphyry are to be found at irregular intervals all along the line of strike, and the weathering of this porphyry into a good soil makes farming on a small scale possible in certain localities.

Numerous veins of milky quartz are very common in these shales, and not being so readily decomposed as the shale, large areas are covered with the angular white fragments. Some of the hills in this region have their cores formed of this quartz, the "Needles" (2,533ft.) being one of them. At the summit of this hill a shaft was sunk some years ago by prospectors for gold, but was abandoned nothing of a payable nature being found. Similar results have been obtained all along this Jerrawa belt.

No. 1 Porphyry.—The Jerrawa shales are bounded on the west by a quartz-porphyry, which I call No. 1, and as mentioned before appears near the $181\frac{1}{2}$ mile railway peg The strike of this porphyry is about 20° W. of N., and Mt. Hawkins (2,588 ft.) is composed of it. This intrusive mass or flow should have careful scrutiny, as in many places it has the appearance of a clastic rock. In the railway cutting near the 183 mile peg it is brecciated and fossiliferous, containing as it does granitic and felsitic lumps mixed with shale, limestone and fossils, such as shell fragments, crinoid ossicles and corals *Cyathopphyllum* and *Favosites.* The binding material or matrix is porphyritic, and the whole mass is very compact and hard. Some portions, probably limestone and fossils, have been replaced by iron pyrites, the weathering of which has caused deep brown stains. This remarkable bed is either a tuff bed or an example of the Silurian sediments being intruded and partly digested by a mass of quartz porphyry. Mr. L. F. Harper has already dealt with a similar occurrence at Boambola, near Yass.[1]

A large massive outcrop of this fossiliferous porphyry is to be seen on the hill a few chains to the north of this spot. In

1 Harper, L. F.: *Records Geo. Surv. N.S.W.*, Vol. IX., Pt. I., 1909.

the ranges near Mt. Hawkins many examples of sedimentary rocks enclosed in the porphyry are to be seen, and it will be interesting to find out the thickness of the beds which have been absorbed by this porphyry if it is an intrusive. In the same railway cutting at 183 mile peg it will also be noticed that the porphyry is decidedly columnar in nature ; so much so that in making the line many of the columns have been thrown on one side, and are still to be seen near the fence. (Pl. III. Fig. 2.) This prismatic jointing is a peculiarity common to some of the Yass porphyries, but so far none have been seen to equal the examples to be found here.

Bango Beds.—The boundaries of the *Bango Beds* both east and west are so intimately mixed with the porphyries, that it has been impossible to decide their extent. If the porphyries are intrusive, a large proportion of the silurian sediments have been engulphed by them, leaving at this part of the section only a very narrow strip of unaltered rocks. The paucity of outcrops of this horizon has resulted in its being entirely overlooked from a geological point of view, although when the southern railway line was being constructed in 1876 an outcrop of a beautiful white limestone was discovered, and a practical use made of it by burning for lime used in the construction of the culverts. Intermittent lime burning has been carried on ever since.

Attention was first drawn to these beds in 1905, when I went at the request of a Yass syndicate to Coolalie to report on the suitability of an outcrop of marble on portion 22, Parish of Bango, as a lime burning industry. The quarry is about a mile to the north of Coolalie Railway Station, and has been known locally as the Coolalie marble quarry. As, however, this name is liable to be confounded with Caloola, near Bathurst, I have thought it advisable to refer to the horizon as the Bango beds. I have found outcrops in portions 56, 22, 19, 17, and 123, the strike of the beds being about 20° W. of N. I have also seen what I consider to be a continuation of the same beds in portion 3, Parish of Blakney, on the same line of strike. The intervening country where flat shows no trace of limestone, which no doubt is covered with recent deposits. In the hilly country it is hidden, if not altogether absorbed by the porphyry.

Where the deposit has been worked for lime, in portion 22, Par. Bango, the stone varies from a coarsely crystalline marble to a close grained limestone, of many shades of colour, ranging from a pure white to dark mottled red and grey, with occasional patches of shades of gold and iron grey. Some of these marbles are very handsome when polished, but no attempt has been made to work the deposit on any other basis than as a lime quarry, and blasting being the only method used to extract the stone, the face of the deposit has been badly starred and fractured. The lime from this quarry, on account of its extra quality, is in great demand ; but, owing to the primitive methods of burning, is not turned out as rapidly and regularly as is necessary to supply a big market, consequently the industry is not as flourishing as it should be.

In the quarry itself I only found fossil remains represented by crinoid stems and ossicles, and some *Favosites*. Some of the crinoid stems are about three-quarters of an inch in diameter, the largest I have found in the Yass district. In one sample of limestone the matrix was of a very light grey, and the crinoid remains were pink.

Nearer Bango Homestead *Halysites* was found, a genus searched for in the Yass beds for some years. The specimens were fairly plentiful in the limestone, and from a micro-section of one considered to be *Halysites pycnoblastoides*, Eth. fil.

Mr. W. S. Dun, of the Geological Survey of N.S.W., has since shown me a specimen of *Halysites*, recently discovered by Mr. E. F. Pittman, Government Geologist, at Canberra, which strengthens my belief that the Canberra beds will be found to be a continuation of the Bango beds, and in all probability the beds there have not been subjected to so much destructive metamorphism as at Bango.

Other fossils since found at Bango are :—*Tryplasma* (2 new species) ; *Heliolites*, *Pachypora*, *Chætetes*, (?), *Cyathophyllum*, *Stromatopora*, (?) *Cyclonema*, and fragments of bivalves. On the right bank of Bango Creek, in altered mudstones—*Arenicolites*.

The thickness of the bed of limestone was not determined, as the outcrops consist mainly of weathered boulders projecting through the soil, but from its appearance in the quarry (Pl. IV. Fig. 3) the deposit should be very solid at a depth. From the quarry back to the 183 mile peg, the country consists of such a confusion of porphyry, altered sediments, small patches of limestone, and fossiliferous porphyry, that with the short time at my disposal I was unable to obtain anything like a clear insight as to the sequence of the various beds.

No. 2 Porphyry.—To the west of this limestone belt the country is just as complicated, as a cursory trip across it, as far as Derrengullen Creek, seems to produce nothing but quartz porphyry. Closer scrutiny, however, brings to light in what looks like massive porphyry unmistakable silurian fossils. At the junction of the Rye Park and Blakney Creek roads, on W.R. No. 118, Parish of Bango, the blue black porphyry contains limestone and shale fragments, together with fossils, such as *Favosites*, *Cyathophyllum*, crinoid stems, and remains of brachiopods. Portions 160 and 153 in the same parish also yield the fossiliferous porphyry, and altered mudstones.

Two samples of rock from portion 138 were submitted to Dr. W. G. Woolnough, University of Sydney, who has kindly undertaken to examine a series of the Yass porphyries. He has not yet had time to make complete determinations, so that his reports are only preliminary ones. He identifies some as quartz porphyry, others undoubtedly quartz porphyry tuff.

At Oak Range, about a mile to the west, on portions 56 and 99, Parish Derrengullen, the porphyry is in places very coarsely spherulitic, and in places splits into slabs, from a few inches to a foot or more thick, which only require a little trimming to make them suitable for door steps, and other building purposes. An outcrop of fossiliferous tuff[1] is also found there, which yielded the following silurian forms :—*Cyathophyllum*, *Favosites*, *Heliolites*, crinoid stems, *Atrypa reticularis*, (?)*Athyris*, *Spirifera*, *Camarotœchia*,(?) *Rhynchotreta*,(?) and *Encrinurus punctatus*; Brunn. sp.

About two miles to the S.W. of Oak Range, in the bed of Derrengullen Creek an outcrop of limestones, shales, and sandstones is exposed, the series forming a continuation of the *Yass Beds* of Jenkins. The intervening country, however, is composed mainly of the No. 2 porphyry belt, which, with the same strike as the other beds—about 20° W. of N.—is met with at Yass Junction, and forms the high cliffs of " Hibernia Crescent," just above the Hume Bridge at Yass. At this locality the porphyry is roughly columnar. (Plates IV. and V.), and has dykes of a creamy coloured spherulitic quartz porphyry running through the main mass.

Yass Beds.—A few chains above the Hume Bridge at Yass the No. 2 porphyry belt dips beneath the *Yass Beds*. These consist of numerous layers of shales, sandstones and grits, with a few thin beds of limestone. The beds are very much faulted, good examples being visible near the tramway bridge and in O'Connell Town, near the rifle range. The lowest beds are of shales and mudstones, apparently fossiliferous. On top of the shales are false bedded sandstones, and sandstone containing clay galls, which in parts look like a shale conglomerate with a sandy matrix. Above these are some coarse grits, and ripple marked and sun-cracked sandstones. Part of this sandstone bed is used for building purposes. The sandstones then give place to more shales and mudstones, containing a few *Lingula* and fragments of *Spirifera*. At the top of these beds is a thin layer of calcareous sandstone, with the upper surface studded with what look very much like the carapaces of *Ceratiocaris*. Above this layer is about 20 feet of thin laminated calcareous mudstones and sandstones, containing undeterminable organic markings, sun cracks, and what appear to be crustacean tracks.

Then follows a thin layer of mudstone containing a branching *Favosites*, which seems peculiar to this bed. It averages about half-an-inch in diameter, and I traced one specimen more than a foot in length, giving off several branches. About a foot above this bed are found great numbers of a brachiopod embedded in shale which are probably referable to *Spirifera plicatella*. L. sp. ; also *Loxonema* and *Grammysia*. These are followed by another layer of casts of *Ceratiocaris* (?)

Six inches higher is a thin micaceous sandstone, containing a remarkable deposit of *Leperditia shearsbii*, Chapman, and *Rhombopteria* (*Pterinea*) *laminosa*, de Kon., together with *Loxonema* (?) *strangulata*, and some distorted shells of *Spirifera plicatella* (?) This layer is very easily picked out in the quarry, of which an illustration is given in Plate VI, as the *Leperditia* and *Rhombopteria* are crowded into a thickness of only about an inch at this particular spot, although they occur scattered singly in the beds immediately above

1 Shearsby, A. J.: "On a Bed of Fossiliferous Tuff," etc., *Proc. Linn. Soc. N.S.W.*, 1905, p. 282.

and below. It also makes a very good dividing line between the upper and the lower series of the *Yass Beds*. The former being highly fossiliferous, whilst the latter are for the most part barren.

Immediately above the *Leperditia* zone is about ten feet of barren calcareous sandstone. This is followed by about three feet of compact fossiliferous limestone, containing, amongst others: *Heliolites* and *Spirifera plicatella*. Succeeding this is a thin layer of micaceous sandstone, followed by about three feet of highly fossiliferous calcareous mudstone, which exhibits on the weathered surface *Heliolites interstincta*, *Favosites*, *Cystiphyllum*, *Rhizophyllum interpunctatum*, de Kon., *R. robustum*, Shearsby, *Tryplasma*, *Spirifer plicatellus*, *Orthothetes shearsbii*, Dun, *Camarotoechia*, *Murchisonia*, and *Encrinurus punctatus*, Brunn. This is succeeded by about 150 feet of shales and mudstones, from which I have not yet obtained any fossils ; but the next bed of limestone, only a few feet thick, contains a large number of fossils :—

Carpospongia, *Heliolites interstincta*, *Heliolites*, *Favosites*, *Chætetes*, *Cyathophyllum* (a small species remarkable for its beautiful calicular budding and rootlets), *Zaphrentis*, *Pachypora*, *Rhizophyllum interpunctatum*, Crinoid remains, *Lingula cff. lewisii*. Sow ; *Orthothetes shearsbii*, Dun ; *Meristina australis*(?), Dun; *Atrypa reticularis*(L.), *Orthis* (*Dalmanella*) *elegantula*(?), Dalm.; *Spirifera fimbriata* (?), Conrad; *Limopteria*(?), *Megambonia*, *Grammysia*, *Loxonema*, *Cyclonema*, *Paracyclas*, *Chonetes*, *Rhynchonella*, *Bellerophon*, *Orthoceras*, *Endoceras*, *Montieulipora*, *Encrinurus punctatus*, Brunn. ; also *Girvanella* (?)*pisolitica*, Wethered(?), on a *Limopteria* shell.

This limestone is succeeded by about 150 feet of sandstones and calcareous shales, with a few undeterminable fossils. These beds dip to the S.W. and disappear under No. 3 bed of porphyry. To the south, at the Rifle Range, the *Yass Beds* are very much faulted and folded. In the target pits are to be found *Leperditia shearsbii*, Chapman, and *Lingula*. On the Flagstaff Hill is an outcrop of quartzite, with numerous annelid burrows referable to *Arenicolites* ; while the limestone on the eastern boundary of the paddock contains the same fossils as mentioned in the other limestone beds.

As previously mentioned, the *Yass Beds* cross the railway line near Yass Junction, and continue on from there about 20° W. of N., where, in the Derrengullen Creek at Wargeila, a good outcrop is found. They are best studied in portions 75, 76, 63, 70a, 62 and 53 of the parish of Derrengullen. At this locality the creek has exposed a series of false-bedded sandstones, grits, shales and limestones as at Yass. The fossils are beautifully preserved in the lime stones, and being in many instances silicified weather out perfectly from the limestone matrix. Corals such as *Rhizophyllum* and a very small *Cyathophyllum* are preserved in silica to the minutest detail, the rootlets of both, although very delicate and long, being preserved in a most wonderful manner.[1] The brachiopods are also well preserved ; in fact the beds here do not bear any evidence of

1 Shearsby, A. J.: "Operculate Corals from N.S.W.," *Geol. Mag.*, Vol. III., 1906, p. 551.

rolled beach deposits such as are common in the *Hume Beds*, which are met with lower down the creek near Bowning.

The commonest fossils found at Wargeila are:—Sponge spicules: *Amplexus(?)*, *Cyathophyllum shearsbii*, Eth. fil. M.S.; *Cyathophyllum*, *Diphyphyllum*, sp., *Cystiphyllum*, *Rhizophyllum robustum*, Shearsby; *R. interpunctatum*, de Kon; *Tryplasma derrengullenses*, Eth fil.; *Favosites*, *Pachypora*, *Alveolites*, *Heliolites interstincta*, *Syringopora* (?), *Stromatopora*, *Pisocrinus yassensis*, Eth. fil.; *Fenestella*, *Lingula*, *Orthis*, *Orthothetes shearsbii*, Dun; *Spirifer plicatellus*, *Meristina*(?) *australis*, Dun; (?)*Rhynchotreta*, *Camarotoechia*, *Atrypa reticularis*, *Spirifer* cff. *fimbriatus*, *Rhomboptera*, sp.; (?)*Modiolopsis*, *Loxonema*, *Orthoceras*, (?)*Endoceras*, *Encrinurus punctatus*, Brunnich; *Leperditia shearsbii*, *Girvanella pisolitica*, Wethered(?) is also found encrusting corals and shells. The decomposed limestone yields on being washed sponge spicules and microscopic casts of *Orthis*, *Modiolopsis*, and numerous undeterminable gasteropods.

No. 3 Porphyry.—Returning to Yass River, about a quarter of a mile below the Hume bridge, it will be found that the *Yass beds* dip below a mass of porphyritic rocks, which vary in composition and appearance, but are not fossiliferous like the other beds of porphyry previously noticed. This No. 3 bed of porphyry varies in width and extends in a direction about 20° W. of N., crossing the Yass River about two miles below Yass. Here the course of the river is through about two miles of variously coloured porphyries, which also forms the bed of a considerable portion of the Derrengullen Creek, and is met with at Wargeila, overlying the *Yass beds* there. It does not extend far in a southerly direction, as it pinches out at Yass, in the Rifle Range near the targets, and forms the "wedge-shaped" mass of rock mentioned by Professor David.[1] The lowest bed has the same dip as the underlying fossiliferous strata, and has been looked upon by many as part of an intrusive mass which has forced itself between the bedding planes of the latter, and differing from the main intrusion in being partly composed of absorbed sedimentary rocks with which it came in contact. It is greenish-grey in colour, and a hand specimen would be liable to lead one to look upon it as the result of contact metamorphism. A specimen forwarded to Dr. Woolnough from the back of Cliftonwood House, where good undecomposed blocks are exposed in a road cutting, was determined by him as a "quartz porphyry tuff, certainly clastic, and showing not the slightest signs of absorption phenomena."

This tuff is overlaid by a much coarser-grained rock, varying in colour and texture in different localities. Where it crosses the river it has a decidedly vertical bedding, some of the beds being of a creamy colour, others chocolate and grey. Veins of calcite, from a hair's breadth to an inch or more in thickness, are common, running for considerable distances with the line of strike. Double

1 David, T. W. E.: "Report on the Fossiliferous Beds, Yass," *Ann. Rep. Dept. Mines, N.S.W.*, 1882, p. 148.

pyramids of quartz and large crystals of biotite mica are very noticeable in these porphyries. Of a specimen from half a mile below the railway weir Dr. Woolnough writes :—" A magnificent quartz porphyry ; certainly a massive eruptive rock, and not a tuff."

Of another beautiful sample, from a paddock to the south and next to the Roman Catholic cemetery, he writes :—" Quartz porphyry, with very remarkable red felspars, the colour being due to alteration, probably stilbite ; calcite and epidote are abundant also."

This porphyry, with a greenish-grey base, is highly ornamental, with its red felspars, and when polished makes a most attractive addition to the ornamental building stones of New South Wales.

These massive bedded porphyries are overlaid to the west by more tuffs. About a mile above Hatton's corner, on the left bank of the Yass River, is to be seen a contact between the porphyry and the tuff beds, which at this spot is in the form of a soft blue-grey rock. Fissures in this tuff are filled with another cherty altered tuff, which is found also to exist as an extensive bed in Marchmont Paddock. This tuff in hand specimens has the appearance of a radiolarian rock, the matrix being studded with innumerable light-coloured spherical masses, having a close resemblance to radiolaria. Dr. Woolnough, however, some years ago decided it was an altered tuff with andalusite.

This bed is overlaid by a layer of volcanic breccia, which is well seen also in Marchmont Paddock. The breccia is succeeded by a very hard, fine-grained rock of a blue-black colour, almost like basalt in appearance. This rock, which Dr. Woolnough considers to be a quartz porphyry tuff, is best examined at Booroo Ponds Creek, about half a mile above its junction with the Yass River at Hatton's Corner. It is remarkable for its distinct bedding and the diamond-shaped blocks into which it splits. Occasional hexagonal blocks are also to be seen. (Pl.VI.)

The tuff which has a dip to the S.W. of about 12° also forms a bar across the Yass River and underlies the big limestone cliff three-quarters of a mile above Hatton's Corner. It forms the highest bed of the No. 3 porphyry belt, and is overlaid by the fossiliferous *Hume beds.*

The Hume Beds[1].—These consist of a series of shales, sandstones, grits and limestones, of a thickness estimated to be well over 2,000 feet, and extending from the No. 3 porphyry at Hatton's Corner to the other side of Bowning Hills. Being very much faulted and folded, the thickness of the beds can only be stated approximately, especially as they vary in thickness in different localities not far distant from one another. Mr. John Mitchell's paper on the Bowning Beds, read before the first meeting of this Association, deals with the Bowning section of the Hume Beds, of which a full description would entail a very lengthy paper, so that a very brief notice will necessarily be given here. At Hatton's Corner the

1 Jenkins, C.: "Geology of Yass Plains," *Proc. Linn. Soc. N.S.W.*, Vol. III., 1878.

uppermost bed of quartz porphyry tuff is succeeded by a lenticular mass of impure limestone—the Bowspring Limestone (Plates vi., vii.), from the name of the locality in which it forms the most prominent feature of the landscape. This consists of a bed of coralline limestone, probably tuffaceous in nature, through which the Yass River has cut its way, leaving a cliff on the right bank of the river about 80 feet high. It is composed of alternate layers of limestone fragments, and calcarous shale or tuff, about three inches thick, which, especially at Booroo Ponds Creek, resembles ruins of ancient walls. This bed, probably originally 100 feet thick at Bowspring, thins out to the south-east to a few feet, and I have not succeeded in tracing it with certainty to the north west. The fossiliferous limestone nodules are very much rounded, pointing to a beach origin ; the matrix in places being as though composed of the denudation products of porphyry.

At Booroo Ponds Creek the fossils are very much silicified, and corals, such as *Favosites* and *Heliolites*, are remarkable for the excellence of their preservation in this mineral, even to the minutest detail of their structure. Although the majority of the fossils are rounded fragments, great solid masses of coral are also met with, some of which must weigh at least a ton.

These large coralline blocks are chiefly *Diphyphyllum* and a compound *Cyathophyllum*, with smaller blocks of a new species of *Spongophyllum* with corallites up to two inches in diameter. Being mostly fragmental the fossils are often indeterminable, the following being the chief representatives :—*Favosites*, at least 3 spp. ; *Heliolites*, at least 3 spp. ; *Cyathophyllum shearsbii*, Eth. fil. M.S. ; *Cyathophyllum*, sp. ; *Spongophyllum*, 2 spp. ; *Stromatopora*, sp. ; *Diphyphyllum flexuosum*, Linn. sp. ; *Tryplasma lonsdalei*, Eth. fil. ; *Cystiphyllum ; Cœnites* ; (?) *Murchisonia* ; *Atrypa reticularis* ; crinoid remains ; sponge remains ; *Encrinurus* ; *Orthoceras*.

The Bowspring Limestone is succeeded by the Barrandella Shales[1], which consist of highly fossiliferous shales and mudstones, with very thin bands of limestone. These shales contain an enormous number of fossils, some of which have the appearance of having been derived from coral reefs in the vicinity, being very much rolled and worn before being finally deposited. Extensive deposits of crinoid stems and ossicles are found in this shale, but I have never succeeded in finding remains of any of the calyces, so that so far the genera to which the stems, etc., belong to have not been determined. The Barrandella Shales are also very prominent in Derrengullen and Limestone Creeks, where, especially in the latter locality, much better preserved fossils may be obtained, the shales being softer to work and less friable than at Hatton's Corner.

An incomplete list of fossils to be obtained in the Barrandella shales is as under :—

Bythotrephis tenuis, J. Hall ; *Receptaculites australis*, Salter (?) ; *Ischadites lindstrœmi*, Hinde ; (?) *Carpospongia*, also a small Hexactinellid (?) sponge encrusting corals ; *Palæocyclus* (?),

1 Etheridge, Junr., R. : *Records Austral. Museum*, Vol. V., 1904, p. 289.

Zaphrentis; *Cyathophyllum shearsbii*, Eth. fil. M.S.; *Cyathophyllum* spp.; *Heliophyllum*; *Heliophyllum yassense*, Eth. fil; *Diphyphyllum*, at least 2 spp.; *Omphyma* (?); *Mucophyllum crateroides*, Eth. fil.; *Spongophyllum bepartita*, Eth. fil.; *Phillipsastræa walli*, Eth. fil.; *Cystiphyllum cylindricum*: Lonsd. (?); *Rhizophyllum interpunctatum*, de Kon; *R. australe*, Eth. fil., *R.* sp.; *Tryplasma lonsdalei*, Eth. fil.; *T. lonsdalei*, *var. minor*, Eth. fil.; *T. lonsdalei var. scalariformis*, Eth. fil.; *T. delicatula*, Eth. fil.; *T. congregationis*, Eth. fil.; *T. dendroidea*, Eth. fil.; *T. derrengullensis*, Eth. fil.; *T. liliiformis*, Eth. fil.: *Favosites gothlandica*, Lam.; *F. multitabulata*, Eth. fil.; *Pachypora*; *Alveolites*, both massive and branching; *Cœnites*; *Aulopora Syringopora*, several species; *Monticulipora*; *Heliolites*, 3 or 4 species; *Stromatopora* (?); *Monograptus* (?), *Dendrograptus*. Crinoid remains are very plentiful, but unfortunately they consist chiefly of stems and arms. I have only found three exceptions, viz.:—*Pisocrinus yassensis*, Eth. fils.; *P. yassensis var. lobata*, Eth. fil., which are rare at Hatton's corner, but very plentiful at Limestone Creek. The third, *Euspirocrinus* (?), a badly preserved specimen, now in the National Museum, Melbourne, consists of crown and stem, but structures enabling identification, such as the plates, are badly preserved, or altogether missing. It has, I am certain, no connection with the majority of the crinoidal remains to be found in this bed. Casts resembling plates of Cystideans are also present. *Spirorbis*; *Eunicites mitchelli*, Eth. fil.; *Arabellites bowningensis*, Eth. fil.; *Stromatopora*, sp.; *Fenestella*, several species; *Pinnatopora*; *Diamesopora* (?); *Ramipora*; *Lingula*, spp.; *Orbiculoidea*, *Orthothetes*, *Chonetes*, *Orthis*, *Clorinda lingnifer*, var. *Wilkinsoni*, Eth. fil.; *Pentamerus australis*, McCoy; *P. hospes*, Barrande; *P. pumilis*, de Kon; *Camarotœchia* (?); *Dayia* (?); *Atrypa reticularis*, Linn. sp.; *Atrypa*; *Spirifera plicatella*, Linn. sp.; (?) *Meristella*; *Spirifera* (?) *fimbriata*; *Orthonota*; *Grammysia*; *Leptodomus* (?); *Palaconeilo victoriæ*, Chapman; *Pterinea*; *Rhombopteria*; *Leptodomus*; *Chelodes calceoloides*, Eth. fil.; *Pleurotomaria*; *Murchisonia*; *Bellerophon*; *Euomphalus*; *Cyclonema*; *Loxonema* (?) *compressa*, Munster; *Loxonema*; *Platyceras*, sp.; *Tentaculites*; *Hyolithes*; (?) *Endoceras*; *Orthoceras*, numerous species; *Protobactrites*; *Spyroceras*; (?) *Ophidioceras*; *Lituites*; *Actinoceras*; *Encrinurus Barrandei*. de Kon; *E. punctatus*, Brunn; *Cromus murchisoni*, de Kon; *Calymmene*, *Chierurus*, *Sphærexochus*, *Bronteus*, *Phacops crosslei*, E. & M.; *Phacops*, *Leperditia*, *Turrilepas* (?) *Mitchelli*, (?) *Ceratiocaris*.

The Barrandella Shales are capped at Hatton's Corner by a bed of limestone about twenty feet thick. It is highly fossiliferous, corals being predominant. The principal are:—*Zaphrentis*, *Cyathophyllum shearsbii*, Eth. fil. M.S.; *Heliophyllum*, *Diphyphyllum*, *Mucophyllum crateroides*, Eth. fil.; *Spongophyllum bipartita*, Eth. fil.; *Phillipsastrea walli*; *Rhizophyllum spp.*; *Tryplasma spp.*; *Favosites*, spp.; *Heliolites*, *Alveolites*, *Cœnites*, *Syringopora*, *Stromatopora*, *Chonetes*, *Atrypa reticularis*, *Spirifer*, *Pleurotomaria*, *Loxo-*

nema, *Orthoceras*, *Encrinurus punctatus*, *Phacops*, *Odontopleura Bowningensis*, *Ceratocephala Vogdesi*.

Immediately above the limestone is a thin bed of shale containing chiefly :— *Cyathophyllum shearsbii*, *Heliophyllum yassense*, Eth. fil. ; *H.*, *sp.* ; *Carpospongia* (very numerous) ; *Aulopora*, *Phillipsastræa*, and a few trilobites.

The shale bed overlying contains a large number of trilobites, including the following :—*Dalmanites meridianus*, E. and M. ; *Phacops sp.* ; *Proetus*, *Odontopleura*, *Ceratocephala longispina*, Mitchell *sp.*

Corals are very rare, besides being small and badly preserved. The commonest is either a *Zaphrentis* or a *Palæocyathus*. A few *Lingula* and *Orthis* are present, also a fair number of a small *Chonetes*. At Rainbow Hill, about half a mile S.W. from Hatton's corner the shale at the top of the scrap is remarkable for the enormous number of remains of *Dalmanites meridianus*. They are chiefly of a fragmentary nature, but many good complete examples will also be obtained at this locality. The compound eyes are beautifully preserved, showing all the details of the facets.

These shales form the *Phacops Bed* of Jenkins, and are followed by a thick bed of barren shales, very much folded and faulted, which are in turn overlaid by Mitchell's *Upper Trilobite Bed*. This bed contains numerous trilobites, including :—*Dalmanites meridianus*, E. & M. ; *Phacops crosslei*, E. & M. ; *P. serratus*, Foerste ; *Odontopleura Bowningensis*, E. & M. ; *O. Jenkinsi*, E. & M. ; *Ceratocephala longispina*, Mitchell sp.

In the impure limestone bed, which outcrops near the junction of Euralie Creek with the Yass River, the following fossils are obtained :—*Cyathophyllum shearsbii*, Eth. M.S. ; *Cyathophyllum* ; *Spongophyllum* (?) *giganteum*, Eth. fil. ; *Cœnites expansus*, de Kon ; *Alveolites* ; *Syringopora* ; *Tryplasma lonsdalei*, Eth. fil. ; *T. lonsdalei*, vars *minor* and *Scalariformis*, Eth. fils.; *T. dendroidea*, Eth. fils. ; *Diphyphyllum sp.* ; *Cystiphyllum*, *Favosites*, *Trachypora*. *Heliolites*, *Stromatopora*, Crinoid remains ; *Spirifera cff. fimbriata*, Conrad ; *S.*, *sp.* ; *Clorinda*, *Loxonema*, *Orthoceras*, *Euomphalus*, *Bellerophon*, *Encrinurus*, and sponge remains, probably *Carpospongia*.

Near Bowning, where the uppermost of these beds are best studied, numerous layers of conglomerate are to be found interspersed with the shales, ranging from a few inches in thickness at the beginning, and increasing to many feet in thickness towards the close of the series, culminating in a very thick bed, known as the Bowning conglomerate, which forms the base of Bowning Hill (2,605 feet). On the Black Range road, about seven miles from Yass, on por. 130, Parish of Yass, the lowest bed of this conglomerate consists of porphyrite and quartzite boulders, mixed with fossiliferous limestone pebbles, containing *Favosites*, *Syringopora*, *Trachypora*, and some brachiopods. These limestone nodules disappear higher up, where the chief constituents of the conglomerate are porphyry pebbles. In portion 2, Parish of Yass, this conglomerate merges into solid quartz porphyry, with light-coloured felspars and quartz, in a bluish base. Transition phases between the conglomerate and porphyry are very common; the alteration from one to the other being clearly noticeable.

Mitchell also drew attention to this metamorphism of the Bowning conglomerates,[1] remarking: "In some parts it has a very homogeneous aspect, and can with difficulty be separated from the metamorphic and porphyritic rocks of the locality." The conglomerate and porphyritic rocks have the same dip as the underlying shales, and form the highest beds of the silurian system of the Yass district.

As one approaches the summit of Bowning Hills, the quartz porphyry changes suddenly into a spherulitic felspar porphyry of a brownish grey colour, very close grained and hard. Weathered portions show a very decided flow structure, which in some specimens are more marked on account of pieces of felsitic material altering the almost parallel lines of flow. Near the summit of the main Bowning Hill, this felspar porphyry shows signs of bedding, and is roughly columnar. It is certainly not intrusive, everything pointing to its being a volcanic flow or series of flows. Its appearance is very similar to some of the volcanic flows investigated by Mr. L. F. Harper, F.G.S,[2] at the Murrumbidgee, and may possibly be an outlier of one of the Rhyolitic flows so common in his section, and which he looks upon as of Devonian age.

Outside of the Devonian area of Yass I have never met with a felspar porphyry of this nature, all the porphyries so mixed up with the silurian sediments being either fine or coarse quartz porphyries, totally different to the Bowning Hill lava. It is purely local, forming as it does the cap of the Bowning Hills, and covering an area about two miles long by half a mile in width. If it is Devonian in age, its solitary occurrence, so far from the main mass of the Devonian lavas, will need explanation.

The Devonian sedimentaries of Yass, which are very extensive, are separated from the Silurian by a thick bed of lavas and tuffs,[3] and, having quite recently been described by Mr. Harper, need not be dealt with in this paper.

In the foregoing summary of the Yass beds, I have referred to the belts of porphyritic rocks, as Nos. 1, 2, and 3, in order to keep them distinct for the present from the *Yass Porphyries* of Harper, which he states to be post-Devonian.[4] The mode of occurrence of the No. 3 porphyry, between the *Yass* and the *Hume Beds* is against the theory of its being post-Devonian, as everything points to its contemporaneity with the Silurian sediments, being more in the nature of a volcanic flow, a view strongly supported by its bedded nature, and associated asit is with the various beds of tuffs and

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1 Mitchell, J.: "Geological Sequence of the Bowning Beds," *Aust. Assoc. Adv. Sci.*, Vol. I., 1887 p. 294.

2 Harper, L. F.: "Geology of he Murrumbidgee District, near Yass," *Rec. Geo. Sur. N.S.W.*, Vol. IX., Pt. I.

3 Shearsby, A. J.: *Loc. cit.* Harper. *Loc. cit.*

Harper, L. F.: *Loc. cit.*,

breccia, which are found both above and below it. When I first had my attention drawn to this No. 3 porphyry, I looked upon it as decidedly intrusive, the beds above and below looking like altered sedimentaries, between which the igneous rocks had been forced, similar to the case mentioned by Mr. P. T. Hammond at Melrose.[1] Later investigations, however, have made me decide otherwise, and I have been further strengthened in my opinion by the help given me by Dr. Woolnough's examination of the rocks in the vicinity.

That Nos. 1 and 2 porphyry are due to a similar origin is also probable, as tuffs and fossiliferous beds are found associated with them. Some parts certainly have the appearance of intrusions, and may be the result of the action of the post-Devonian porphyries, which Harper points out have caused such havoc amongst the silurian sediments at Boambolo.

The quartz porphyry between the conglomerate and the felspar porphyry of Bowning Hills might be termed for the present No. 4 porphyry. It forms the country to the south and south-west of Bowning Hill, and the lower parts of Derrengullen and Bowning Creeks run through it. It crosses the Yass River, and continues on to the Murrumbidgee, through the Parishes of Warroo and Boambolo, thus joining up with the *Yass porphyries* of Harper. This No. 4 porphyry is therefore directly in touch with it, and I look upon it as part and parcel of Harper's post-Devonian intrusion.

Another reason why I consider some of the porphyries are much earlier than the Devonian, is that the Bowning conglomerates are mainly composed of porphyry, alike in every respect to that obtained in Nos. 1, 2, and 3 belts. Not only is the uppermost bed of porphyritic origin, but the lowest, which are only thin beds, contain the rounded porphyry pebbles. The interbedded shales, being of decided Silurian age, show that the conglomerates were laid down during Silurian times, and from their composition prove the existence at that time of beds of porphyry.

Other references to the Yass Porphyries and Granites :—

Clarke, Rev. W. B. : "Parliamentary Blue Book," 1853, p. 84 ; "Southern Goldfields of N.S.W.," 1860, pp. 103, 104, 105, 236.
Wilkinson, C. S. : *Ann. Rep. Dept. Mines and Ag., N.S.W.*, 1876, p. 149, 155.
Leigh, W. S., and Etheridge, R., Junr. : *Ann. Rep. Dept. Mines and Agr. N.S.W.*, 1893, p. 134.
Carne, J. E. : *Ann. Rep. Dept. Mines and Ag. N.S.W.*, 1894.
Watt, A. J. : *Ann. Rep. Dept. Mines and Ag. N.S.W.*, 1897, p. 186, 188.
Baker, R. T. : "Building and Ornamental Stones of N.S.W.," 1909, p. 26, 70, 72, 74, 75

EXPLANATION OF MAP AND PLATES.

PLATES III.—VII.—PHOTOGRAPHS OF SILURIAN FORMATIONS AND PORPHYRY OUTCROPS YASS DISTRICT.

PLATE VIII.—GEOLOGICAL SKETCH MAP OF THE YASS DISTRICT.

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[1] Hammond, P. T. : "Note on Intrusive Porphyry at Melrose," *Rec. Geo. Surv. N.S.W.*, Vol. III., p. 33.

4.—NOTE ON THE GEOLOGY OF JENOLAN.

By C. A. SUSSMILCH, F.G.S.

ABSTRACT.

THE area referred to is a tableland (part of the Central Tableland of New South Wales), the surface of which has an elevation of about 3,800 feet, and is a peneplain cut out of lower Palæozoic rocks. Residuals of an older peneplain rise above this level and culminate in Mt. Bindo, which has an elevation of 4,460 feet. This tableland, in common with all the tablelands of New South Wales, was probably elevated to its present altitude at the close of the Pliocene Period; since then it has been considerably dissected by the development of numerous valleys and gorges during the present cycle of erosion, which are still in the youthful stage of their development.

The oldest rocks in the region are of Silurian age, and consist of limestones, slates, radiolarian cherts and claystones, and rhyolite lavas and tuffs, all of which are strongly folded and tilted. One limestone bed has a thickness of upwards of 400 feet, and in this occurs the Jenolan Caves. The limestone is composed of the remains of various marine organisms, including Corals, Crinoids, Brachiopods and Mollusca. The rhyolite flow has a thickness of about 300 feet and evidences the occurrence of extensive submarine volcanic eruptions during the Silurian Period. The occurrence of fossiliferous Devonian quartzites and claystones was also referred to. It was then shown that the Silurian and Devonian strata has been subjected to extensive orogenic earth-movements at the close of the latter perod and strongly folded; this was accompanied by large intrusions of granite and quartz-porphyry. With regard to these intrusions, the author expressed the opinion that the field evidence favoured Daly's theory of "Overland Stopeing."

The denudation of this region and the production of an extensive peneplain during the Carboniferous and Lower Permo-Carboniferous Period was then dealt with, followed by a description of the subsequent deposition of the Upper Permo-Carboniferous and Triassic strata. The paper concluded with a reference to the outpouring of basaltic lavas during the Tertiary Period. The paper was illustrated with a number of specimens and diagrams.

5.—NOTE ON THE LIMITATIONS OF DE CHAULNES METHOD OF DETERMINING REFRACTIVE INDEX.

By LEO. A. COTTON, B.A., B.Sc., Linnean Macleay Fellow in Geology.

THIS note was prepared about three years ago at the suggestion of Dr. W. G. Woolnough, whom I wish to thank here for his encouragement in its preparation.

De Chaulnes' Method for Determining Refractive Index.

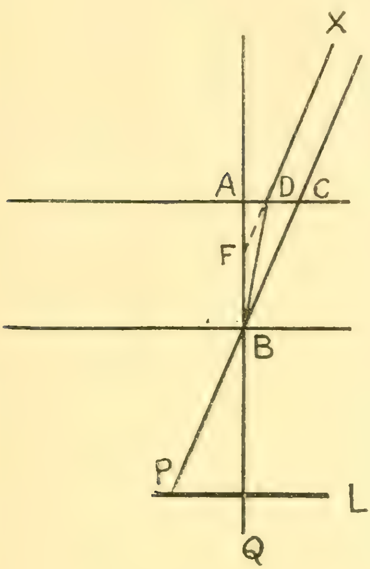


Fig. 2.

If light be converged by a lens L and passed through a glass slip or mineral section with parallel faces, each ray is refracted. Suppose the converged light after passing through the slip AB to be received into a microscope which has QB the normal to the plane faces of the slip as its line of collimation.

Let PBQ be the angle that the converged light makes with the normal to the plane faces of the slip.

On entering the slip the ray will be deflected along some direction BD such that sin. PBQ : sin. ABD $=\mu$: I where μ is the refractive index of the substance of which the slip is made.

On emerging from the slip the light is again refracted and passes along a path DX which is parallel to its former direction PB.

If an object lies at B, then the introduction of the slip causes it to appear at F.

If the microscope was focussed on the object at B before the introduction of the slip, then in order that the object may be in focus after the introduction of the slip it will be found necessary to raise the objective through a distance FB.

The refractive index of the slip can be expressed in terms of the distance BF and the thickness of the mineral section as follows:—
Let BF$=d$ and AB$=t$.

Then the refractive index is given by the relation

$$\mu=\frac{\text{sin. PBQ}}{\text{sin. ABD}}=\frac{\text{tan. PBQ}}{\text{tan. ABD}}$$ since the angles PBQ and ABD are small.

$$\text{Hence } \mu=\frac{\text{AD/AF}}{\text{AD/AB}}=\text{AB/AF}=t/(t-d) \quad . \quad . \quad . \quad . \quad (1)$$

To investigate the limits of error the following procedure is adopted.

Let μ denote the refractive index

Then $\mu=t/(t-d)$

To obtain the error in μ due to errors in t and d equation (I) is differentiated as follows:—

$$\partial\mu=\frac{\partial}{\partial t}\left(\frac{t}{t-d}\right)\partial t + \frac{\partial}{\partial d}\left(\frac{t}{t-d}\right)\partial d$$

$$=\frac{-d}{(t-d)^2}\partial t + \frac{t}{(t-d)^2}\partial d \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The values of ∂t and ∂d are, from the nature of the measurements, equally likely to be positive or negative, and hence the negative sign attaching to the coefficient of ∂t has no practical significance.

From (I) $t-d=t/\mu$
and $d=(\mu-1)/\mu$.

Hence by eliminating d from (1) and (2)

$$\partial\mu = -\frac{\mu(\mu-1)}{t}.\partial t + \frac{\mu^2}{t}\partial d \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

As the real test of accuracy is the ratio of the error to the amount measured, it is better to write equation (3) in the form

$$\partial\mu/\mu = -\frac{\mu-1}{\mu}.\partial t + \frac{\mu}{t}\partial d \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)\text{A}$$

From this equation the following facts are clear:—

(1) For a given thickness of material more accurate results are obtained with minerals of low refractive index than with those of high refractive index.

(2) In determining the refractive index of any mineral more accurate results are obtained from thick than from thin sections.

Since the great majority of minerals have refractive indices between 1·4 and 2 it will be sufficiently practical to consider the variations between these limits.

The values of ∂d are of a definite order of magnitude, which, according to my own observations, approximates to .01 m.m.

Mr. Sorby,[1] who has made a series of experiments with this method, states that "an accuracy of .001 inches can easily be obtained."

The value of t may be ascertained to any required degree of accuracy, but in practice it is usually determined by the same method which is used in obtaining the value of d. Thus, the value of $\partial t=\partial d=.01$ m.m.

If the thickness of the plate used be such that the co-efficient of ∂d in (3) A be not greater than unity, then μ can be calculated with considerable accuracy,

The maximum errors which can occur in determining refractive indices of the values 1·4 and 2 are shown to be respectively as follow:

1 H. C. Sorby: "On a Simple Method of Determining the Index of Refraction of Small Portions of Transparent Substances," *Min. Mag.*, 1877, Vol. I., pp. 97 98.

Suppose $\mu/t=1$ and $\partial t=\partial d=.01$ m.m.
and also $\mu=1.4$;

Then substituting in equation (3) A gives

$$\partial\mu/\mu = -\frac{\cdot 4}{1\cdot 4}\times\cdot 01+\cdot 01$$
$$= -\cdot 0029+\cdot 01.$$

Since ∂t and ∂d may each be either positive or negative this gives a maximum value of $\partial\mu/\mu=\cdot 0129$, which is an error of 1.29 per cent.

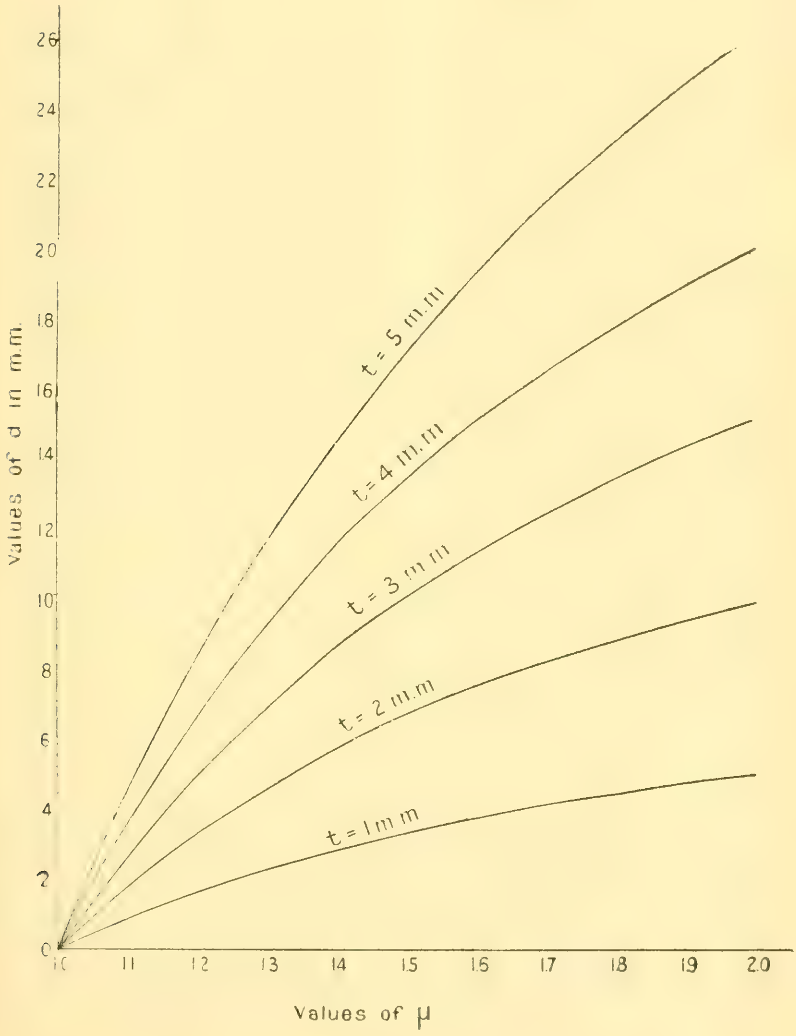


FIG. 3.

Thus a number of observations should give the value of U correct to much less than one per cent.

Again, suppose $\mu/t=1$, $\delta t=\delta d=\cdot01$ and $\mu=2$;
the substitution in equation 3 A gives

$$\delta\mu/\mu=-\tfrac{1}{2}\times\cdot01+\cdot01;$$
$$i.e.,\ \delta\mu/\mu=-\cdot005+\cdot01,$$

and this gives a maximum value of .015 if δt and δd are of opposite sign. This is an error of 1·5 per cent., and a number of observations would reduce the probable error to much less than one per cent. As δt and δd are measured in millimetres this indicates that

(1) For minerals with relatively low refractive indices a thickness of material not much less than 1·4 m.m. should be used to give values correct to one per cent;

(2) For minerals with relatively high refractive indices a thickness of material not much less than 2. m.m. should be used to achieve a similar result.

Mr. Sorby[1] states that if the thickness be from $\frac{1}{8}$th to $\frac{1}{4}$ inches "the errors ought to be limited to the third place of decimals."

Most that is contained in the foregoing may be represented graphically as follows:—

If the curves $\mu=t/(t-d)$ be plotted for different values of t, making μ and d the variables, a series of rectangular hyperbolas is obtained, all passing through the point 0.1 and all being asymptotic to the line $d=t$ for the particular value of t belonging to it.

The curves for $t=1$, 2, 3, 4 and 5 m.m. are represented in the accompanying diagram. From these it is apparent that as μ increases the curves become flatter, bending over to become asymptotic to the lines $d=t$. Hence on any curve a small change δd makes a greater change in the value of μ when μ is large than when μ is smaller. If the ratio $\delta\mu/\mu$ be tested it will be found to increase continuously with μ, and this corresponds to statement (1) on page 121.

Again, as t increases the curves rise more steeply, which means that for any given value of μ the change $\delta\mu$, and hence the ratio $\delta\mu/\mu$, is smaller for thick than for thinner plates of material, and this corresponds with statement (2) on page 122.

6.—NOTES ON THE BRISBANE SCHISTS.

By R. A. WEARNE, B.A.

Previous work on the subject.—A paper was read by Dr. H. I. Jensen at the Brisbane (1909) meeting of the Association upon "The Metamorphic Rocks of S.E. Queensland." He thus refers to the Brisbane Schists :—

> "The Brisbane Schists, also provisionally marked Gympie by our Geological Department, are so crushed, folded, foliated and faulted, that they must be assigned to the Middle Zone, and consequently they are likely to be older than the true Gympie. What age we cannot say, but possibly Pre-Devonian."

1 *Loc. cit.*

Every geologist who has visited Brisbane has commented on the highly distorted schists that form the main geological feature of the environment of that city.

Hitherto these schists have been officially classed as Permo-carboniferous, and said to belong to the Gympie series.

My object in writing this short note is to give, at least, food for discussion which may bring forth evidence in support of the theory that the Brisbane schists belong to a much older period than Permo-carboniferous. I have carefully examined these rocks on the western flanks of the southern portion of the D'Aguilar Range and along their junction with the Ipswich Coal Measures between Brisbane and Fernvale, a small township on the Brisbane Valley railway line, 16 miles from Ipswich.

There is no positive evidence to determine their age, but from the following data I am of opinion that some at least of these schists are possibly Pre-Cambrian :—

1.—In lithological character they resemble some of the Pre-cambrian rocks of South Australia. The whole series has been completely metamorphosed and some intrusive igneous rocks have been rendered completely schistose in character.

The chief rock types met with are mich-schist, quartz-schist, quartzite, dolomite, serpentine, amphibolite, etc.

2.—A marked uniformity exists between the Brisbane schists and the Ipswich Trias-Jura coal measures.

At Fernvale, a fine section has been revealed by a creek about 1 mile from the railway station. Here the schists dip at an angle of 80°, while the coal measures are practically horizontal.

3.—*Absence of Fossils.*—The true Gympie beds contain a plentiful supply of marine Permo-carboniferous fossils, whereas the Brisbane schists have been found to be entirely barren despite the fact that numerous deep railway cuttings have been made through them.

While investigating the alkaline eruptives near Mt. Barney, a few miles to the north of Mt. Lindsay on the New South Wales border, I came across a sandstone ridge in which I found a well defined fossil of *Fenestella.* It was referred to Mr. W. S. Dun for determination, and he states the area undoubtedly belongs to the Permo-carboniferous. Now, if the rocks belonging to this period are quite undisturbed and retain their fossil imprints so clearly despite the volcanic agencies that have played such an important part in forming the topography of this district, it is only reasonable to suppose that the Brisbane schists if of Permo-carboniferous age would, at least, retain their finger prints in areas free from volcanic or plutonic intrusions.

I admit the evidence deduced is negative and far from conclusive, but I trust the subject will receive more detailed attention in the near future.

7.—A BIBLIOGRAPHY OF THE MINERALS OF AUSTRALIA.

By. C. ANDERSON, D.Sc.

(WITHDRAWN)

8.—NOTES ON THE FAUNA OF THE GYMPIE BEDS OF QUEENSLAND.

By W. S. DUN.

(To be Published in "Records Geol. Survey, N.S. Wales.")

9.—THE ALKALINE ERUPTIVE ROCKS OF WEST MORETON, QUEENSLAND.

By R. A. WEARNE, B.A., and W. G. WOOLNOUGH, D.Sc., F.G.S.

(Published in Journ. R. Soc. N.S. Wales for 1911)

10.—ON THE OCCURRENCE OF NEPHELINE IN PHONOLITE DYKES AT OMEO.

By PROFESSOR ERNEST W. SKEATS, D.Sc., A.R.C.S., F.G.S.

[Plate IX.]

Introduction.—On two or three occasions in the petrographic literature of Victoria the occurrence of one or other of the felspathoids has been recorded. In Ulrich's catalogue of the specimens of rocks of Victoria in the Industrial and Technological Museum, Melbourne, 1875, Nepheline is recorded from the older basalt of Philip Island. In the second edition of the same book by J. Cosmo Newbery, 1894, the same rock is described in identical terms, with the exception that apatite replaces olivine in the description. There can be no doubt that the amended identification is correct. In Professor Gregory's paper on the Geology of Mt. Macedon[1] he records the presence of nosean in the alkali rocks of this area. Mr. Summers and myself, working in the same area, at first accepted this view, and in a presidential address to Section C at the Brisbane meeting of the Australasian Association for the Advancement of Science, in 1909, where I summarised the evidence we had obtained, I recorded the presence of nosean in several of the rocks, and, in addition, referred a peculiar minute prismatic mineral with internal fibrous structure to the species melilite. Further work, however, on these rocks has caused us to doubt the presence of nosean, and help from Dr. Flett has enabled us to convince ourselves that the so-called melilite is in reality a peculiar fibrous form of apatite. I am glad to have an opportunity of making this correction. Lastly, Mr. Mahony, working on the ejected blocks from L. Bullenmerri, at first was inclined, I believe, to refer a colourless mineral to Hauyn, but on further examination has referred it to analcite, and as such he describes it in the published report.[2]

It will be seen that all the references to the occurrences of felspathoids in Victoria hitherto made appear to be incorrect. A few months ago, however, I was examining some rocks from the collection left by Dr. Howitt to the Geological Department of the University of Melbourne. Among them was a collection of dyke rocks from the Omeo district in

1 *Proc. R. Soc., Vict.*, 1901, p. 185.
2 Memoirs *Geol. Surv. Vict.*, No. 9, 1910.

Gippsland. This collection and a sketch geological map of the area were made by the late Mr. James Stirling in 1884, and sent to Dr. Howitt for examination. Beyond having some rock sections made, Dr. Howitt does not appear to have done any further work with these rocks. This communication deals with a few of these dykes.

It is to be noted that the nearest nepheline bearing dykes to those about to be described occur at Kosciusko, in New South Wales. They were described by Professor David, Dr. Woolnough and Mr. Guthrie in the Proceedings of the Royal Society of New South Wales, 1901, p. 347. They are described as tinguaites, and besides being more basic than the Omeo rocks present other points of difference.

Physical Geography.—The area lies north and south of the Omeo township, in Eastern Gippsland. Between Wilson's and Day's Creeks, two confluents of the Livingstone Creek, there rises a somewhat abrupt hill to the height of about 500 feet above the levels of the streams. This is locally known as Day's Hill or Frenchman's Hill. The township is built on undulating ground, which continues to the south, and it is in this area that the numerous dykes of the district chiefly occur. (See map, Plate IX.)

Geology of the Area.—Howitt has given a description of the district.[1] A brief summary of the geological relations was given by myself in a presidential address to Section C at the Brisbane meeting of the Australasian Association for the Advancement of Science in 1909.

The oldest rocks lie to the east of the area under consideration, and consist of crystalline schists and gneisses of unknown age. They are probably pre-Ordovician and possibly pre-Cambrian. Intrusive into these are acid granites and aplites and also quartz diorites. Surrounding these plutonic masses are dykes of varying character, ranging from older to younger, as follows :—

1. Orthoclase, muscovite quartz.
2. Orthoclase, quartz.
3. Quartz, orthoclase, schorl.
4. Quartz with a little mica.
5. Quartz.

In Howitt's map he shows a north and south fault bringing the plutonic rocks abruptly against the older schists.

Younger than these plutonic rocks with their associated dykes are the intrusive rocks of Frenchman's Hill, described by Howitt as orthophyres consisting mainly of orthoclase with a little soda-augite. I have shown (*op. cit.*) that the felspar is principally anorthoclase, that most of the rocks are better described as anorthoclase trachytes and solvsbergites, and that in the central part of the hill, where the rocks approach a plutonic habit, a little interstitial quartz occurs. Radiating from Frenchman's Hill are a series of trachytic dykes, some of which are shown on Howitt's map, and

[1] Howitt, A. W.: "On Certain Plutonic and Metamorphic Rocks at Omeo," *Rep. Min. Dep. Vict.*, March, 1890, p.p. 32-40. Plates and Maps.

in more detail on Stirling's manuscript map, which he sent to Howitt with the collection of dyke stones. Among these dykes are some which contain a little quartz, sometimes granular, sometimes in graphic intergrowth with felspar. One of the dykes in section is mineralogically and chemically in agreement with the typical bostonites. Analyses of these rocks are given in Howitt's paper, and some of them I have quoted in the address referred to above.

Further to the south in the township of Omeo and to the south of it are a number of dykes, most of which strike almost east and west. Their positions are shown on Stirling's map, and some of them are indicated on the map accompanying this paper. They include, relatively, acid and basic types, to which Stirling has given the field names of felspathic dykes and diabases respectively. It is interesting to note that Stirling describes lenses and veins of quartz as being in places directly associated with and forming part of the felspathic dykes. The youngest dykes in the district, according to Stirling, are two (No. 3 and 3*a* and No. 43 on Stirling's list), which, striking north and south, cut, in the one case a diabase, in the other a felspathic dyke.

It is with these two north and south dykes that this paper is principally concerned. On examining sections of these two rocks a few months ago I was interested to find that nepheline is present in each in considerable amount and that the rocks have the habit and texture of phonolites, although occurring as dykes.

Petrographic description of the Phonolite Dykes.—No. 43. Phonolite dyke, south of Omeo. (See map, Plate IX.).

Megascopic.—The rock is fine-grained and grey in colour, with dark crystals. The grey areas consist of nepheline and felspar and show minute areas with bright lustre. The dark areas consist of irregular crystals and patches of Aegirine. The specific gravity of the rock is 2.59.

Microscopic.—The rock is seen to consist of three minerals, which are identified as nepheline, aegirine and soda-orthoclase. The minerals crystallised in that order since the felspar is moulded on the two other minerals, while the aegirine, idiomorphic to the felspar is in places moulded on the nepheline. A determination of the quantitative gravimetric proportions of the constituent minerals by Rosiwal's method[1] gave the following percentages by weight :—

Soda Orthoclase	=46.4
Nepheline	=28.5
Aegirine	=25.1
Total	=100.0

The texture of the rock is nephelinitoid and trachytic. The nepheline occurs mainly as fairly equi-dimensional rectangular phenocysts with some hexagonal sections. The ægirine is partly elongated and lath shaped, but partly as irregular masses. Its

1 Rosiwal: *Verhandl. d. K.K. Geol. Reichanstalt* .1898, p.p. 143, *et seq.*

FIG. 1.—TERTIARY (MIOCENE ?) LEAF BEDS, DALTON.

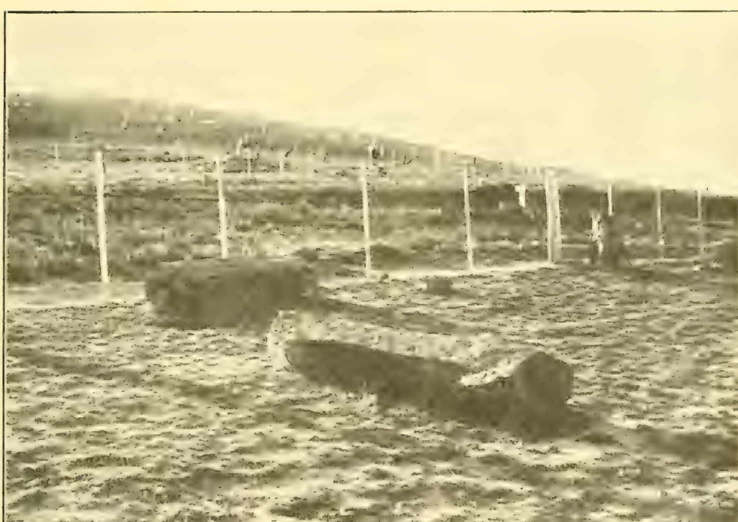


FIG. 2.—COLUMNS OF NO. 1 PORPHYRY, NEAR COOLALIE.

Fig. 3.—Marble Quarry, Bango Beds, Coolalie.

Fig. 4—Hibernia Crescent, showing columnal nature of No. 2 Porphyry.

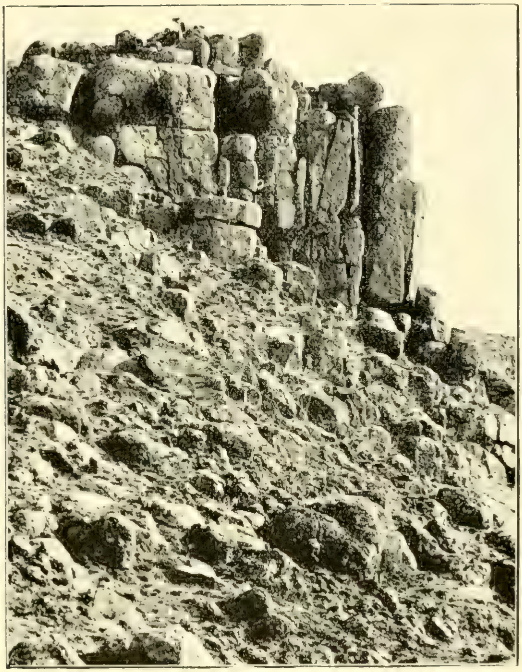


FIG. 5.—NO. 2 PORPHYRY, HIBERNIA CRESCENT.

FIG. 6.—OSTRACODA ZONE (WHITE LINE) IN YASS BEDS, NEAR CLIFTONWOOD.

FIG. 7.—No. 3 PORPHYRY, BOOROO PONDS CREEK, HATTON'S CORNER, VOLCANIC TUFT "*a*", BOWSPRING BEDS "*b*."

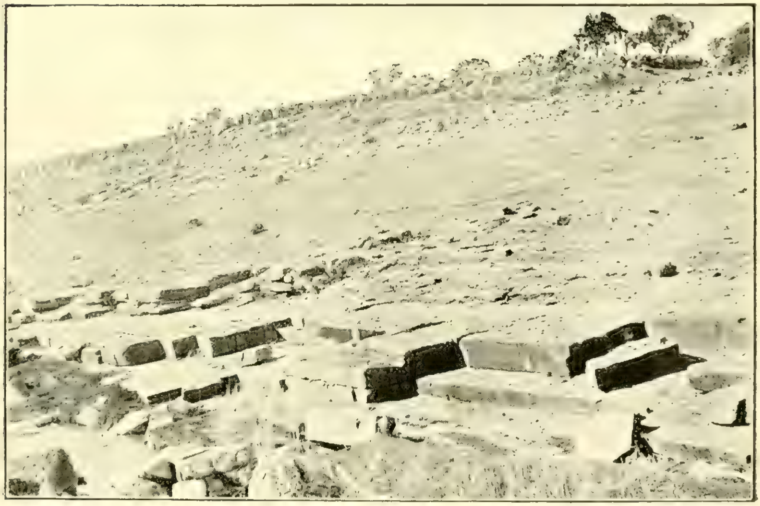
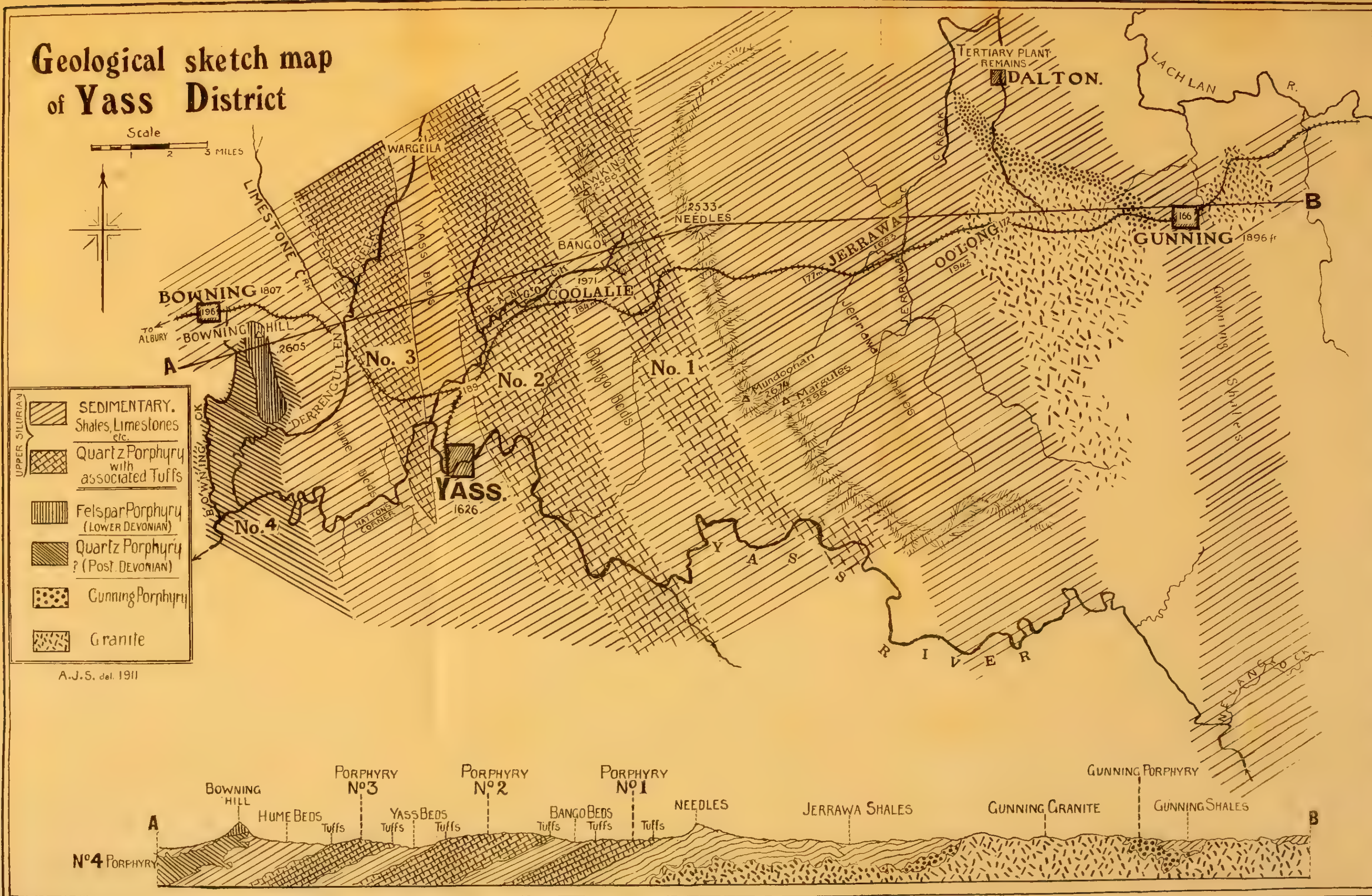


FIG. 8.—PORPHYRY TUFF BED (No. 3. PORPHYRY), BOWSPRING BEDS, NEAR HATTON'S CORNER.

Plate 7.

FIG. 9.—BOWSPRING BEDS UNDERLYING BARRANDELTA SHALES EXPOSED AT HATTON'S CORNER.


Geological sketch map
of Yass District
Scale
1
2
3 MILES
SEDIMENTARY.
Shales, Limestones etc.
Quartz Porphyry with associated Tuffs
UPPER SILURIAN
Felspar Porphyry
(LOWER DEVONIAN)
Quartz Porphyry
? (Post. DEVONIAN)
Gunning Porphyry
Granite
A.J.S. del. 1911
BOWNING 1807
BOWNING HILL
2605
TO ALBURY
WARGEILA
LIMESTONE CK
YASS BEDS
HAWKINS
2580
2533
NEEDLES
BANGO
1971
COOLALIE
JERRAWA
OOLONG
TERTIARY PLANT REMAINS
DALTON.
LACHLAN R.
GUNNING 1896 ft
No. 1
No. 2
No. 3
No. 4
YASS.
1626
Bango Beds
Hume Beds
HATTONS CORNER
DERRENGULLEN
BOWNING CK
Mundoonan 2674
Margules 2596
Jerrawa Shales
Gunning Shales
YASS RIVER
A
B
BOWNING HILL
HUME BEDS
PORPHYRY No3
YASS BEDS
PORPHYRY No2
BANGO BEDS
PORPHYRY No1
NEEDLES
JERRAWA SHALES
GUNNING GRANITE
GUNNING PORPHYRY
GUNNING SHALES
Tuffs
No4 PORPHYRY

extinction angle ranges from 0° to 7°, and the mineral is markedly pleochroic. The felspar forms the background to the rock and occurs as lath shaped crystals, rather cloudy from alteration and showing a defined fluidal texture. The extinction is practically straight.

Nepheline.—It is rather surprising to note that the crystals of nepheline, except at their margins, are generally clear and unaltered, while the felspar of the ground mass is cloudy. The recognition of the mineral was based on the following considerations :—

Form.—Sections are mostly rectangular, but some are hexagonal in outline.

Extinction and Polarization colours.—The rectangular sections give uniformly straight extinctions and polarization colours, not rising above white of the first order. Hexagonal sections are isotropic.

Figure.—Hexagonal sections give a uniaxial negative figure determined by the selenite plate in convergent polarized light. Rectangular sections give partial uniaxial figures.

Alteration.—The phenocrysts are surrounded by a narrow margin of a colourless material which is isotropic, apparently secondary in origin, and which may be analcite. In places it extends towards the centre of the crystal and then shows a fibrous habit.

Refractive Index.—The refractive index of the nepheline is about the same as that of the Canada balsam, considerably higher than that of the altered rim, and slightly higher than that of the lath shaped felspars of the ground-mass.

Micro-chemical tests.—When attacked with hydrochloric acid of 20 per cent. strength for five minutes most of the nepheline crystals are gelatinised and stain with malachite green. In some crystals the attack appeared to be feeble, while in others the crystals were entirely or partially dissolved out of the section.

Chemical composition.—No complete chemical analysis of the rocks has yet been made.

To one of my assistants, Mr. F. L. Stillwell, B.Sc., Kernot Research Scholar in the Geological Department, I am indebted for a determination of the percentages of the alkalies in the rock. The result is as follows :—

$$\begin{aligned} Na_2O. &= 10{\cdot}33 \\ K_2O. &= 5{\cdot}25 \\ \hline \text{Total} &= 15{\cdot}58 \end{aligned}$$

The high total alkalies, and especially the very high soda content of the rock in conjunction with the microscopical and micro-chemical evidence, serves to show that the rock is rich in nepheline. Its occurrence as a dyke suggests a comparison with the tinguaites but its texture shows that it is perhaps better described as a nepheline phonolite.

No. 3A.—*Phonolite dyke from south of Omeo* (*See map, Plate IX.*).

Megascopic.—The rock is grey and specklsd and rather coarser in grain than No. 43. The light minerals show bright lustre in reflected light. The dark mineral is *aegirine.*

Microscopic.—The rock contains the same minerals as in No. 43, but with rather different habit. Ægirine occurs in more stumpy prismatic crystals and in small allotriomorphic fragments in the ground-mass, which have separated out after the felspar. The felspar occurs in clear lath-shaped crystals, between which are moulded rather cloudy to clear material polarizing in colours ranging from low neutral to yellow in the first order. This mineral may be felspar, but may possibly on further examination turn out to be cancrinite. In places an isotropic mineral with very low refractive index is moulded on other minerals and sometimes shows a faint purplish colour. I am not yet prepared to give a name to this mineral. Nepheline occurs rather less abundantly than in No. 43, and generally is present in rectangular to hexagonal crystals.

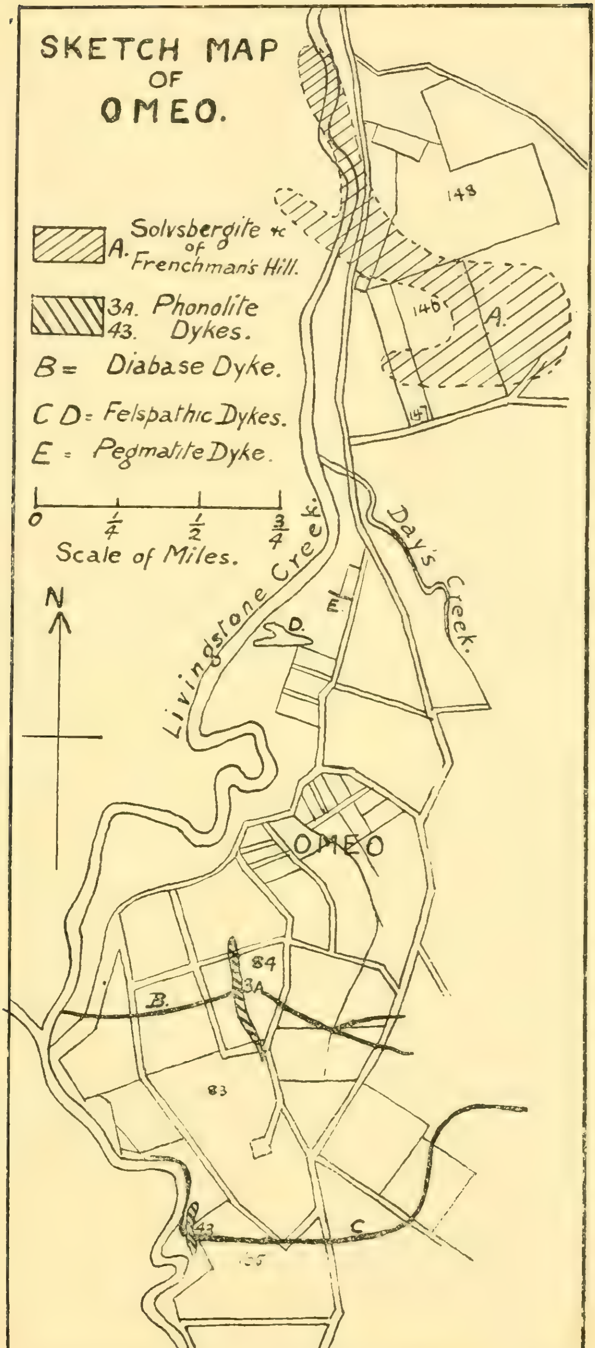
Texture.—The rock is porphyritic in habit, owing to well developed crystals of nepheline and ægirine, and is also trachytic in respect to the fluidal arrangement of the lath-shaped felspars in the ground-mass.

Microchemical evidence.—The rock is very readily attacked and gelatinised by 20 per cent. hydrochloric acid, and the nepheline is stained by malachite green. Some areas are dissolved out, especially the interstitial material, which may be cancrinite. The rock is best described as a nepheline phonolite.

Summary and Conclusions.—Previous reported occurrences of felspathoids in Victoria are shown to be either undemonstrated or inaccurate. The rocks with which this communication deals form part of a collection of dyke stones from Omeo, collected by the late James Stirling and sent to the late Dr. Howitt. Pre-Ordovician schists lie to the east of Omeo and intrusive granites and quartz diorites occur to the west of the schists. Associated with the plutonic rocks are acid dykes and quartz veins. Later than these is the intrusive mass of Frenchman's Hill, composed of trachytes and solvsbergites. Radiating from this hill are a series of trachytic dykes. Further south, near Omeo, a series of dykes, some diorites or diabases, others trachytes, trend nearly east and west. Some of the trachytic dykes have associated lenses or veins of quartz. The youngest rocks, which lie more than a mile to the south of Omeo, appear to be two dykes trending north and south and cutting a diabase and a trachytic dyke respectively. These youngest dykes, examined microscopically are shown to contain abundant phenocrysts of nepheline associated with ægirine and lath-shaped crystals of soda orthoclase. One of these dykes on analysis yielded 5.25 per cent. of potash and 10.33 per cent. of soda. Further field work is necessary before it will be possible to discuss fully the age and field relations of these dykes and the rocks of Frenchman's Hill and their bearing on the genesis of the alkali rocks.

Plate IX.—Sketch Map of Omeo.

PLATE IX.


SKETCH MAP
OF
OMEO.
A. Solvsbergite &c of Frenchman's Hill.
3A. 43. Phonolite Dykes.
B = Diabase Dyke.
C D = Felspathic Dykes.
E = Pegmatite Dyke.
0
1/4
1/2
3/4
Scale of Miles.
N
Livingstone Creek.
Days Creek.
OMEO
148
146
147
A.
D.
E.
B.
84
3A
83
C
43

11.—PRELIMINARY NOTE ON THE ALKALI ROCKS OF DUNDAS (VICTORIA).

By H. S. SUMMERS, M.Sc., Lecturer and Demonstrator in Geology, University of Melbourne.

Introduction.—The very suggestive paper by Dr. Jensen[1] on the origin of alkali rocks has led to increased interest in the occurrence of such rocks in Victoria. Professor Skeats[2] has shown in his presidential address at Brisbane that four areas are known in Victoria in which alkali rocks occur, viz., Mt. Leinster area and Frenchman's Hill, in Gippsland; Macedon district, in Central Victoria, and the Coleraine area in south-western Victoria. Anorthoclase felspar occurs in some of the Victorian basalts, so that further microscopic work may show that it is necessary to include some of these rocks in the alkali series. Professor Skeats and the author paid a hurried visit to the Coleraine area some two years ago, but there was not sufficient time available to carry out any detailed work. During the present year, in company with Mr. C. Wilson, I was able to spend one of the vacations in the field, and these notes are a summary of the observations made; but it will probably require another visit to the locality and further work in the laboratory before I will be in a position to publish a detailed account of the petrographical features of the area.

Previous Literature.—In 1893 the late Mr. Dennant[3] read a paper before the Association at its Adelaide meeting, in which he described various igneous rocks of south-western Victoria. Certain rocks are described as containing sanidine felspar, and these were shown to be associated with basic rocks containing abundant olivine. The rocks were not named, and on the sketch map accompanying the paper are referred to as "Sanidine and Olivine Rocks."

In 1894 Mr. W. Ferguson[4], of the Victorian Geological Survey, made brief mention of the alkali rocks, and recorded the occurrence of glacial conglomerate near Coleraine.

The glacial conglomerates were further described by Mr. E. G. Hogg[5] in 1898 at the Sydney meeting of the Association, and in his paper Mr. Hogg describes a dyke through Adam and Eve, near Coleraine, as being trachyte, and briefly refers to other igneous rocks in the area In the same year, 1898, Mr. Stirling[6] reported on portion of the Western District, but made little mention of the volcanic rocks.

An important contribution to the petrology of the alkali rocks was a paper by Mr. Hogg[7] read before the Royal Society of Victoria, in 1899, in which he describes more fully the dyke at Adam and Eve. The felspar is identified as sanidine, and this mineral, together with apatite and opaque matter and some glass, is stated to constitute

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1 *Proc. Linn. Soc. N.S.W.*, Vol. XXXIII., pt. 3, 1908, p. 491.
2 *A.A.A.S. Brisbane*, 1909, p. 173.
3 *A.A.A.S., Adelaide*, 1893, p. 389.
4 *Geol. Survey. Vict. Prog. Rep.*, No. VIII., 1894, p. 58.
5 *A.A.A.S. Sydney*, 1898, p. 356.
6 *Geol. Survey. Vict. Prog. Rep.* No. IX., 1898, p. 85.
7 *Proc. Roy. Soc. Vict.*, Vol. XII. (N.S.), Pt. I., 1899, p. 90.

the rock. Other rocks in the Coleraine area are also described as trachytes.

In 1901 Mr. Dennant[1] contributed further notes on the trachytic rocks of this area. He confirmed Mr. Hogg's determination of the rocks as trachyte, and also gives chemical compositions of the rock and of the porphyritic felspars.

At the last meeting of this Association, Professor Skeats[2] in his presidential address briefly described some of the rocks of this area, the rock from the quarry at Coleraine being described as an anorthoclase trachyte, consisting essentially of orthophyric prisms of anorthoclase, with some ægirine, partially or wholly changed to chlorite.

Physiographic Features.—The area in which the alkali rocks occur extends from the neighbourhood of Coleraine westward to Casterton, and northward to the Glenelg River. This area may be described as forming part of the extensive coastal plain which occupies a large portion of the extreme west of Victoria. The more elevated portions are perfectly flat-topped, and are capped by Tertiary deposits. In general this plain has been deeply dissected by numerous streams, and it is only along the courses of these creeks that outcrops of early Tertiary and Pre-tertiary rocks are exposed.

From a general survey of the country it is evident that before the formation of these comparatively youthful valleys little, if any, rocks other than the late tertiary deposits were exposed at the surface. As, in addition, the whole area is generally covered with a deep mantle of soil, and the floors of the valleys consist of deep alluvium, it follows that any attempt to work out the relationship of the various rocks in the district is attended with the utmost difficulty.

One very noticeable feature near Coleraine is the number of deep "cut-aways" which are present in the minor valleys leading to the main stream courses of the district. These cut-aways have gorge-like courses up to 15 or 20 feet in depth, and generally expose a corresponding thickness of alluvium, although the underlying rocks may outcrop along the floor. Most of these cuts are of fairly recent origin, and the number is increasing every year. At first sight it would appear that the cause of the activity of these small rivulets was that they had been rejuvenated owing to recent uplift. A more probable explanation, however, is that the valley floors were formerly protected from denudation by the thick crop of reeds and grass which then covered the surface of the ground. Owing to the stocking up of the country with sheep the reeds and grass have been thoroughly eaten down, and the running water has readily dissected the soft alluvium now shorn of its protection. Mounts Adam and Eve were undoubtedly formerly completely buried under Tertiary deposits, but owing to the dissection of this portion of the area by the Konong-Wootong Creek and its tributaries

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1 *Proc. Roy. Soc. Vict.*, Vol. XIV. (N.S.), Pt. I., 1901, p. 10.
2 *Op. cit.*, p. 207.

are now fully exposed. The Giant Rock and its neighbour, the Little Rock, are also only exposed on account of dissection by a tributary of the Konong-Wootong Creek.

Outline of the Geology.—The area round Coleraine and Casterton is undoubtedly one of the most interesting in Victoria, notwithstanding the fact that the relationship existing between the various formations are masked by the later tertiary deposits.

Archæan.—The oldest rocks in the area are a series of crystalline schists and gneisses which form part of the Archæan Series. One exposure of these rocks is in a creek section a little to the north of Carapook, where biotite gneisses and schists intersected by veins of graphic granite and coarse pegmatite are well seen. Near Wando Dale station quartz and mica schists with tourmaline pegmatites are exposed along the Wando River. Further exposures are found along the Glenelg River, and similar schists and gneisses also occur to the south of Mt. Stanley near Bushy Creek.

Granite rocks are fairly extensively developed near Harrow and Balmoral, but at present there is no evidence as to their age, as in no place have they been observed in contact with deposits other than the Archæan, Permo-carboniferous and Tertiary. All that can be stated with certainty is that they are intrusive into the Archæan gneisses and are pre-Permo-carboniferous. It is quite possible that these granite rocks belong to the upper part of the archæan and correspond to the Great Granitoid series of Chamberlin and Salisbury[1], the schists and gneisses corresponding to the Great Schist series of the same authors.

Ordovician.—At the Hummocks serpentine and chert occur, and these, as stated by Professor Skeats[2], possibly belong to the same horizon as the cherts and diabases of Heathcote—*i.e.*, they are basal Ordovician. At Lower Steep Bank Rivulet, Nolan's Creek, and along the Glenelg the rocks exposed are similar in every way to normal Ordovician sediments, and both Ferguson[3] and Stirling[4] have pointed out that they differ entirely from the gneisses and schistose rocks. Unfortunately, no junction between the two types has been observed, so that definite field evidence is not forthcoming, and so far no fossils have been obtained from the sediments. At present they are included in the Ordovician, as the intense folding points to at least a Lower Palæozoic age, and the geographical position of the area suggests Ordovician rather than Silurian. Of course there is the possibility that these sediments may be Cambrian or pre-Cambrian, the only evidence against such a suggestion being their association with the cherts and serpentine which elsewhere appear to be not older than basal Ordovician.

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1 Chamberlin and Salisbury: "Earth History," Vol. II., p. 142.
2. *Op. cit.*, p. 179.
3. *Op. cit.*, p. 59.
4. *Op. cit.*, p. 86.

Permo-carboniferous.—Mr. Ferguson[1] was the first to record the occurrence of glacial beds in this area, and these beds were more fully described later by Mr. Hogg.[2] One very good section not mentioned by the above author is to be seen in a river cliff section near Coleraine. A considerable thickness of glacial material is here exposed, and striated boulders are fairly common

Mr. Hogg discusses the ages of these beds, and although making the statement that the glacials appear to occupy a pocket in the trachytic rock, concludes that they belong to the Permo-carboniferous, and there is little doubt that this is their correct position, although direct evidence is not forthcoming. At Mt. Koroite the simplest reading of the succession is as follows :

Tertiary sands, etc.
Trachytes and associated basic rocks.
Jurassic sandstones.
Glacial beds.

It should be added that the glacial is only exposed low down on the flank of Mt. Koroite, whereas Mr. Dennant[3] records the occurrence of *Otozamites* from near the summit, so that the inference is that the Mesozoic overlies the glacial.

Jurassic.—A glance at the Geological Survey Map of Victoria will show that a considerable area to the south of Coleraine and Casterton is occupied by rocks of Jurassic age. From the point of view of the present paper the main interest centres round the relationship of these beds with the trachytic rocks of Mt. Koroite, where the two occur associated with one another, but discussion of this relationship is reserved till later in the paper.

Tertiary.—The author considers that the alkali series belongs to the Tertiary Period, but reasons for this view, together with descriptions of the rocks and their occurrences, are given later.

Ferguson has recorded fossiliferous deposits from various places within the area, but the only fossil mentioned is *Trigonia semiundulata*. He states that the fossils have a Miocene aspect, so that taking the above fossil into account it is probable that the limestones at least are Barwonian in age. (Note.—The Miocene of the Survey corresponds to the Eocene or Barwonian of some authors.)

Unfortunately these fossiliferous beds are not known to come into contact with the alkali series, although at Koolomer the two are not far apart.

The Upper Tertiary deposits which cover the higher parts of the district consist mainly of sands and clays, and have so far proved unfossiliferous. The character of the material is such that fossils would not readily be preserved, so that their absence does not necessarily signify absence of marine conditions, and the widespread deposition of these beds overlying fossiliferous beds certainly points to a marine origin.

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1 *Op. cit.*, p. 59.
2 *Op. cit.*, p. 358.
3 *Op. cit.*, p. 395.

The Alkali Rocks.—Under this heading it is proposed to give a description of the occurrences and characters of the alkali rocks.

Lying to the north of Coleraine, and just separated from the township by the Koroite Creek, is a ridge composed of trachytic rocks. At the south-western end of the hill a deep quarry exposes a good section. Near the surface the trachyte shows signs of considerable alteration, and is light-brown to whitish in colour. In the deeper parts of the quarry, however, the rock is comparatively fresh and is greenish-brown in colour. This rock has been described by Professor Skeats[1] as an anorthoclase trachyte. The felspars are mainly anorthoclase, but some soda-sanidine is also present. Ægirine and ægirine-augite are the principal ferro-magnesian minerals, but both are altered. Chlorite and aragonite occur as secondary minerals. Near the Konong Wootong Creek estate are situated the hills Adam and Eve, a third hill in the same line being known locally as The Devil. These three hillocks occur on an east and west line and are all connected by a ridge with one another. The general appearance suggests a fissure eruption, the hillocks being formed by local widening of the fissure.

Mr. Hogg has described the basic rock of Adam as an olivine basalt ; but it differs from normal basalt in that corroded crystals of anorthoclase are not infrequent. The ground mass is fine grained and consists of plagioclase (andesine to labradorite) and a slightly pleochroic augite with abundant magnetite. Numerous phenocrysts of olivine and some of augite, the former showing incipient alteration to serpentine, are, together with anorthoclase, the porphyritic constituents. The anorthoclase is similar to that which occur in the alkali rocks of the Macedon area. Numerous spherulitic aggregates of small crystals of augite are scattered through the section. This rock should be described as an anorthoclase olivine basalt.

Running east and west through these hills is a light-coloured trachytic dyke. This dyke has been fairly extensively quarried for building stone, the Konong Wootong Creek homestead being built of this material, and the toning in the stones due to varying amounts of iron is very effective. The ground mass is holocrystalline and has the typical orthophyric structure, the felspars being short, stout prisms of anorthoclase. Throughout the ground mass is considerable oxide of iron, mainly the hydrated form, and this is undoubtedly due to the alteration of some ferro-magnesian mineral, probably ægirine. Original magnetite is rare. The phenocrysts are fairly numerous and consist entirely of felspars. In some cases there is a central core of plagioclase surrounded by a fringe of alkali felspar, Soda-sanidine and anorthoclase are both present, the latter showing at times almost ultramicroscopic twining. The anorthoclase also shows a perthitic intergrowth of albite. Ferguson pointed out that this dyke was not only intrusive into the basic rock but also into the glacial conglomerate, but Hogg considered that the conglomerate

[1] *Op. cit.* p. 207.

had been banked up against the dyke by landslip. On our recent visit to the district a fresh "cut-away" across the junction of the two rocks confirmed Ferguson's observations. Further, Mr. F. Shilton pointed out that across the creek in a continuation of the line of the dyke boulders of the trachyte could be picked up, so that it appears certain that the dyke crosses the valley of the Konong Wootong Creek and is intrusive into the glacial conglomerate on the farther side of the creek.

At the back of the Konong Wootong Creek homestead more trachytic rock occurs. On the eastern face of the hill at the back of the house is a fine grained whitish rock, which on sectioning shows typical trachytic structure, but without any phenocrysts.

Northward from Adam and Eve, but on the opposite side of the stream, is a somewhat different type. The rock is coarser in grain and the felspars are distinctly visible in the hand specimen. Under the microscope the ground-mass is seen to be distinctly trachytic, and the rock shows evidence of flow structure, all the felspars, including the phenocrysts, being approximately parallel. The principal ferro-magnesian constituent is ægirine showing pleochroism and practically straight extinction. Occasional large flakes of brown biotite are present. Calcite and oxides of iron occur as secondary mineral. The phenocrysts are numerous and are mainly soda-sanidine, but anorthoclase is also present.

Still further northward at Wotong Vale is a fine volcanic plug, "The Giant Rock." This is situated in the valley of a tributary of the Konong Wootong Creek. The Giant Rock bears a striking resemblance to the Hanging Rock at Woodend, but is on a somewhat smaller scale. Mr. Dennant stated that this rock was little more than a mass of kaolin, but some moderately fresh material was obtained. A section from this showed an orthophyric ground-mass merging in part towards trachytic. The felspars are comparatively fresh, but the ferro-magnesian minerals are not identifiable. Phenocrysts of anorthoclase are sparingly present. An analysis quoted by Mr. Dennant of "The Little Rock," which adjoins the Giant Rock, shows soda in excess over potash.

The relationship of the rocks at Mt. Koroite is somewhat complex. Several types of igneous rock occur, ranging from sub-acid to basic. Mt. Koroite is flat-topped and is best described as a hill of circumdenudation. The upper part of the hill consists mainly of basaltic rocks. There is some variation in the microscopic characters of different samples, but in general they may be described as olivine anorthoclase basalts. Augite and plagioclase showing ophitic structure, olivine, altered brown glass and magnetite are the principal constituents. Secondary calcite is abundant in some sections. Phenocrysts of anorthoclase do occur, but are rather rare. In the ground-mass there are two felspars, one a plagioclase showing lamellar twining and a second showing lower refractive index and extremely wavy extinction. This latter is probably anorthoclase. Just to the west of Mt. Koroite, but separated from it by a gully, is a hill composed of almost white rock. This at first sight looks like sandstone, especially as it shows tabular jointing, which give it a stratified appearance. A close examination of the hand specimen shows that it is igneous in origin, and this is confirmed by a microscopic examination. The section shows the rock to consist mainly of felspar showing trachytic structure. Bleached remnants of what was probably ægirine are present. together with some magnetite. This rock is a trachyte.

About a mile to the north of the township of Carapook trachyte occurs overlying the archæan gneisses and schists. The rock is greenish in colour and under the microscope shows phenocrysts of anorthoclase in a trachytic ground mass. Ægirine is the principal ferro-magnesian mineral.

One of the most interesting rocks in the area occurs near Koolomert Station. On the side of a valley near the homestead a small quarry has been opened exposing a white columnar rock. The columns exposed are up to six feet long, and may be of far greater length. Perfect columns about four feet long and six inches in diameter have been obtained from the quarry. Overlying the white columnar rock is a dense black igneous rock which weathers to a light colour. Mr. Dennant concluded that the columnar material was only bleached igneous rock, and in the field this seems a probable explanation, but a micro-section from one of the columns shows at once that the rock is a sandstone, mainly composed of sand grains with a felspathic matrix.

A section of the overlying igneous rock discloses a rock type different from anything else noted in the area, and it is rather difficult to find a name for it. Augite, olivine and magnetite form the greater part of the rock. They are idiomorphic and were the first minerals to crystallise out. These minerals are set in a clear colourless ground mass consisting mainly of allotriomorphic alkali felspars. In some parts moderate sized areas of this colourless felspar are seen, but in general it fills up the interstices between the basic minerals. This acid residuum consists of at least two types of felspar. Plagioclase showing lamellar twinning is present, but frequently shows a border of untwinned material. Other areas show the characteristics of anorthoclase, and some portions are completely isotropic. Under ordinary light it is impossible to separate these isotropic areas from the felspar, as the refractive indices are approximately the same and the cleavage of the felspar is not apparent. Under crossed nicols the separation is quite definite, and then on picking up a junction it is found (by means of Becke's method) that the isotropic material has a slightly lower refractive index than the felspar. The simplest explanation seems to be that the light coloured residuum had approximately the composition of alkali felspar, and that part of it crystallised out as such, while the remainder solidified as a glass. Unless we coin a new name we must call this rock an anorthoclase limburgite. Somewhat similar. rocks occur in the Macedon area.

The Age of the Alkali Rocks.—As stated earlier in the paper, the relationship of the alkali rocks to one another and to the other rocks of the area is very obscure, owing to the mantle of Later Tertiary and alluvial deposits.

Mr. Dennant[1] has recorded the occurrence of otozamites in a "felspathic tufa" from near the summit of Mr. Koroite, but makes no deduction from this, except that in a later paper he states that he doubts if the trachytic rocks are younger than the Mesozoic. Mr. Hogg,[2] in referring to this record, says :—"This bed of tufa lying at a higher level than the railway cutting through Mt. Koroite is possibly connected with the trachytic rocks which occur in the neighbourhood of Coleraine ; but I am inclined to regard them of later origin myself." A careful search on Mt. Koroite failed to show the excavation from which Mr. Dennant obtained his specimen, but a microscopic section taken from the original material containing the *Otozamites* showed an extremely altered material, which might just as well form part of the Mesozoic sediments, which are in the main composed of igneous material, as a tuff belonging to the alkali series. As Mr. Dennant advances no evidence in favour of his identification of the rocks as a felspathic tufa, the balance of evidence is in favour of its forming part of the jurassic series which undoubtedly occur lower down the slopes of Mt. Koroite, and if so it has no connection whatever with the alkali series. But for this record there would have been no hesitation on anyone's part to place the alkali rocks as Post-Jurassic. At Mt. Koroite the basaltic type associated with the trachytes distinctly overlies the slightly tilted Jurassic sediments, which are exposed in the railway cutting, though unfortunately no junction between the two has been noted. At Koolomert a certain amount of evidence is forthcoming, but it is rather indefinite. As stated before, an alkali basalt has broken through a bed of sand and produced columnar jointing in the same. The absence of bedding in this sandstone and the perfect columnar structure are most easily explained as the result of the drying out of moisture from a loose, incoherent sand by the heat of the intrusion. The field evidence points to the basic rock occurring as a plug through the sandstone rather than as part of a superficial lava flow. Quartzites, similar in every respect to the Tertiary quartzites so common in Victoria, also occur just underlying part of the igneous rock at Koolomert. Within half-a-mile from the columnar sandstones and the quartzites fossiliferous beds of Barwonian (?) age occur at about the same elevation as the sub-basaltic material, so that they possibly belong to the same horizon. In this case the alkali rocks would be Post-Barwonian in age. This evidence is given for what it is worth, as at present it is the best that is available. Mr. Hogg has called attention to the youthful appearance of the hillocks Adam and Eve, and certainly the form of these hills and that of the Giant Rock suggest a tertiary age for these rocks.

1 *Op. cit.*, p. 395.
2. *Op. cit.*, p. 360.

12.—CORAL REEFS OF THE COOK AND SOCIETY ISLANDS.

By PROFESSOR P. MARSHALL, M.A., D.Sc., F.G.S.

[PLATES X., XI.]

An expedition to the Cook and Society Islands, undertaken as a member of a Research Committee appointed by this Association to investigate the distribution of alkaline eruptive rocks in the Pacific, enabled me to make some observations on the coral reefs of the islands of these groups. These are perhaps sufficiently important to justify me in stating them in the form of a paper to be communicated to this meeting of the Association. Before detailing these observations it is as well to state briefly the theories that have been advanced from time to time in order that it may be clearly seen to what extent they are supported or opposed by the statements here made. The following appears to me to be a brief but fair statement of the different theories:—

(1) Darwin:[1] The theory of subsidence. Coral structures are all supposed to have commenced as fringing reefs. Subsidence of the land as rapid as the upward growth of the coral would cause the fringing reefs to develop into a barrier. Still further subsidence until the land completely disappeared would change the barrier into an atoll. This view was strongly supported by Dana in his work.[2]

(2) Murray, Sir J.:[3] "That when coral plantations grow up from submarine banks they assume an atoll form owing to the more abundant supply of food to the outer margin and the removal of dead coral from the interior portion by currents and by the action of carbonic acid gas dissolved in sea water.

That barrier reefs have been built out from the shore on a foundation of volcanic debris or on a talus of coral blocks, coral sediment and pelagic shells, and the lagoon channel is formed in the same way as a lagoon."

Murray's theory is often known as the solution theory.

(3) Agassiz, A.:[4] The Coral Reefs of the Tropical Pacific. This eminent observer, who has spent more time than any other author in investigating this subject, regards all coral reefs as arising on submarine platforms, the surface of which is less than 100 fathoms below the sea level. In nearly all cases these platforms are supposed to be the result of the action of marine erosion on previously existing land. The theory might almost be called the theory of erosion. Thus on page 16 he says: "It became very evident after we had examined a number of atolls that the underlying ledge is a remnant of a bed of tertiary coralliferous limestone which at one time covered the greater part of the area of the lagoon, portions of which may have been elevated to a considerable height."

(4) Stanley-Gardiner:[5] This author from his observations in the Maldives further extended the action of marine erosion in preparing

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1 "Geological Observations on Coral Reefs," 1851.
2 "Corals and Coral Islands," 1872.
3 *Proc. Roy. Soc. Edin.*, 1879 80 p. 517.
4 *Mem. Mus. Camp. Zool. Harv.*, Vol. XXVIII., 1903.
5 *Geographical Journal*, 1902, XIX., p. 396.

a platform for coral growths. He states that the Maldives stand on a coral swept plateau 190 fathoms below the sea level. On this banks have been built up and reefs have grown on them, and they have gradually extended outwards. Atolls arise from the fusion of reefs and the washing away of their interior portions as the circumscribing reefs became more perfect. He supported the theory partly by a comparison between soundings made in the middle of the 19th century and those made by himself. The accuracy of the early soundings was questioned by Admiral Wharton.

(5) Wood-Jones, 1910.[1]—Corals grow only above the limiting level of sedimentation. Atolls may often be developed from a reef by the distribution of detrital matter derived from the reefs by wave action.

It is, I think, well to consider the bearing of recent work upon these different theories. The results of the Funafuti Expedition is naturally of great importance.

On the one hand, before the report on the boring was published, Agassiz said (*loc. cit.* P. xxi., xxii.) : "The boring at Funafuti reached 1114 feet. It passed at first through the modern reef rock material, and below that must have, judging by analogy, penetrated either an underlying mass of tertiary limestone, or have passed through the mass of modern reef rock forming the outer talus of the atoll of Funafuti."

On the other hand, Dr. Hinde, who examined and identified the organisms contained in the bore, says in the *Report*, p. 334 : "Although there are considerable differences in the character of the rock in different parts of the main boring, the evidence appears to me to indicate a continuous formation of reef rock without any abrupt break from 1114 feet to the present day."

P. 319 : "It seems highly probable that the corals all belong to well known genera of reef building-corals, and most of the species appear to be closely allied, if not the same as the species already described."

P. 316 : "The various organisms from the borings all belong to existing genera, and with some exceptions the species so far as they can be determined are still living. The greater number have been recognised in the dredgings from the outer slope of the reef and from the lagoon, and in the collections made on the reef at Funafuti. Some, however, have not been met with in the recent fauna of the locality."

This appears to me to entirely negative the predictions made by Agassiz and to justify the statements made by Sollas that the boring did not penetrate tertiary limestone, and that throughout it consisted of reef material with corals growing in *situ*. "Age of the Earth," p. 130.

Wood-Jones, however, still maintains that the bore after reaching the limit of coral growth passed through talus material only.

1 "Coral and Coral Atolls."

Hedley and Taylor[1] strongly support Darwin's theory as satisfactory in accounting for all the features of the Great Barrier Reef of Australia. This had been strongly opposed for this particular reef by Agassiz.

To return to the more immediate subject of this paper. Very strong and opposite statements have been made in regard to the reefs of the Society Islands, as the following extracts show. It is merely necessary to premise that each of the islands is surrounded by a barrier and a fringing reef separated by a lagoon channel usually $\frac{1}{4}$ to 2 miles wide.

Darwin[2]: "At the Society Archipelago the shoalness of the lagoon channels round some of the islands, the number of islands formed on the reefs of others, and the broad belt of low land at the foot of the mountains indicate that although there must have been great subsidence to produce the barrier reefs, there has since elapsed a long stationary period." (Pl. X., Fig. 1.)

Endorsed by Dana in "Corals and Coral Islands."

Agassiz, *loc. cit.*, p. xv.

"On Tahiti the reefs of the north-west and west coast show admirably how a wide fringing reef may gradually become gouged out into a barrier reef edging a shallow lagoon, and ultimately a wide and deep barrier reef lagoon."

Agassiz, *loc. cit.* p. 160.

"In the vicinity of all the ship passes leading into the lagoon either on the east or west shore, numerous islands and islets remain; outliers indicating the position of ridges or spurs of the volcanic slopes that have been eroded and which once extended to the outer edge of the reef flat." Rautoanui, Iriru, Avopiti Passes are quoted as examples.

I was naturally keenly on the lookout to observe whether there was any geological evidence of depression or of the influence of marine erosion. The former would evidently be found in the presence of submerged stream valleys and the latter in the presence of steep and lofty cliffs on the shore line of the volcanic rock of the islands, especially at the ends of the mountain spurs.

Charts of all the Society Islands, except Tahiti, show that a great number of drowned stream valleys are present, and now appear in the form of deep, far-reaching inlets, such as Papetoai in Moorea, Hamene Baie in Tahaa, and Apumau River in Raiatea, all from two to three miles long. These must be held to prove that the islands are now at a far lower level than when these stream valleys were eroded.

On the other hand the volcanic rock nowhere reaches the sea level in steep and high cliffs, so that geological evidence of marine erosion appears to me to be entirely wanting.

Agassiz also lays insistence upon the presence of volcanic outliers as islands on either side of the ship passes leading into the lagoon

1 *A.A.A.S.*, Vol. XI., Adelaide, 1907, p. 413.
2 "Geol. Obs. on Coral Reefs," 1851, p. 128.

(Pl. X., Fig. 2). Some of these had been long ago recognised by Captain Cook as formed by wave action upon the detritus derived from the coral reefs. All of those that I saw were certainly of this origin, and correspondents living in this group of islands have been good enough to inform me that though they have landed on a great many islets on the barrier reef on either side of ship passes, they do not know of one that is formed of volcanic rock.

I was not able to make any observations that would bear on the questions whether solution had or had not taken place on the reef masses to any extent, but it is important to note that the fringing reef of the present day situated on the land side of the lagoon consists still of living coral.

It will be seen from the chart that Tahiti evidently is rather different from the other islands, as its lagoon is less continuous and less deep, and the fringing reef and barrier are in many places united. Darwin maintains that this points to a long continuance of the present elevation. Agassiz, on the other hand, maintains that the level has changed so recently that the effect of solution has not yet become pronounced.

There certainly seems in the presence of the wide alluvial plains, and of the stream valleys filled with detritus, strong geological reason to agree with Darwin in this question. That Darwin did not neglect the possibility of the action of marine erosion is well seen in the following extract. :—

Darwin, "Voyage of Beagle," p. 455. J. M. Dent, "Everyman's Library. Barrier Reefs." "Are we to suppose that each island is surrounded by a collar-like submarine ledge of rock or by a great bank of sediment ending abruptly where the reef ends. If the sea had formerly eaten deeply into the islands before they were protected by the reefs, thus having a shallow ledge all round them under water, the present shores would have been invariably bounded by great precipices, but this is most rarely the case."

Much emphasis has been laid on the presence of raised coral in the neighbourhood of atolls or barriers. It does not appear that this is necessarily of great importance, for the lapse of time within even the most recent geological periods is sufficient to allow of the elevation of one reef and subsequently of depression from an elevated position, during which the atoll or barrier may have been formed.

In regard to this question Agassiz quotes with approval the remark of Dana.

Agassiz, *loc. cit.*, p. xxi.

" Dana very justly remarks ' It is important to have in mind that the coral reef era probably covered the whole of the quaternary and perhaps the Pliocene tertiary also, and hence the local elevations that may have taken place were not crowded events of a short period.' "

In many instances Agassiz states that reefs are based upon a platform of eroded tertiary coralliferous limestone. This appears a very definite statement, and the basis upon which the classification as tertiary rests should certainly be stated, for it appears from the Funafuti Report that the greatest care has to be exercised to distinguish whether such limestone is recent or not. In particular, some of the tertiary limestone from the Paumotus should have been closely examined, or if this was done a definite statement of the reasons for classing it as tertiary would have been most interesting.

The Cook Group was not visited by Darwin and Aitutaki was the only island visited by Agassiz. The following extracts give his views in regard to that island :—

AITUTAKI.—" There are a number of volcanic negroheads on the flats. This group is an excellent example of a volcanic rock flat upon which corals are growing. The formation of the underlying base can be traced. as volcanic outliers crop out at many places on the barrier reef."—Agassiz, *loc. cit.*, p. xvii.

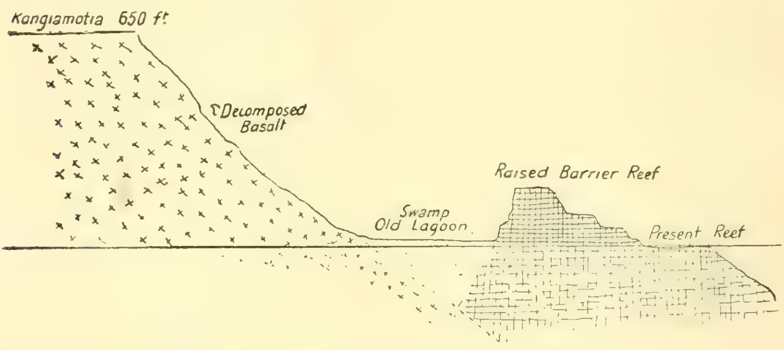

FIG. 4.

SECTION ACROSS WESTERN PART OF MANGAIA ISLAND.

THE COOK ARCHIPELAGO.—" The elevated islands have narrow reef-flat platforms formed by submarine erosion."

I was not able to visit Aitutaki, but did go to Rarotonga and Mangaia. Raratonga has a fringing reef which at the south end is nearly a mile distant from the coast. (Pl. XI,. Fig. 3.) This wide reef platform here contains some spots a few fathoms deep, but there is no lagoon comparable with those in the Society Group. There is raised coral 10 feet above sea level at many places on the coast of this island, notably at Ngatangiia, and between this raised coral and the volcanic rock is a swamp that may mark an earlier lagoon. (Pl. XI., Fig. 4).

Mangaia is of great interest. Here there is a well-developed marine erosion surface forming the summit of the island 650 feet above sea level. An alluvial flat a few feet above sea level separates

Fig. 1.—Barrier Reef, Lagoon, and Fringing Reef, Raiatea Island.

Fig. 2.—Awapiti Pass, Raiatea.

Fig. 1.—Fringing Reef, Rarotonga.

Fig. 2.—Raised Coral, Rarotonga.

the high volcanic land from a ring of coral 125 feet above sea level. This ring entirely surrounds the island. It is 200 or 300 yards from the volcanic land, though here and there united by limestone, and in my opinion it represents an old barrier raised by movements of elevation that succeeded the gradual depression to which the formation of the barrier was due. There is no sign of marine erosion on the floor of the alluvial land, and no cliffs fringe the volcanic hill. The outer surface of the coral ring shows three terraces, and the present reef platform is 200 yards wide.

In conclusion, the author is compelled to say that after observing the reefs of the Society and Cook Islands with considerable care and with a knowledge of the statements and observations of previous visitors, he found no reasons to consider Darwin's theory as in any way unsatisfactory, and many reasons to consider it entirely satisfactory. On the other hand, many observations were directly opposed to the statements of Agassiz, and he could find no facts that supported Murray's theory.

Wood-Jones' theory, which depends on the effect of sedimentation, could not be tested during such a short visit. It must be remembered that wherever there is a check to the movement of water the limiting level of sedimentation rises. Such check would be experienced wherever coral structures grow, and the sediment would be deposited in the sheltered spots of all coral calices. This appears to be an important consideration, for suspended matter is present in greatest quantity when the wave breaks on the coral, and whenever there is a small sheltered spot some of it will be deposited.

Two of the latest opinions on this subject are those of Suess and of Langenbeck. The former says :—" Yet notwithstanding the valuable investigations quite recently made, and notwithstanding the objections which such distinguished investigators as Semper, Murray and Agassiz have made, it must still be admitted that the depth of the enclosed lagoon has not yet been satisfactorily explained." (Suess, E., " Face of the Earth," vol. iv., 1910, p. 327) ; and the latter,after reviewing the whole question, states, p. 59 :— " Dass Dagegen die Darwin-Danasche theorie and sie allein eine befriedigende Erklarung fur dieselben giebt." (Langenbeck " Die Theorieen über die Entstehung der Koralleninseln und Korallenriffe," Leipzig, 1890, p. 59.)

EXPLANATION OF PLATES X. AND XI.

PLATE X.

1.—Barrier reef, lagoon, and fringing reef. Looking north-east from Mt. Tapioi, 960 feet, Raiatea Island, Society group.

2.—Awapiti Pass, Raiatea Island, Society group. From top of Mt Tapioi, looking south-east.

PLATE XI.

3.—Fringing reef, Rarotonga, Cook Islands. From top of Mt. Mamgatea 860 feet, looking north.

4.—Raised coral, Ngatangiia, Rarotonga Island. Looking south.

13.—ON THE TRANSPORT OF MUD BY A RIVER IN FLOOD.

By THOS. STEEL, F.L.S.

DURING an unusually heavy flood which occurred on the River Yarra, Victoria, in the month of July, 1891, I took the opportunity of making a daily examination of the amount of suspended mud carried by the water. The samples were drawn from the river at the Sugar Refinery, Yarraville, at a point just above the junction of the Goode Canal with the river, and hence include the flood waters of the Saltwater River and those of the Yarra itself, except what escaped by the Goode Canal. In normal times at Yarraville and for some distance further up the river is tidal, and its water contains a large proportion of sea water. The suspended mud was coagulated by the addition of a minute quantity of alum to a measured volume of the water ; allowed to settle, the clear water decanted and the mud collected on a tared filter, dried in the water bath and weighed. The dry mud was then ignited and the loss in weight noted. During part of the period of observation the chlorine in the water was determined as an index of the amount of sea water working up the river from Hobson's Bay.

The table following shows the results of the observations. The quantities are stated in parts per 100,000 water :—

1891	Total Mud.	Mud after Ignition.	Chlorine.	Equivalent Percentage Sea Water.	State of River.
July 10	101.85	96.50	—	—	High—Rising.
,, 13	171.80	153.65	—	—	Highest.
,, 14	81.65	73.85	—	—	High—Falling.
,, 15	48.85	42.95	—	—	,, ,,
,, 16	25.75	22.05	—	—	Falling.
,, 17	16.40	13.75	—	—	Almost level.
,, 18	11.20	9.60	—	—	About level.
,, 20	10.80	8.90	63.1	3.5	,, ,,
,, 21	11.55	9.50	120.7	6.8	Level.
,, 24	12.45	9.40	142.0	8.0	,,
,, 29	13.70	10.50	166.9	9.4	,,
Aug. 3	290.80	263.80	6.4	.4	Strong fresh.
,, 4	147.05	133.25	2.8	.16	Falling.
,, 5	65.80	58.15	4.3	.24	Level.
,, 6	31.05	26.50	43.4	2.4	,,
,, 7	24.40	20.75	72.9	4.1	,,
,, 8	20.90	17.65	74.7	4.2	,,

It is interesting to note how with the recurrence of rain a second flood was in evidence on August 3rd and 4th, which brought down on one day considerably more mud than on the heaviest day of the primary flood. Doubtless this was due to the washing down of mud which had been freshly deposited on the river banks and was disturbed again by the rising waters.

The Chief Engineer for Water Supply, Mr. Stuart Murray, kindly furnished me at the time with the official departmental estimate of the quantity of water flowing past the spot where the samples were taken, during the period from 10th to 22nd July inclusive, this being 14,000,000,000 cubic feet. I was unable to ascertain the daily flow, but taking the mean figures 10th to 21st July, as given in table above, the amount of mud carried by the water would be about 53.32 parts per 100,000. This gives a total of about 207,000 tons dry mud transported by the water during the period mentioned.

Much of this load of mud was deposited in the bay, near the mouth of the Yarra, forming a huge bank extending towards St. Kilda. While the river bed was pretty completely scoured clear of mud, leaving the hard bottom, it was estimated that the entrance was silted up at least two feet, and several steamers ran aground while endeavouring to enter the river.

The late Professor Kernot contributed a paper descriptive of this flood, and detailing the methods to be carried out to prevent a recurrence, to the Royal Society of Victoria.[1]

I have to ackowledge the assistance of Messrs. H. L. Whitaker and W. E. Appleby in the determination of the amounts of mud in the water.

With regard to the composition of the mud brought down by flood waters, an analysis of a sample deposited on the banks of the Tweed River, New South Wales, by a flood in November, 1882, which I examined at the time, will be of interest. The mud formed a coating varying up to one inch in thickness on the river banks, and on drying cracked into flat biscuit-like pieces. The analysis was made by boiling with hydrochloric acid, the solution being dealt with in the usual manner..

Sample dried at 110°C.

Organic matter, etc.[2]	22·47
Sand and insoluble	55·38
Soluble silica	·31
Ferric oxide	5·51
Ferrous oxide	1·73
Alumina	10·78
Lime	1·16
Magnesia	·71
Potash	·20
Soda	·07
Sulphuric anhydride	·67
Phosphoric oxide	·36
Carbon dioxide	·13
Chlorine	·03
Not determined and loss	·50
	100·01
Oxygen equivalent to chlorine	·01
	100·00

1 *Proc. R. S. Vict.*, IV., Part 2 (N.S.), pp. 209, 210, 1892. Observations were also made by W. W. Culcheth. (*Proc. Vict Inst. Eng.*, 1891).

2 Containing Nitrogen, .63 Water in air-dried sample, 5.48

14.—AN INVESTIGATION OF THE RELATIONSHIP BETWEEN THE ORE BODIES OF THE HEEMSKIRK-COMSTOCK-ZEEHAN REGION AND THE ASSOCIATED IGNEOUS ROCK.

By L. KEITH WARD, B.A., B.E.

[PLATE XII.]

CONTENTS.

I.—INTRODUCTION.

CONSEQUENT upon the detailed study of a large number of different varieties of ore-bodies in many parts of the world there has arisen a fixed belief, on the part of the great majority of mining geologists, in the doctrine of the genetic relationship between igneous rocks and certain metallic ores.

The exact meaning of this consanguinity is but seldom stated at all; and in many cases very different views appear to be held by geologists with regard to the nature of the relationship.

It appears to the author of this paper that there is a need for the detailed statement of the case, if only for the benefit of those to whom is entrusted the work of exploiting the ore deposits. When engaged upon the geological investigation of mining fields the geologist is brought into touch with mine managers by whom the doctrine of the inter-relationship between ore deposits and igneous rocks is accepted. But to many of these the actual genetic relationship is not apparent. The association has been noted and perhaps compared in a general way with other similar associations in the same or in a neighbouring mineral field.

In order that accidental characteristics of similarity or dissimilarity may be distinguished from essential ones, and thus that sound comparisons may be drawn, a much fuller appreciation of the significance of association is necessary. The more detailed investigation assumes a directly practical aspect when the attention is attracted towards alterations in the character of the primary ores. These alterations are found to take place in all ore-bodies, and those to which most attention is naturally given are characterised by an impoverishment of the lodes in the particular minerals which are the immediate object of mining operations. Confronted with such phenomena many mine managers find that their conceptions of the genesis of the ore-bodies upon which they are working are wholly inadequate to provide satisfactory explanations of the evident facts. The result is that either all faith in their former beliefs is abandoned, or an appeal is made to the interaction of certain ill-recognised local conditions which have no genetic significance.

Again, curiously distorted views are sometimes expressed with regard to the location of the proximate source of the metallic ores. Thus, with regard to the origin of tin ore-bodies which are situated outside the boundaries of granite or granite porphyry intrusions, one often hears the contact zone referred to as the ultimate goal of mining operations. It is apparently believed that, once the boundaries of the igneous rock are reached, the actual source of the mineral wealth of that district will have been discovered and that a great concentration of tin ore will be found. This is all the more extraordinary in view of the many occurrences now described in which tin ore-bodies have been traced downwards without interruption from the intruded rocks, through the contact zone, into the igneous rock masses themselves.

The author proposes in this paper to deal with the question of the relationship of a group of genetically connected ore-bodies to the associated igneous rocks. The ore-bodies in question are those of the Zeehan, Comstock and Heemskirk districts of the western coast of Tasmania, and the discussion is restricted to those particular points which bear upon the question of genetic relationship, and which may have an application beyond the limits of this particular region.

II.—Summary of the Geology of the Region.

The area with which this paper is concerned is structurally complex. The oldest rocks present are believed to be either Upper Cambrian or Lower Ordovician in age, and are referred to as Cambro-Ordovician. They consist of a great series of slates and sandstones, with which are interbedded tuffs and lava flows. At a later period a considerable thickness of silurian sediments —conglomerate, shale, limestone and sandstone—has been laid down upon them.

Serious dislocations of the crust have followed the period of deposition of the Silurian sediments. The Pre-Devonian formations have been invaded by igneous rocks which are believed to have ascended from greater depths at the beginning of the Devonian period. At this period Tasmania was apparently undergoing elevation—the strand-line had certainly suffered a negative displacement since the Silurian period. It is not known whether any of the Devonian igneous rocks actually reached the surface. There are no effusive rocks preserved, and a long cycle of erosion apparently continued without intermission over all Tasmania until the beginning of the Permo-Carboniferous period. The result of this and succeeding erosion cycles is that the plutonic igneous rocks now outcrop on the west, north, and east of Zeehan, and the dyke rocks penetrate the mining field at a number of places.

The period of igneous invasion was followed by a certain amount of faulting, in which the dyke rocks have been to some degree crushed and dislocated.

There are a few small isolated patches of glacial till which are probably of Permo-Carboniferous age. Any sediments of later date which have covered the area surrounding Zeehan have been completely removed by the long cycle of erosion which has been operative in western Tasmania since the close of the Mesozoic Era.[1] The region is an elevated one, in which the maturity of the erosion cycle has been somewhat masked by successive negative movements of the strand-line.

III.—The Igneous Rocks of Devonian Age and the Relationship between them.

From the uprising magma which made its appearance in almost every part of Tasmania in or about the beginning of the Devonian period, many varieties of non-metallic consolidation products which we call igneous rocks have been born.

The rise of molten material has certainly not been one massive upwelling of homogenous material from the deeper regions of the earth's mass. There have been at least two distinct periods of irruption, and two great groups of igneous rock types have successively consolidated.

The two groups may be conveniently referred to as the acidic and basic groups.[2]

The rocks belonging to the basic group made their appearance in the earlier period of igneous invasion. Those of acidic character followed after them, actually penetrating them in some instances, and almost always producing some contact metamorphic effects upon them.

Geological evidence in all cases is in favour of the rapid succession of the acidic after the basic irruption. The two types are found together in a number of widely separated localities, and there is a singular lithological resemblance between the members of each type in these localities. Both groups show a marked tendency towards the development of differentiated rock types, but the acidic group is on the whole less characterised by differences between its component members than is the basic.

The constant features of association, the constant but small difference of age, and the recurrence of similar rock-types all point to the derivation of the acidic and basic magmas from one mother-magma by the process known as magmatic differentiation. Moreover, the variation within each group appears to have arisen from a continuation of the operation of the same process at a period later than that of the first differentiation which produced the groups.

In the region which is under discussion there is a marked disparity between the relative bulks of the acidic and basic types

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1 It is doubtful whether any but the low-lying areas of the western part of Tasmania were protected from denudation by submergence beneath the sea in early Tertiary time.

2 Compare E. Suess' Sal and Sima, "The Face of the Earth," Vol. IV., pp. 544, *et seq.*

developed on the eastern and western borders. To the eastward at North Dundas, the Five Mile, and Dundas, is a notable development of basic rocks—gabbros, norites, pyroxenites and peridotites, together with the gabbro-amphibolites, amphibolites and serpentines derived from them by secondary processes. The granite porphyry and quartz porphyry of North Dundas form relatively small masses.

To the westward lies exposed the great granite *massif* of Mt. Heemskirk, and round its borders are disposed smaller bodies of gabbro-amphibolite and serpentine.

Of the dykes, which penetrate the central portion of the field, only one of basic character has been detected, while there are numerous small intrusions of acidic composition.

The greater part of the Heemskirk *massif* is composed of a reddish, coarse-grained granite, which contains both orthoclase and plagioclase felspar and biotite mica. Without any defined boundaries this variety passes over into a paler granite which is characterised by the presence of muscovite, in addition to the minerals named, but more especially by the presence of enormous numbers of nodules composed of quartz and tourmaline, with smaller quantities of felspar and traces of cassiterite. These nodules vary from an inch to six inches in diameter, and stand out in relief upon weathered surfaces of the granite containing them. The granite *massif* is traversed by numerous dykes or veins of pegmatite, aplite and quartz-tourmaline rock, some of which extend beyond the granite margin into the surrounding rocks.

The dykes of granite porphyry which traverse the Zeehan field are without doubt apophyses from the magma which produced the granite of Mt. Heemskirk.

The basic rocks surrounding the granite do not exhibit a great variety of types. The principal masses which have come under geological examination are on the one hand gabbros, in which the pyroxene has given way to massive and fibrous amphibole, or on the other hand serpentines.

A dyke of an uncommon type—mica-gabbro—has been recognised in one part of the Zeehan district, and side by side with it occurs an aplite of normal character.

The detailed investigation of the country bordering on the granite has not yet been made. There may be present many other rocks of basic composition.

To the eastward of Zeehan many different varieties of basic rocks occur which have been penetrated at one point by dykes of granite porphyry[1].

From the study of the field relationships of the members of both groups the author is inclined to state the succession and genetic relationship of the igneous rocks as follows :—

In a deeply seated magmatic reservoir differentiation had already produced a separation into an acidic and a basic magma at a time when the igneous material was enabled to rise into still

1 *Vide* "Geological Map of the Tin Field of North Dundas," *Geol. Surv. Tas. Bulletin* No. 6, Plate II

higher regions of the earth's crust. The basic portion was the first to ascend, and when it came to rest at some distance below the surface further differentiation separated it into a number of rock types and sub-types differing from each other, but often merging into each other by insensible gradations.

At a period following closely upon this basic invasion there was an irruption of acidic material which was charged with a high content of aqueous vapour and mineralizing agents The apophyses of the magma penetrate the already solid basic rocks in at least one place[1]. The consolidation products of the earliest phase do not exhibit primary minerals into the composition of which the mineralizing agents enter.

The magma proceeded to solidify, and the process was marked by the gradual alteration in the composition of the still liquid material through the subtraction of the fractional portion already solidified. Through different fissures, probably due to the contraction of the cooling solid crust of the magma, the fluid contents were from time to time expelled.

The tendency for silica, aqueous, boric and other vapours to collect into the heart of the magma was checked in some portions of the mass for reasons thus far not fully determined[2], and a number of small separate and isolated segregations of quartz and tourmaline resulted. Thus the nodular tourmaline granite was formed.

But at least some of these ingredients were gathered together into the heart of the magma. The deeper fissures which tapped this concentration of the more mobile and more acid constituents of the magma allowed the outward passage of the pegmatitic and aplitic material and finally a quartz-tourmaline aggregate. These various dykes which were formed during the various stages of solidification have penetrated not only the granite itself, but in some cases the rocks surrounding the acidic *massif*[3].

The inequalities of surface produced by erosion have laid bare in different places portions of the acidic and basic masses, the relations of which to each other appear to the author to be in harmony with the sequence which has here been stated. It is true that a large number of chemical analyses must be made before this statement of the succession[4] can be claimed to have a perfectly firm status ; but from the field evidence already collected the writer would submit that it is substantially in accordance with facts.

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1 If the author's contention with regard to the succession is correct, the age relationship between the acidic and basic groups is afforded by this intersection. For the basic rocks are intersected by what appear to the author to be the very earliest consolidation products of the acidic magma—the granite porphyries and quartz-porphyries.

2 The idea at once suggests itself that the nodules might be formed at the periphery of the magma where cooling has proceeded too rapidly to admit of the concentration of the quartz and tourmaline from the many centres at which they had collected. The distribution of the nodular granite with respect to the normal variety has not yet been investigated in detail; yet, from observations which have been made, it appears that the nodular variety is *not* restricted to the outer mantle of the *massif*.

3 The neighbouring *massif*, which outcrops on the coast line between the Pieman River and Sandy Cape exhibits similar differentiation phenomena, but not with such variety and detail as does that of Heemskirk.

4 For example, the referring of the granite porphyry dykes to the very earliest stages of the process of consolidation requires chemical support. The comparison between the composition of these dykes and that of the normal granite is especially required.

IV.—The Metallic Ores and the Relationship Between Them.

The metallic ores of the area, considered apart, show considerable diversity of character, and yet are characterised by an equally noteworthy blending of types. The diversity is expressed by the fact that common reference is made to the western part (Heemskirk) as a tinfield, while the eastern portion (Zeehan) has hitherto been regarded as essentially a silver-lead field. But this passage from a tinfield on the west into a silver-lead field on the east is not characterised by any sharp line of demarcation in the matter of distribution nor in the mineralogical composition of the ores.

A more detailed discussion of the mineralogical constitution of the ore-bodies will be found in an official publication[1]. For the purposes of this paper it will suffice to give the following summary:—

The tin-bearing lodes of the Heemskirk district exhibit some variety of composition[2] They are marked in almost every case by the presence of pyrites, and less often by the existence of small amounts of bismuthinite, molybdenite and wolframite with the cassiterite. Of the gangue minerals, tourmaline is the most characteristic and most widely distributed. Fluorite is not abundant.

Lying to the eastward (and southward) of this area, in which cassiterite is the most constant metallic mineral, are the magnetic masses of the Comstock district. The magnetite is found in very large bodies which are seldom free from admixture with other metallic minerals. Although often nearly perfectly pure, the magnetite is found associated with galena, blende, chalcopyrite and pyrite, and one instance is known in which cassiterite accompanies it.

Still further to the eastward lie the large pyritic lodes of the western portion of the Zeehan field. Pyrites is the most abundant mineral, and blende and galena are associated with it. At one point there is a notable development of stannite, with which are associated pyrite, chalcopyrite, galena, bismuthinite, wolframite, tetrahedrite, siderite, and sporadic traces of fluorite.

The eastern limit of the area under consideration—the Zeehan field proper—is characterised by lodes of which a considerable portion consists of siderite, with which are found galena, blende, and smaller quantities of tetrahedrite and chalcopyrite.

Between these broad groups lie many associations which clearly mark transitional stages. Certain metals have been proved to exist in almost every type, and as the work of developing the mines proceeds fresh discoveries are continually being made of the presence of small proportions of certain metals in lodes which were formerly not known to contain them.

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1 *Geol. Surv. Tas.* Bulletin No. 8, 1910, pp. 45-54.

2 G. A. Waller: "Report on the Tin Ore Deposits of Mt. Heemskirk," 1902, pp. 8-10. The author acknowledges his great indebtedness to this and other reports of Mr. Waller, whose researches in the region considered have so largely contributed to the knowledge of the ore-bodies and of their genetic relationships.

The gangue minerals in the lodes are also found to transgress the limits of the main groups referred to above.

There are no known instances in which a lode characteristic of one zone or group is actually intersected by a lode belonging to another zone. This evidence, negative though it may be, is certainly most suggestive, since a very large number of lodes have been worked from time to time and thus exposed for examination. It appears that the members of the different groups belong all to a series (or at most, two series[1]), of which the different components were formed during a single stage in one metallogenetic epoch.

All these phenomena strongly support the view that the ores which have been mentioned are derived from a common source, and that the differences between them are only quantitative variations in the proportions of the constituent elements.

In seeking the cause of the variations it will be necessary to investigate the relation of the distribution of the ores to the geology of the region.

V.—The Geological Relations of the Ores.

Geological investigation has shown that all the rocks in the area which are of greater age than the Permo-Carboniferous have been traversed by the vein fissures. The sedimentary and igneous rocks have all been affected by stresses sufficient to produce rupture, and certain of the resulting fractures have served as loci for ore deposition. Thus we conclude that the period of ore deposition was later than that of the main invasion of the acidic igneous magma.

When the several groups of ores, for which a genetic relationship is claimed, are considered separately it is seen that there is a most marked connection between their distribution and the exposed granitic *massif* of Mt. Heemskirk. There is a zonal arrangement of the groups of ores about the granite such that a very cursory examination of the district suggests some causal interdependence.

Within the granite borders the lodes are almost exclusively cassiterite-bearing. These lodes do extend beyond the igneous boundaries, but not to any considerable distance.

The magnetite-bearing ore-bodies are restricted to the contact-metamorphic aureole surrounding the granite, and beyond these lie the pyritic and sideritic lodes as the distance from the granite increases.

From these facts of occurrence the conclusion to be drawn is that the character of the ore is in some way controlled by its degree of proximity to the granite.

Moreover, since certain types of ore deposits (for all of which genetic relationship and contemporaneity of deposition are here claimed) are found only within the granite boundaries or for a short distance outside of these, it follows that the source of these ores is located within the heart of the granite, not at its periphery.

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1 Vide *Geol. Surv. Tas.*, Bulletin No. 8, 1910, p. 68.

VI.—The Relationship of the Ore-Bodies to the Igneous Rocks.

A.—The Source of the Metallic Ores.—In seeking to establish the relationship of the ore-bodies to the igneous rocks it will be apparent that the attention must be directed towards certain particular phases in the genetic evolution of both.

It has been already stated that there are good reasons to believe that the metallic ores of Heemskirk, Comstock and Zeehan constitute a genetically related series. In common with almost all the ore-bodies of Tasmania they are associated with the complex intrusion which occurred in Devonian time. The several ore-bodies of different types are arranged zonally about a visible outcrop of granite, and the ores of the innermost zone extend downwards into the heart of the granite.

If, then, our hypothesis of the inter-relationship of these ores is correct, they have all proceeded from some source within the heart of the granite.

On the other hand, in discussing the igneous rocks of the acidic group, it has been pointed out that there has been a progressive alteration in the nature of the magma during consolidation. The granite is the earliest product of consolidation, and the pegmatite, aplite and quartz-tourmaline dykes are the latest products to which the name "igneous rock" would be accorded without hesitation.

These dykes cut through the granite and have clearly proceeded from a source situated within its innermost core.

We find, then, that there are on the one hand metallic ore veins (cassiterite-bearing and tourmaline-bearing), and on the other hand, quartz-tourmaline, aplite, or pegmatite dykes proceeding from the same source.

Upon these tabular deposits of mineral material—the dykes and the veins—we may therefore centre our attention.

At once we are confronted with the difficulty of establishing a definition which will serve to satisfactorily distinguish between a "dyke" and a "vein." We may only conclude from the field evidence that certain of the tabular bodies, composed of quartz and tourmaline, solidified from liquid material less highly charged with aqueous vapour than others. Yet all gradations exist and may be visible in a single dyke or vein.[1]

So the structural features—especially that of crustification—have no great value as distinguishing criteria between veins and dykes.

Turning to other phenomena in the search for such criteria, very little satisfaction is given if we examine the wall rocks traversed by these dykes and veins. It is apparent that a very much greater alteration of the wall rock takes place in some cases than in others, but this alteration is by no means proportionate to the mass of the vein or dyke. For, in many cases, there is a considerable width of altered wall rock on either side of a mere film, occupying the central fissure.

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1 Entirelysimilar phenomena recur in the neighbouring tin field of North Dundas. Vide *Geol. Surv. Tas.*, Bulletin No. 6, 1909, pp. 53-54.

The amount of the metallic ingredients present does not appear to the author to offer a means of distinction, since the metallic minerals present (chiefly cassiterite and pyrite) are at times very sparsely distributed. No quantitative limit can be drawn between these veins and dykes composed of the same minerals in ever varying proportions.

It does not seem possible to determine definitely how much of the vein-matter (or dyke-matter) is restricted by the boundaries of the central fissure, and how much has been distributed by metasomatic replacement in the adjoining country. Different occurrences vary in this respect.

The author would therefore submit that there is *no essential difference between a dyke and a vein of this character.* Different dykes or veins are characterised by the presence of different amounts of mineralising agents and different amounts of metallic ingredients. Such variations as are recognisable appear to the author in no way to invalidate this conclusion.

If this interpretation of the field relationships between the igneous rocks and the metallic ores of this region is correct, we are in a position to establish a number of most important deductions :—

(1) The actual source of the metallic ores is located within the heart of the earlier consolidation products.

(2) The period of expulsion from the igneous hearth coincides with the final stages of consolidation.

(3) The metallic veins and igneous dykes of the latest stages of consolidation are essentially identical in mode of origin, in place of origin, in composition and in structure. They are indistinguishable, and if we refer to one series as dykes, the other should receive the same name.

(4) In the case of this series of genetically related ores, all the members, whether remote from the source or in immediate proximity to it, must be regarded as direct products of the consolidation of the igneous magma—*i.e.*, as true igneous rocks, or, in view of their usual tabular form, as dykes. The silver-lead lodes of Zeehan are to be regarded as dykes in precisely the same way as are the quartz-tourmaline-cassiterite lodes of Mt. Heemskirk.

(5) The metallic ore veins, the dykes, the quartz-tourmaline nodules, and the normal granite of the Heemskirk *massif* are consolidation products of different stages in the differentiation of a single magma. The existing end-products of the process of differentiation are on the one hand the granite, and on the other hand the sideritic silver-lead veins. These end-products we may readily distinguish as igneous rocks and as mineral veins respectively; but no such distinction can be drawn between the latest-formed dykes and the roots of the vein series.

(*b*) *The Mode of Derivation of the Ores from the Magmatic Hearth.*—Passing mention has been made above of the presence in the acidic magma at the time of its irruption of certain volatile ingredients. These ingredients, called "mineralizers," combining with the metallic contents of the magma, formed volatile compounds of the several metals which were incapable of solidification while they were retained within the highly heated magmatic hearth.

From the study of the metallic ores it is found that the mineralizers which were contained within the particular magma under consideration were principally compounds of boron, sulphur, and carbon. Fluorine was present, but in relatively small amount, and arsenic was present in traces.

The metals present in the magma were iron, zinc, lead, tin, copper, antimony and silver, with very much smaller amounts of tungsten, molybdenum and bismuth.

Over and above these mineralizers and metals there has been present a considerable amount of aqueous vapour, which has undoubtedly served in no small degree as the transporting agent of the metallic compounds.

Upon the development of fissures, which penetrated to the heart of the cooling magma, these gaseous compounds were enabled to pass outwards through the already solidified portions of the igneous magma into the surrounding rock masses. In such fissures the metallic burden was deposited.

As has been already indicated, the zonal arrangement of the metallic ores about the granite is well-defined, and it remains to investigate the probable nature of the control exerted by the granite over the precipitation of the ores.

(*c*) *The Precipitation of the Metallic Ores.*—The principal facts of occurrence, to which reference has been made above, are the gradual alterations in the mineralogical characters of the ore-bodies in passing from Heemskirk on the west to Zeehan on the east, and the general restriction of the broader groups of mineral associations (vein-types) to the granitic, contact metamorphic and transmetamorphic *terrains*.

In the attempt to determine the causes which have contributed to establish these geological relationships, it is necessary to consider briefly both the causes which produce primary variations in ore-bodies in general, and the special circumstances applicable to this area in particular.

(a) General Principles.—In the case of the gradual consolidation of such a magma as that which has here been described, the segregation of the metalliferous vapours appears to take place at a number of different centres, especially when the magmatic reservoir is a large one. Within these different centres of segregation the proportions of the different metals are variable, sometimes so much so that from one centre ores of one metal result, and from another centre ores of another metal. These differences will under such circumstances be more apparent to the mining community than to geologists who possess some knowledge of the geology of the district. The differences of this kind in the distribution of the segregated metals will, in general, be more marked in the case of large areas than in the case of small ones.

Different fissures, being connected in depth with different centres of segregation, may therefore be filled with different metals or with the same metals in different proportions.

The fissures which have connection with the centres of segregation offer the means whereby the imprisoned vapours are enabled to ascend into the upper portions of the crust. During this upward passage precipitation takes place, and the minerals of the primary ore-bodies are formed. It is probable that the metallic compounds at the moment of leaving the magmatic hearth existed in the gaseous form, but with the fall of temperature and pressure which they experience during their upward migration, they attain the solid form, or pass into solution in the complex solutions formed by the condensation of the several vapours when the temperature and pressure become low enough to admit of the existence of these in liquid form.

From these solutions the dissolved metallic compounds are precipitated, according to definite physico-chemical laws. The most important immediate causes of precipitation are the conditions of temperature and pressure, while these are modified by the chemical composition of the solutions (*i.e.*, by their dissolving power).

It appears to the author most probable that the emerging vapours, issuing from the several centres of segregation within a cooling magma such as that which we have been considering, will at the moment of their expulsion have a temperature which is sensibly constant. For, if the hypothesis outlined above with regard to their genesis is correct, they represent the residues left after the solidification of certain definite rock types. In the consideration of this point, it is essential to remember that the temperature referred to is not that of the fusion of the dry rock. From the foregoing discussion it is plain that the solidification of the aplites and pegmatites takes place in the presence of abundant vapours, which have the effect of very materially lowering the freezing point of such rocks. Working on the lines suggested by Messrs. F. E. Wright and E. S. Larsen[1], it has been found by Mr. E. S. Bastin that the temperature of solidification of the pegmatites of Maine, U.S.A., lies between 560°C. and 580°C.[2] How far varying proportions of different mineralizing agents are capable of altering the temperature of solidification of pegmatites is not yet known. By the comparison of Mr. Bastin's results with those obtainable from the pegmatites of different regions, much valuable information is to be obtained. If the conclusions arrived at by Mr. Bastin with regard to the Maine pegmatites prove upon investigation to be of universal application, we are in a position to ascertain the maximum temperature of the mineraliz-

1 "Quartz as a Geologic Thermometer." *American Journal Science*, June, 1909, pp. 423-447.
2 "Origin of the Pegmatites of Maine." *Journ. Geol.*, May-June, 1910, pp. 297-320.

ing vapours which remained after the crystallisation of the major part of the non-metallic constituents of the magma with which this paper deals.

The precipitation of the metallic contents from different centres will therefore depend almost wholly upon the physico-chemical conditions obtaining at different points along the paths of emergence of the expelled vapours[1].

If we follow for the moment the emerging vapours from one segregation centre along a fissure-system extending into higher portions of the crust, the precipitation of the metallic ores will depend upon :—

(1) The temperature of the rocks traversed. The further the metalliferous solutions travel from their source and from the mantle of hot igneous rock enveloping the source the lower their temperature becomes, by loss of heat to the wall rocks.

(2) The pressure at points along their course. The pressure to which the solutions are subject decreases continually with their ascent.

(3) The rate of migration from the hearth. The ease or difficulty with which the expelled materials are able to ascend will materially influence precipitation. Where the upward path is free and open the migration will be rapid, and the solutions will carry their materials further before the conditions of precipitation are reached. Where the path is restricted and complex, precipitation will be brought about more quickly and at a less distance from the source, mainly on account of the inevitable loss of temperature which the solutions will suffer under such conditions.

(4) The thermal conductivity of the several rocks traversed. This will play some part, perhaps unimportant, in inducing precipitation.

(5) The physical characters of the rocks, and consequently the structural features of the fissures traversing them.

Of these conditions which control precipitation it appears to the author that the most important by far is the first. The temperature acquired by the escaping materials is the main deciding cause for the deposition of the mineral load ; and the other conditions, save that regarding pressure, are of importance, in that they decide the particular points at which the temperature necessary for precipitation is attained. Thus, if the temperature has almost reached the point at which the metalliferous solutions become supersaturated, and if a retardation in the rate of migration takes place, the temperature will fall sufficiently to enable precipitation to begin at that part of the fissure-system.

Thus far we have considered the simple case of the disposition of mineral material of one kind in one fissure system which is connected with a single segregation centre. When several metals are

1 The author desires to acknowledge his indebtedness to the writings of W. H. Weed and others for many of the conceptions involved in this discussion.

migrating together by way of one fissure from the igneous hearth deposition will take place in the inverse order of the solubility of the metallic compounds. So, under ideally uniform conditions, a mineral-bearing fissure would exhibit a successive series of zones of precipitation in which the different metallic minerals in turn give place to others with increasing distance from the source.

Different fissures supplied with similar materials will be filled with similar materials ; but on account of the inevitable variation in the conditions controlling precipitation the different minerals will be deposited at varying distances from the source.

If the author's contention with regard to the superior importance of temperature changes in effecting precipitation is correct, and if it be granted that the hypothesis regarding the origin and mode of derivation of the metallic ores is sound in essential particulars, it will follow that in such a case of ore-genesis as that which is being considered:

(1) Precipitation of metallic ores may take place within the boundaries of the igneous rock (the already solid portion of the parent magma) only in those parts which have cooled sufficiently to chill the isuing vapours to the necessary degree.

(2) Precipitation of the metallic contents of the issuing vapours will be selective, and only such minerals will be deposited within the boundaries of the igneous rock as are rendered on the one hand solid by loss of temperature, and are on the other hand insoluble in the vapours or solutions which are being expelled.

(3) Beyond the boundaries of the heated magma which has partially or almost completely solidified there will be successive zones of precipitation, which will have a tendency to follow the isogeotherms at the period of precipitation.

(4) Where the upper limit of the igneous rock is uneven the boundaries of the zones of precipitation will, save where material variations are caused by conditions already cited, be curves somewhat flatter than the isogeotherms of the period—the degree of curvature being reduced by the conditions of pressure, for the isogeotherms will probably conform closely to the igneous boundaries.

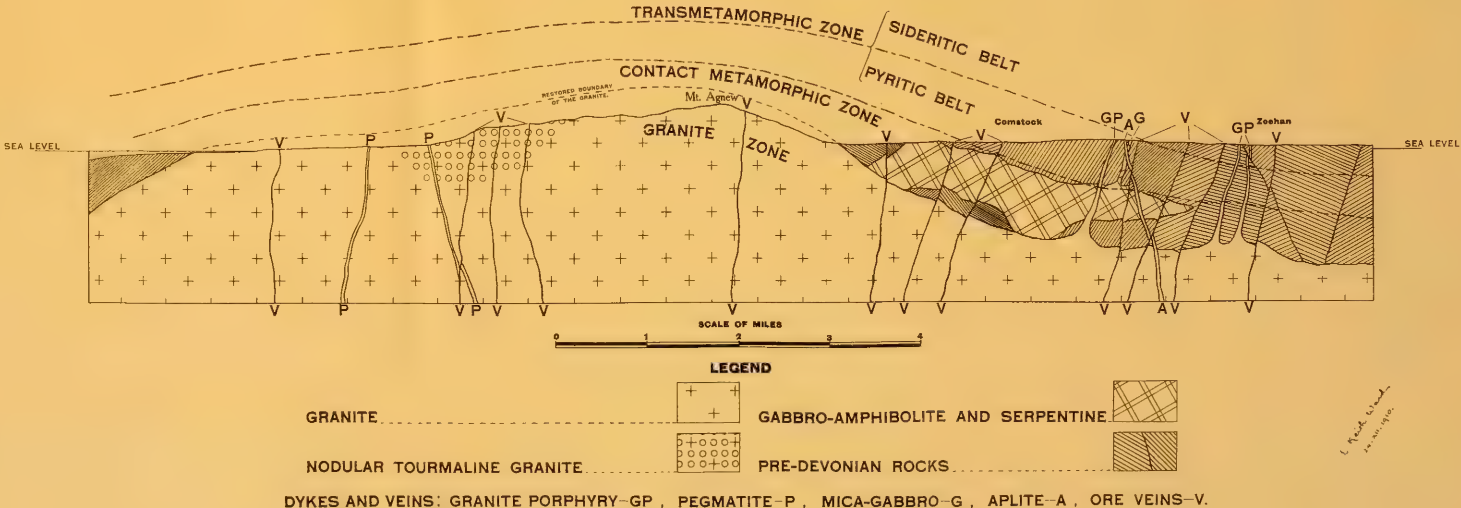
(5) The region in which the several zones of precipitation are most likely to overlap will be that in which the successive isogeotherms are most closely crowded together. This region is probably the contact metamorphic zone.

(6) The region in which the nature of the precipitated material is least liable to variation will be that in which the temperature conditions are most equable. This region is that which is enclosed within the boundaries of the still heated but already solid portion of the igneous magma.

DIAGRAMMATIC SECTION THROUGH

THE HEEMSKIRK RANGE—COMSTOCK—ZEEHAN

SHOWING HYPOTHETICAL RESTORATION OF THE ZONES OF PRECIPITATION



(b). The Application of the General Principles to the Area under Consideration.—When we turn to the particular area with which this paper deals, a number of difficult problems arise, any solution of which must of necessity involve certain hypotheses with regard to the subterranean structure and composition. In the solution which is offered by the author no small weight has been given to the evidence afforded by the neighbouring regions in which it has been his fortune to make geological investigations.

The first question is concerned with the exact source of the metallic ores of Zeehan, Comstock, and Heemskirk ; and the answer will largely depend upon individual interpretation.

The author holds the belief that the several ores of this area were not derived from a single point of origin, but that they were derived from several centres of segregation within the heart of the acidic magma. For the area containing the lodes is a large one, and the lodes of the eastern portion descend, in most cases nearly vertically, towards different subterranean regions. Yet it does not appear probable that, with the exception of the centre, whence the stannite-bearing lodes were derived, the metallic segregations in the different centres were materially the same. The ore bodies derivable, upon the hypothesis of the author, from similar segregations far outweigh the exceptions both in bulk and in importance.

Exact equality in the proportions of the different metals (characteristic of different zones of precipitation[1]) at the different centres appears to be immaterial when the resultant ores are reviewed as a group ; since separation into approximately constant types will result through the operation of the chemical and physical laws to which reference has been made above. Thus, if much tin is present the cassiterite lodes from such centres will be richer, while the great part of the lead is carried beyond the zone of precipitation of the tin. The types in general will thus be constant.

But when metals such as lead and silver, the compounds of which are co-zonal as regards precipitation, are concerned, the resultant ore-bodies will have their contents determined by the proportions of these metals present in the centre of segregation. Thus the silver content of the galena lodes of Zeehan derived from different centres will be always variable for this reason alone.[2]

Of the immediate causes of precipitation, the fall in temperature would seem to have always been the chief. The other controlling conditions which have been mentioned do not call for special mention. In the principal productive portion of the Zeehan field the path for the passage of the mineralising solutions has been determined at a number of places by the intersection of lode fissures with certain fault zones or *ruscheln*, and at these places precipitation has been most marked. This precipitation is the result of the restriction of the solutions to the more open portions of the fissure rather than the direct effect of changes of temperature and pressure.

1 Tin and lead are thus characteristic of distinct zones in the great majority of cases. But it is recognised that in exceptional cases the ores of these metals do actually overlap.

2 Silver being a precious and useful metal, its distribution comes more prominently into notice in mining. The exact percentages of the baser metals are but seldom available with such minuteness, and the same weight cannot be attached to them in the comparison of lodes.

The feature of greatest prominence which is revealed by the geological examination of the whole area is that concerned with the zonal distribution of the different types of lode matter about the exposed granite. Yet, from what has already been stated, the lodes of the Zeehan field do not proceed from the centre of the Heemskirk *massif*, but from some hidden source below the field itself.

It remains, then, to investigate the exact nature of the zonal distribution of ores, and the significance of the granite at a distance from the position of the source of the lodes situated (in Zeehan) on the fringe of the area discussed.

From the presence of the granite porphyry and gabbro dykes in the very heart of the Zeehan fields it must be granted that there exists some continuity of the acidic and basic rocks at some unknown depth below. No mine workings have penetrated to them, nor has the zone of contact metamorphism which lies above the granite been exposed in depth, for both acidic and basic rocks outcrop to the eastward at North Dundas, and there can be little doubt about the continuity of these in depth through the intermediate area. The igneous magma has apparently risen to a greater altitude in the western portion of the area (Heemskirk) than it has in the eastern (North Dundas),[1] but in no place have we evidence that solidification took place actually at the surface. Though buried beneath a surface cover at the time of irruption, the highest peaks of the irregular surface of the igneous rocks have been laid bare at the surface through the subsequent removal of the invaded rocks. In the troughs or depressions of the surface of the igneous rocks the older rocks still remain, since the total effect of the erosion cycles has not yet sufficed to expose continuous areas of the igneous masses.

The basic magma of the whole region has had practically no contact metamorphic effect upon the intruded rocks, but the acidic magma which succeeded it is surrounded by an aureole of metamorphosed rocks at the border of the exposed granite. It must be considered certain that the aureole visible at the present surface is merely the exposed outcrop of a zone which once completely covered the granite surface. It has been partially lost by denudation where the actual granite appears, and it dips down below the unaffected members of the invaded rocks, and is lost to view as it follows the granite surface underground.

Thus the geological plan gives precisely similar information to that which would be afforded by a vertical section. A complete section could be drawn with approximate accuracy if we were aware of the profile of the granite below the contact aureole. The successive visible zones of precipitation which lie horizontally beyond the contact zone are really but the intersections of inclined zones (which conform closely to the granite boundaries) with the surface determined by epigene agencies.

So the nature of the variations in the lode matter, as observed in a horizontal direction, is sensibly identical with that which would

1 Compare the extraordinary differences of altitude attained by the basic rocks in the North Dundas district, to which reference has been made by the author *Geol. Surv. Tas.*, Bulletin No. 6, p. 24

be visible in a vertical direction could we but follow a single lode downwards towards its source, if the materials supplied to the several fissures throughout the area have been approximately the same.

The general result appears to have been that cassiterite ores have been precipitated within the igneous boundaries by the ascending vapours and solutions which, as they traversed the successively cooler zones, have deposited in turn magnetite or mixed magnetite and sulphides, then pyritic zinc and lead ores, and finally sideritic lead ore. Inequalities in the surface of the granite mass have caused the precipitation of these different ores at different levels, and subsequent denudation has exposed the deposits of different zones of precipitation at the level of the present surface in zones of distribution which conform to the boundaries of the granite.[1]

VII.—Conclusion.

The main object of this paper has been to draw the attention of mining engineers and geologists towards the fact that the inter-relationship between an ore-body and its parent magma needs more careful study, and that an ore-body of such a kind as those which have been mentioned is in reality only a variety of igneous rock.

For the author believes that greater prominence should be given to the fact that the original magma whence the ore was derived contained both the non-metallic and metallic products of consolidation. Thus the lead ore of Zeehan is not derived from the granite ; but both lead ore and granite are co-derivatives of a magma which contained them and other minerals as well at the time when consolidation first began.

In the case of the magma which has been under consideration, the different products of consolidation result from the operation of two main processes which are materially distinct :—

(1) The process of the separation of the constituents of the metallic compounds from the main mass of the non-metallic portion within the boundaries of the magma. The process is one of progressive expulsion of these metallic ingredients from the solidifying non-metallic aggregate.

(2) The process of the solidification of the different metallic compounds thus separated, when they are released from the bondage of the intra-magmatic foci into which they have been gathered, and are enabled to ascend into regions of lower pressure. Under the varying physico-chemical conditions to which the issuing compounds are subject during their ascent, selective consolidation will take place, partly within the boundaries of the magma and partly beyond.

1 The hypothetical arrangement of these zones of precipitation is shown in the diagrammatic section which accompanies this paper.

The metallic ore-bodies do not lose their character as igneous rocks when they are expelled from the magmatic hearth. They are still as truly igneous rocks as are the apophyses and dykes which are derived from the same magma. The issuing mineral-bearing vapours and solutions, by the alteration of the wall rocks of the fissures which they traverse, are effecting what is really only a special case of contact metamorphism. In cases where there is a metasomatic replacement of the wall rock there is really a special variety of "assimilation," or "magmatic stoping." The mineralising solutions are at a lower temperature than igneous massifs at the time when the contact metamorphic effects are being produced, and are very different with respect to mass. But the author would contend that there is no essential difference between the "alteration of wall rock" and "contact metamorphism," these terms being employed in their usual senses.

If such a hypothesis as has here been briefly stated can be accepted in its essential details, and if the several vein-phenomena which are met with in the progress of mining ores of this character are read in the light of such a hypothesis, a more ready a· preciation of the significance of primary variations in an ore-body will be possible. While it is granted that a mine manager is on the whole more concerned with the structural details of the lode which he is working, he should be prepared, by an intimate knowledge of its genetic relationships, to provide sound advice when confronted with the problems introduced by the horizontal and vertical variations in the mineralogical composition of the ore. Such variations may be gradual, or they may be abrupt, but they occur in almost ever type of lode. They are to be understood only through the systematic study of the genesis of the lodes, and a knowledge of the geological conditions existing over a far wider area than that enclosed within the boundaries of a single mining lease.

EXPLANATION OF PLATE XII.

The section is essentially a diagram.

Every endeavour has been made to attain accuracy in all particulars The same scale has been adopted for the vertical as for the horizontal measurements lest exaggeration in any particular arise.

The points of emergence of the several dykes and veins shown in the section have been projected on to the plane of the section, which has been chosen in position so that there may be depicted the greatest amount of information pertinent to the objects of the paper in a single diagram.

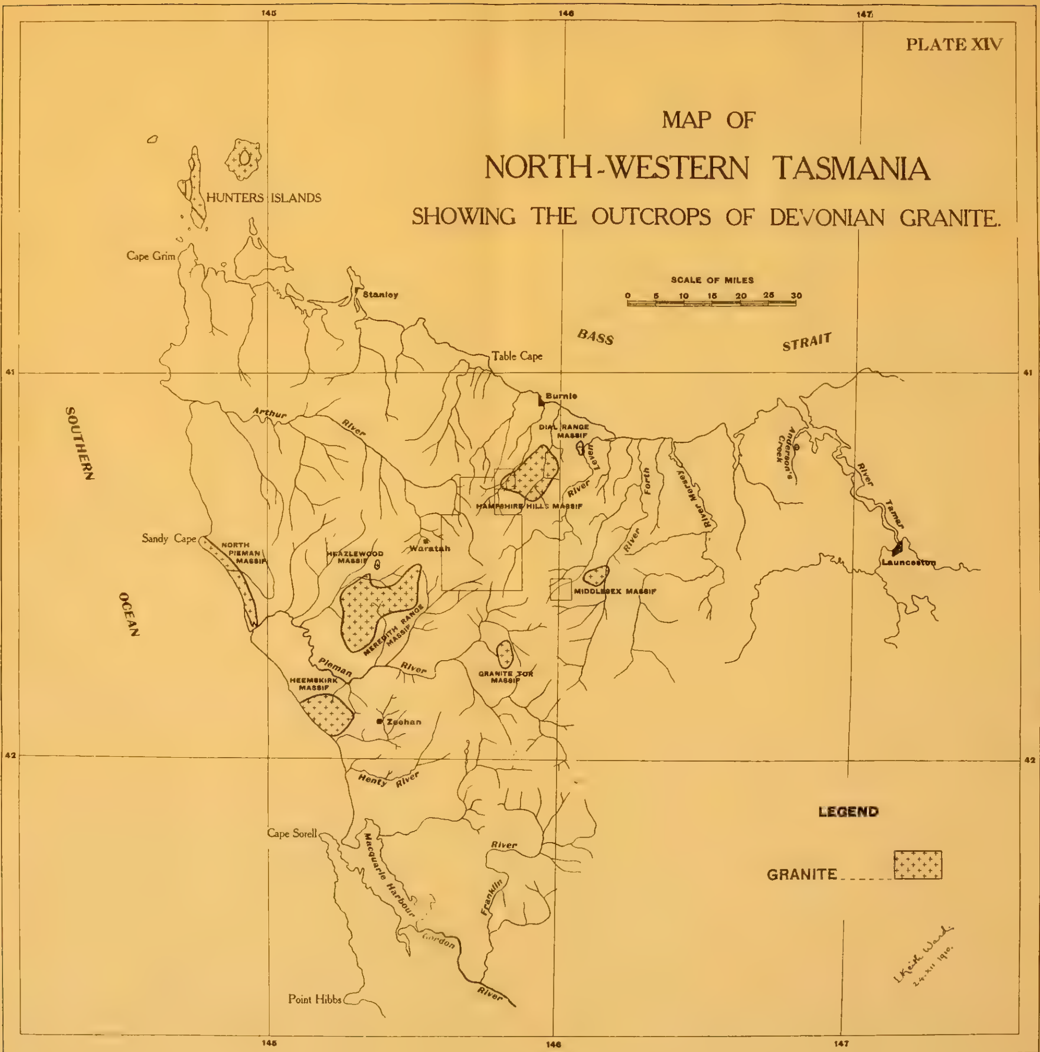
The direction of the plane of the section is N. 77 degrees E. (magnetic bearing).

The Pre-Devonian rocks are shown undifferentiated for the reason that their complex structural arrangement remains still unexplained. But certain faults which antedate the vein-fissures are diagrammatically shown.

The several subterranean contours are delineated in accordance with the views put forward in this and other papers presented by the author at this meeting of the A.A.A.S. They are entirely hypothetical, being constructed from the surface evidence and the author's reading of that evidence.

SKETCH MAP OF A PORTION OF

THE WESTERN COAST OF TASMANIA


MAP OF
NORTH-WESTERN TASMANIA
SHOWING THE OUTCROPS OF DEVONIAN GRANITE.
SCALE OF MILES
0 5 10 15 20 25 30
145
146
147
41
42
HUNTERS ISLANDS
Cape Grim
Stanley
BASS
STRAIT
Table Cape
Burnie
SOUTHERN
OCEAN
Arthur
River
DIAL RANGE MASSIF
Leven
River
HAMPSHIRE HILLS MASSIF
Forth
River
River Mersey
Anderson's Creek
River
Tamar
Launceston
Sandy Cape
NORTH PIEMAN MASSIF
HEAZLEWOOD MASSIF
Waratah
MIDDLESEX MASSIF
MEREDITH RANGE MASSIF
Pieman
River
GRANITE TOR MASSIF
HEEMSKIRK MASSIF
Zeehan
Henty River
Cape Sorell
Macquarie Harbour
River
Franklin
Gordon
River
Point Hibbs
LEGEND
GRANITE
L. Keith Ward 24.XII.1910.

15—THE HEEMSKIRK MASSIF—ITS STRUCTURE AND RELATIONSHIPS.

By L. KEITH WARD, B.A., B.E.

CONTENTS.

[Plates xiii. and xiv.]

I.—Introduction.

Most students of that branch of geological enquiry which is concerned with ore deposits have within recent years come to believe that a large number of ore deposits are genetically related to masses of igneous rock material which are to different degrees exposed in the immediate vicinity of the ore bodies.

With the progress of systematic mapping it has become apparent that ore deposits are distributed unevenly among the rocks of different ages, and that thus the periods of ore deposition may be determined. For example, the majority of the ore deposits in Tasmania are distributed through rocks of which the age ranges between the pre-Cambrian and the Silurian. Looking at the matter in another way : those portions of Tasmania in which the Permo-Carboniferous, Mesozoic and Cainozoic rocks are found at the surface (with the exception of one small region[1]) carry no primary metalliferous deposits of material importance.

By the comparison of the age of the ore bodies and that of the associated igneous rocks it has been found that there is a definite time relationship between igneous invasion and ore deposition in many different parts of the world.

The statement of the historical aspects of oie deposition has been made for America by W. Lindgren,[2] for the British Isles by A. M. Finlayson[3], for various regions in Europe, Africa and Asia by L. de Launay[4], and for Tasmania by W. H. Twelvetrees[5].

In the discussion of this problem there are two rather different aspects which should for some reasons be kept distinct. The author would lay stress on the distinction between the " metallogenetic epoch " and the " metalliferous province "—the relation in time and the relation in space. This distinction must be borne

1 The vicinity of Port Cygnet.
2 " The Gold Production of North America." *Trans. A.I.M.E.*, Vol. XXXIII., 1903, pp, 790-845. Also " Economic Geology," Vol. IV., No. 5, 1909.
3 *Q.J.G.S.*, Vol. 66, 1910, pp., 281-298
4 *Ibid.*, literature quoted in foot note, p. 281.
5 *Geol. Surv. Tas.*, Bulletin No. 9.

constantly in mind when general problems concerning ore deposition are under discussion ; for in those cases in which ore deposits have been formed in a single region at different periods a certain confusion may result[1].

It is regarded by petrologists as an established fact that periods of igneous activity have been, throughout geological history, coincident with periods of crustal deformation, and that the sites of crustal movement have been the sites of co-ordinate igneous invasion[2].

By a number of mining geologists a parallel claim is made, viz., that periods of ore deposition have in like manner corresponded in time with the periods of igneous invasion[3].

The coincidence of mineralised areas with areas marked by igneous invasions has already been referred to. Hence relationship in time must be considered with relationship in space.

The igneous rocks which are found associated with ore deposits are, in different places, products of different phases of igneous activity. In the present paper the author proposes to briefly discuss the form and relationships of certain products of the plutonic phase from the points of view indicated above.

The question is one requiring discussion in the light of data to be provided by many different metalliferous provinces. The present paper has been written in the light of the evidence presented by certain granite masses which play an important part in the geological history of Northern and Western Tasmania. Incidentally the intrusive rocks which are to be referred beyond doubt to the same source as the plutonic rocks are mentioned, and all are shown together upon one of the sketch maps which accompany this paper.

II.—The Proximate Source of Igneous Rocks and Metallic Ores.

Concerning the ultimate origin of igneous materials little can be said that is not based upon theories of cosmogony ; [4]and since the primary source of all metallic ores must needs be igneous material,[5] the ultimate origin of the ores cannot be traced back with certitude through the more or less hypothetical stages of the early history of the earth.

We must be content for the present to accept only certain broad generalisations with regard to the composition of the earth as a whole. With respect to the distribution of heat and the physical conditions in the interior we are not, for the purposes of this paper, concerned.

1 A. M. Finlayson (*loc. cit. supra.*) seeks to avoid such confusion by introducing such a term as a "metallogenetic inlier."

2 A. Harker: "The Natural History of Igneous Rocks," p. 13.

3 This correspondence in time is in most cases really the most conclusive proof of the genetic relationship between the igneous bodies and the associated mineral deposits.

4 *Vide* A. Harker: "The Natural History of Igneous Rocks," pp. 3 and 4.

5 *Vide* J. F. Kemp: "Genesis of Ore Deposits," *A.I.M.E.*, p. 684, and many other writers *passim*.

The author feels that we may safely accept the following statements as being substantially true :—

1. That the interior of the earth is largely composed of metallic ingredients—the "barysphere" of Posepny[1] or the "nife" of Suess.[2]
2. That these metallic ingredients are expelled from time to time into the outer portions of the earth's mass and thus come into place in the zones which are open to geological investigation.

Of the mechanical processes involved in the upward migration of the heavy metals but little can be inferred.

It is, in the opinion of the author, an indubitable fact that the metallic contents[3] of at least many ore deposits have ascended in association with much larger masses of igneous material of different composition. From the ascending materials, in certain cases at least, three principal products are derived, viz. :—

1. The igneous rock masses (mainly non-metallic).
2. The metallic ores and many of their gangue minerals.
3. The juvenile or magmatic vapours and solutions.

Rather than state that the igneous rocks or vapours have served as carriers of the metallic ores the author would affirm that all three groups together constitute the real essence of the magma.

The question of the relationship between the metallic ores and the igneous rock masses demands a detailed discussion for each region in which the relationship may be declared to exist. A study of one such region[4] has been made by the author and his conclusions stated elsewhere.

In some cases the metallic ores are disseminated through the igneous material with which they have ascended ; in other cases they have been collected with the assistance of the magmatic vapours into certain foci, from which they are expelled during the final stages of consolidation.

In either case it is evident that the metallic ores and igneous rock materials have ascended together from the deeper portions of the earth's mass.

With regard to the separation of the metalliferous magma which ascended in the Heemskirk-Comstock-Zeehan district into its several component parts, the author has claimed that a very definite succession of events may be detected from the field evidence. In the evolution of the magma towards the solid state it appears perfectly certain that the granite is the earliest product and that the ore deposits are the latest products of consolidation.

With the completion of the process of consolidation the period of igneous activity and the metallogenetic epoch closed. It is claimed by the author that *the period of complete solidification of the whole magma and the period of cessation of primary ore deposition are coincident and coordinate for this region.*

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1 "Genesis of Ore Deposits," *A.I.M.E.*, pp. 11, 73, 79.
2 "The Face of the Earth," Vol. IV., p. 544.
3 With regard to the Tertiary andesitic goldfields, Dr. Malcolm MacLaren has put forward other hypotheses. *Vide* "Gold," 1908., p. 61.
4 The Heemskirk—Comstock—Zeehan region of Western Tasmania.

It is highly probable that this statement, advanced with confidence for the region mentioned, is applicable also to the other occurrences shown on the maps, in which like igneous rocks are associated with like ore bodies. With regard to the particular region mentioned the field evidence appears to be particularly conclusive.

III.—The Structure of the Heemskirk Massif.

(*a*) *The visible contours.*—From the progress of erosion in the region to which special reference is here made, we are enabled to form a reasonably complete mental picture of the upper portion of the sum total of the consolidation products of the magma as they would have appeared before erosion—with all the intruded rock masses stripped from them—in the district immediately adjacent to the Heemskirk Range.

The granite *massif* of Heemskirk appears to have possessed an arched or dome-like surface, from which certain tongues or narrow ridges (of granite porphyry) extended upwards.

Traversing the smooth surface of the granite, and even cutting across the apophyses of granite porphyry, the tabular dykes and veins of later date have formed ribs or flanges standing out far in relief above the granite boundaries.

This much we may deduce from the study of the present features of the granite *massif*, its borders, and the immediately adjacent country.

(*b*) *The invisible contours.*—(i.) In a horizontal direction.—When the immediate vicinity of the exposed *massif* is left, the mental construction of the form is to be made only by the application of inferences to be drawn from observation. The upper boundary of the granite dips below the intruded rocks and has not been encountered in mining operations. But the subterranean extension of the granitic portion of the magma beyond the limits of the exposed *massif* of Heemskirk may be, from field evidence, regarded as certain.

Dykes of granite porphyry are found at several points in the Zeehan district, and must of necessity imply an underground extension of the magma in that direction. No less significant, in the opinion of the author, is the distribution of the mineral veins, which are, according to his view, also derivatives from the same mother magma.

The horizontal contours of the invisible extensions of the granite *massif* may thus be to some degree determined by the observation of the distribution of the dykes and veins at the surface, if the hypothesis of the author with regard to the genetic relationship between the ore-bodies and the igneous rocks is true. The limitations of such a method of mapping the underground extensions are obvious. The amount of erosion subsequent to consolidation, the depth of the granite below the present surface, the vertical extent of the dykes and veins, and the ease or difficulty with which surface phenomena may be examined, all influence the degree of success which any such attempt may attain.

(ii.) In a vertical direction.—With regard to the vertical extensions of the concealed portions of the granite *massif*, still greater difficulties are involved. Here we are confronted with the great problem of the structural features of a great plutonic intrusion —a problem to which more than one solution has been offered. One of the objects of this paper is to offer a brief discussion of one aspect of the question from the point of view of the student of ore genesis.

The granite *massif* of the Heemskirk Range would, in all probability, be classified by different geologists under different names, according to individual taste and usage.

An admirable compendium of existing nomenclature has been given by Professor R. A. Daly, in his paper on the "Classification of Igneous Intrusive Bodies,"[1] to which reference is here made on several occasions.

The igneous *massif* under discussion is one of which the outcrop occupies a considerable area (approximately 37 square miles), and which appears to descend with steeply sloping sides below the surrounding rocks. Such a mass would probably be termed by different geologists a stock,[2] boss,[3] or batholite[4]; and being thus named, one most important structural hypothesis would be implied, viz., that with increasing depth the area occupied by the igneous mass is ever increasing, and that the upper portion of the igneous material rests only upon the more deeply-seated part of its own mass[5].

It is to this view that the author would demur from the consideration of the field relationships of the ore-bodies which are believed by him to be genetically related to the granite, as has been discussed elsewhere.

The grounds for the author's objections are largely hypothetical, but are based upon a hypothesis constructed from the evidence of actual occurrences.

The points upon which stress is here laid are four in number :—

(1) The ore-bodies of the region appear to constitute a genetically related series, of which the several types are on the whole distinct, but connected by "passage-types."

(2) The ore-bodies of one type are not known to intersect those of another type.

(3) The roots of the vein series appear to be, beyond all shadow of doubt, direct products of differentiation.

(4) The period of primary ore deposition appears to have terminated abruptly.

While the cooling of the magma as a whole may well have extended over a long period, the metallogenetic epoch has been,

1 *Journ. Geol.*, Vol. XIII., 1905, pp. 485-508.
2 *Ibid*, p. 502..
3 *Ibid.* pp. 501, 502.
4 *Ibid.* p.p. 503-505 Note: The English usage of a termination in '—ite' rather than '—ith' is here followed for all such words.
5 *Ibid.* p. 506. See also J. Barrell: "Geology of the Marysville Mining District, Montana." Prof. Paper No. 57. *U.S.A. Geol. Surv.*, 1907, p. 168, and E. Suess: "The Face of the Earth," Vol. IV., p. 551.

according to the views of the author, of relatively short duration—beginning when consolidation was already far advanced, and itself marking the utter termination of consolidation.

If the batholitic structure exists, it is difficult to believe that existing facts of occurrence could have resulted. For then it appears probable that consolidation would have extended over a much longer period, and that from time to time the derivatives of successively deeper portions of the magma would have been extruded. The result would undoubtedly be a marked intersection of the older veins characteristic of one zone by younger veins characteristic of a higher zone, as the source of the vein matter became deeper and deeper, through consolidation of the magma.

It appears to the author impossible, in view of the field evidence, to admit the alternative view of a batholitic mass in which the mineralisers and metallic ingredients have floated to the top and there collected in a reservoir, so that the metallogenetic epoch closed, not with the complete consolidation of the magma, but with the exhaustion of the reservoir of mineralisers and metals. The observed facts point to a general, if irregular, distribution of metallic ingredients and mineralisers throughout the whole mass of the magma, or at least through portions which have always possessed very different altitudes since they reached their *mise en place.*

We therefore appear compelled to adopt the view that the mass of the magma is limited. The substructure of the Heemskirk Range is not an ever-expanding mass of granite which is connected with the deeper portions of the earth. When once the limited mass of igneous material has passed into the completely solid state, all connection with the abyssal region has been effectively sealed up. This view implies the necessity for a very definite *bottom* to the greater part of Heemskirk *massif*, above which lie the magmatic foci whence the ore deposits have been expelled.

What then are we to call the Heemskirk *massif?* The only term applicable appears to be that invented by Professor Daly—chonolite. The definition of a chonolite, according to the creator of the term, is[1] :—

> " An igneous body (*a*) injected into dislocated rock of any kind, stratified or not ; (*b*) of shape and relations irregular in the sense that they are not those of a true dyke, vein, sheet, laccolite, bysmalite or neck ; and (*c*) composed of magma either passively squeezed into a subterranean or orogenic chamber or actively forcing apart the country rocks."

The form of the particular mass under consideration is probably extremely complex. The visible outcrop resembles that of a batholite or stock ; but, as has been indicated above, it is highly probable that this particular outcrop is that of a mass possessing some of the features of an irregular transgressive laccolite.[2]

1 *Loc. cit. supra.*, p. 499.
2 *Vide* A. Harker: "The Natural History of Igneous Rocks," p. 68, fig. 11.

It remains still to investigate the relationships of this chonolite to the other neighbouring outcrops of similar material, and to those masses which have not been revealed by erosion, but the existence of which we surmise from the observation of dykes and veins identical in character with those found in association with known outcrops.

IV.—The Relation of the Heemskirk Massif to Neighbouring Massifs of Similar Composition.

If the contention of the author with regard to the nature of the Heemskirk *massif* is sound, certain difficulties attend the discussion of its relationship to the other developments of granite at the North Pieman and the Meredith Range. These difficulties are not met with if the batholitic hypothesis with regard to the substructure of the Heemskirk *massif* is supported; for the outcrops mentioned (together with several others lying to the northward, and shown also upon one of the maps) may be regarded as the surface exposures of one great granite mass which underlies an extremely large proportion of Tasmania.

All geological evidence supports the view that all these granites are derived from the same source, and that they attained their *mise en place* synchronously.

Yet if a chonolitic form be assigned to each *massif*, a continuous subterranean connection between all of them cannot be assumed (except, of course, at an extreme depth below the surface).

An alternative hypothesis, which the author offers for consideration, as being of possible application to the region under discussion, is as follows:—

> The present visible outcrops of granite are the exposures of chonolites of limited extent, though possibly all of greater areal dimensions at some depth below the present surface than at this level. These chonolites extend in a horizontal direction below certain regions, and may in certain cases unite with others. The distribution of the several chonolites is determined by crustal or subcrustal stresses and their results. Hence the distribution tends to be more nearly lineal than that of the more symmetrical bodies (laccolites) which have been injected into unfolded or unfractured regions in other parts of the world. Chonolites, between which connections exist, are arranged along lines or zones of crustal weakness.

This hypothesis, since it states that any connections that may exist between neighbouring chonolites are distributed in accordance with zones of crustal weakness and even dislocation, demands some treatment of the question of the distribution of the igneous rocks and ore-bodies in space.

Without wishing to enter upon a full discussion of the metalliferous provinces of the region to which reference has been made, the author would draw attention to certain already ascertained facts which appear to have some bearing upon the question of the subterranean continuity of the granitic magma.[1]

Unfortunately, the study of the structural geology of the whole region is not yet sufficiently far advanced to permit of the discussion of the relation between structure and the distribution of the igneous rocks in detail. However, the distribution of the igneous rocks and the ore-bodies has been to some extent ascertained, and to this matter of distribution some reference should be made.

When the attempt is made, on the assumption of the essential intimate consanguinity of the acidic igneous rocks and the ore deposits[2], to follow the course of the Devonian intrusions of the ore-bearing magma, according to the method indicated above, certain striking facts concerning the distribution of mining fields, granite *massifs* and granite porphyry intrusions arrange themselves before us with singular simplicity.

Taking the Heemskirk *massif* as our starting point, and following the mining fields, we pass along a zone which is absolutely continuous in one direction. From Heemskirk we pass to the Comstock, thence to Zeehan, and on through the Fivemile, North Dundas, Colebrook, Rosebery and Mt. Farrell to Granite Tor. (Perhaps also the Barn Bluff field belongs to this mineralised zone.) Beyond Granite Tor the Dove River and Mt. Claude mineral fields carry on the line, which perhaps extends much further still.

The continuity is as remarkable as are the features of similarity and relationship between different ore-bodies in the mining fields mentioned. From point to point structural features vary in detail. These variations are, for the most part at least, introduced by local conditions, and have no genetic significance.

On the other hand, restricting our attention to the distribution of the acidic igneous rocks of Devonian age, we find on following the same course from the Heemskirk *massif*, that dykes of granite porphyry occur at Zeehan and North Dundas[1], and that granite itself outcrops massively at Granite Tor. Beyond these, and in general line with them, lie the granite porphyry at the foot of Bond's Peak, near the western boundary of the V.D.L. Co.'s Middlesex Block, and the granite mass north of the Dove River and west of Mt. Claude. Then, after a great interval, but still in line, comes the aplitic and pegmatitic granite of Anderson's Creek near Beaconsfield.

This coincident lineal extension of the acidic igneous rocks and mining fields appears to the author to be of the greatest significance, and to imply the existence of some lineal direction of weakness in the crust.

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1 The words 'granitic magma' are used to imply the magma from which the granite, *inter alia*, is derived, as has been explained above.

2 The consanguinity of the ore deposits cannot be doubted. A specimen of typical first-class galena ore, with its characteristic blebs of chalcopyrite, is of constant habit, whether it be obtained from Zeehan, the Fivemile, Mt. Farrell, or Mt. Claude.

3 Apilte has been also recorded in Zeehan, *Geol. Surv. Tas.*, Bulletin No. 8, pp. 27-28. A doubtful case of the occurrence of pegmatite has been observed to the south of Mt. Farrell, *Annual Report, Sec. Mines Tas.*, 1909, p. 83.

Some confirmation of this view is afforded by the general parallelism of distribution of the consolidation products of an earlier igneous invasion—that of Cambro-Ordovician time. The keratophyric tuffs and the spilite of Zeehan[1], the keratophyric tuffs and breccias of North Dundas[2], the schistose keratophyres or porphyroids and porphyrites of North Dundas, North-east Dundas, Rosebery, and Mt. Farrell are on this belt. The granite porphyry which extends from the north-west of Granite Tor to the Dove River, the schistose porphyry of Mt. Roland, and possibly even the epidote porphyrite of Beaconsfield, are to be taken into consideration with these others. The distribution of these related rocks is, at least, significant in support of this hypothesis. Along this line, or rather zone, are situated some of the most important mining fields of western Tasmania.

The relation of other mining fields and igneous rocks to those which have been mentioned demands passing notice.[3]

A prominent feature in the geology of the west coast region is the distribution of certain old igneous rocks—schistose tuffs, porphyries, porphyrites, syenites and granites, some of which occur along a meridional zone which extends from Mt. Darwin to the north of Mt. Black. Plutonic, intrusive, and effusive phases are all represented in this group (that of Cambro-Ordovician age already mentioned), the present distribution of which is clearly axial, even if the lineal arrangement has been accentuated by orogenic disturbances subsequent to consolidation.

The distribution of the Mt. Darwin, Mt. Jukes, Mt. Huxley, Mt. Lyell, Mt. Read and Chester mineral fields is, in general, coincident with that of this belt, but in the opinon of the author the ore-bodies belong to the Devonian metallogenetic epoch. The reasons for this statement cannot be here fully discussed. It suffices to state that the author believes that the mineralogical character of the ores of this belt of orogenic disturbance points most strongly to the necessity for classifying them with the Devonian ore-bodies. Hitherto there have not been found any igneous rocks along this belt which may be assigned to the Devonian intrusion. The author anticipates that these will yet be recognised, but he believes that the characters of the ore-bodies themselves are sufficient evidence of the existence of the Devonian granitic magma along this zone below the surface.

The two zones already mentioned appear to unite in the neighbourhood of Rosebery, not far from Mt. Black.

These two zones do not include within their limits a number of the important outcrops of granite and granite porphyry of Tasmania, nor do they embrace some well-known mining fields. Of these other mining fields the author has no detailed knowledge.

Having, however, indicated that there is one very well defined zone of intrusion and mineralisation between Heemskirk and

1 *Geol. Surv. Tas.*, Bulletin No. 8, pp. 15-19.
2 *Geol. Surv. Tas.*, Bulletin No. 6, pp. 16-18.
3 For they too extend along restricted zones. Between the zones of intrusion by igneous materials there are no known mineral fields.

Middlesex, it is interesting to observe that the outcrop of granite at the Meredith Range and Heazlewood, the granite porphyry at Mt. Bischoff, the outcrop of granite on the Blyth River to the east of the V.D.L. Co.'s Hampshire Hills Block, and again that of the Dial Range, are disposed in a zone which is approximately parallel to the former. The further investigation of this zone cannot at present be made.

There remains the North Pieman *massif*, which is not a prominent one, its surface being barely exposed by the total effect of successive cycles of denudation. With it are to be grouped the dykes on the coast line to the south of the Pieman Heads. The relationship of this *massif* to that of Heemskirk and that of the Meredith Range cannot be said to have been definitely recognised in any particular.

Whether the Meredith Range *massif* has any connection with the Heemskirk-Middlesex zone remains to be proved. Should the hypothesis here put forward be sound in principle, it will be of interest to investigate in the future the already recognised zone of intrusion, marked by the basic rocks which extend from the Colebrook Hill towards the Parson's Hood, for signs of the acidic magma.

V.—Conclusion.

From the several considerations discussed, the author would affirm that the relationships of the Heemskirk *massif* to its immediately surrounding rocks, to the associated dykes and ore-bodies, to certain other similar *massifs* and other ore-bodies, and to certain of the main structural features of Tasmania are approximately known. These relationships may be briefly summed up as follows :—

(1) *The relationship to the surrounding rocks.*—The granite outcrop is that of a massive transgressive intrusion of irregular form, but limited mass—that is to say, of a "chonolite" or irregular transgressive laccolite.

(2) *The relationship to associated dykes and ore-bodies.*—The granite is one of the products of the consolidation of a magma which gave birth, during its passage into the solid state, to a definite succession of fractional parts, all of which taken together constituted the essence of the magma at the time of irruption. Of these fractional parts the granite is the greatest in mass. The ore-bodies formed within the limits or in the immediate neighbourhood of the *massif*, are the latest-born products of the parent magma, and are zonally disposed with regard to the granite. The temperature of the granite at the period of ore-deposition has exerted a potent controlling influence upon this zonal distribution of metallic ores.

(3) *The relationship to other similar massifs and other ore-bodies.*—The Heemskirk *massif*, with its apophyses and cognate dykes and veins, is genetically related to the similar invading materials which made their irruption into many parts of Tasmania shortly after the close of the Silurian period. They are most directly related

with the igneous dykes and ore-bodies arranged along a zone extending from Heemskirk through Middlesex (perhaps even to Beaconsfield). Along this zone the granite itself outcrops at several points, the granitic apophyses at intermediate points; while the ore-bodies are distributed along a practically continuous belt of mineral fields. At some depth below the surface there is possibly complete continuity of the granite along this zone.

(4) *The relationship to certain of the structural features of Tasmania.*—While the actual form assumed by the Heemskirk *massif*, its apophyses, and its associated dykes and veins are all to be ascribed very largely to local structural conditions, the general distribution of these derivatives of the ascending magma has been decided by the existence of an old zone of crustal weakness. For no less remarkable than the lineal definition of this zone is its geological persistence. The granite of Heemskirk lies upon an axis of at least two igneous invasions, viz., those of Cambro-Ordovician and Devonian time. Still another invasion (of gabbro, norite, and serpentine) affected some portions of this zone at a period which is of Post-Silurian but pre-granitic age.

With the acceptance of this statement of the structure and relationships of the granite of the Heemskirk Range, many problems of interest and of economic importance suggest themselves. The author cannot here undertake the discussion of such problems, but desires to lay stress upon the necessity for regarding the granite *massifs* of western Tasmania as being themselves of limited extent in a vertical direction, and extending horizontally along lines of crustal weakness which are axes of igneous invasion.

The author desires to acknowledge the receipt of no small amount of information with regard to the distribution of the rocks here mentioned from Mr. W. H. Twelvetrees, from whom he has obtained permission to publish the accompanying maps.

EXPLANATION OF PLATES.

Plate XIII.

The sketch map of a portion of the western coast of Tasmania has been prepared to show the granite *massifs*, the acidic dykes and the distribution of the mining fields.

The circles indicate the positions only of the observed outcrops of the dykes. The direction of elongation of these is in many cases unknown. Hence it has been impossible to represent them by conventional symbols. Their magnitude at the surface is very variable and cannot be represented on the map. Thus the outcrop at Mt. Bischoff exceeds in mass the total of all the others shown.

The position of the principal mining fields is shown by names only, these being located centrally in each case.

Plate XIV.

All the known granitic *massifs* of north-western Tasmania are here shown in their relative positions. The relative sizes of the several outcrops are shown in all cases but those which occur at Anderson's Creek. In this place the several outcrops are all small, and they have been collectively shown by a single mass to comply with the demands of the scale of the map.

16.—THE ORIGIN OF CERTAIN CONTACT ROCKS WITH A HIGH CONTENT OF LIME AND MAGNESIA.

By L. KEITH WARD, B.A., B.E.

CONTENTS.

I.—Introduction.

In this paper the author proposes to deal briefly with certain rocks which in his belief owe their special features to the contact metamorphic effects of the Devonian granite of Tasmania.

No comprehensive study having yet been made of all the known developments of the Devonian granite and its border zones, the conclusions hereafter cited must necessarily rest upon the evidence acquired in localities in which investigations have already been made. Moreover, in the absence of quantitative chemical analyses of the granite the contact rocks themselves, and the rocks invaded by the granitic magma, the discussion of the question of the origin of the contact rocks can be based only upon the quantitative characters of these rocks and their actual mode of occurrence.

Nevertheless, the author believes that sufficient evidence has been acquired to justify the formulation of a very definite hypothesis regarding the genesis of certain peculiar mineral groupings, and to suggest the possibility of the formation of certain specific mineral aggregates from entirely different sources.

With regard to the essential processes involved the views of the author are in entire sympathy with the expressed opinions of Prof. A. Lacroix with respect to the contact phenomena exhibited by the granite of the Pyrenees[1].

Certain rock types mentioned are very similar to those described by Prof. A. Lacroix, though the source of the greater part of the lime and magnesia content of these rocks is, according to the hypothesis here advanced, distinct from that claimed by Prof. Lacroix for the similar rocks in the Pyrenees.

II.—Classification and Description of the Rocks.

A number of rather uncommon mineral aggregates are here considered together. The aggregates, as will be seen from the following condensed descriptions, are complex. Yet the occurrences of the complex aggregates are not isolated, for recurrences of essentially identical types have already been observed in different districts or different parts of the same district.

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1 Vide *Bulletins des Services de la Carte Géologique de la France*, Nos. 64, 71.
Also, Sir A. Geikie: "Textbook of Geology," IV. Edition, Vol. II, p. 780; and J. Geikie, "Structural and Field Geology," pp. 215 and 217.

The several rocks are grouped qualitatively according to their mineralogical composition, and this grouping is in entire harmony with their field associations. Two main groups have thus been established. Between them there are many significant points of similarity, and certain specific minerals are common to both groups. The characteristic feature of all the rocks is the high proportion of lime-bearing and magnesia-bearing minerals. These minerals of which these rocks are composed still await chemical analysis. It is therefore impossible to state the exact proportion of lime and magnesia contained in them. However, the lime-bearing and magnesia-bearing species are here tabulated and their recognised empirical formulæ shown. Their occurrence in the main groups and divisions here adopted is shown by the crosses in the table.

MINERAL.	EMPIRICAL FORMULA.	GROUP A.		GROUP B.	
		A	B	A	B
Diopside	$Ca\ (Mg, Fe)\ (SiO_3)_2$	×	×	×	?
Garnet (Grossularite)	$Ca_3\ Al_2\ (SiO_4)_3$	×	×		×
Vesuvianite	$H_2\ Ca_6\ (Al, Fe)_3\ Si_5\ O_{18}$	×	×		×
Serpentine	$H_4\ Mg_3\ Si_2\ O_9$	×	×		
Clinochlore	$H_8\ (Mg, Fe)_5\ Al_2\ Si_3\ O_{18}$		×	×	
Pennine	$H_8\ (Mg, Fe)_5\ Al_2\ Si_3\ O_{18}$ ..		×		×
Phlogopite	$(H, K, MgF)_3\ Mg_3\ Al\ (SiO_4)_3$ ..		×		
Actinolite	$Ca\ (Mg, Fe)_3\ (SiO_3)_4$	×	?	×	×
Epidote	$HCa_2\ (Al, Fe)_3\ Si_3\ O_{13}$	×			×
Axinite	$H\ (Ca, Fe, Mn)_3\ Al_2\ B\ (SiO_4)_3$ ..			×	×
Danburite	$Ca\ B_2\ (SiO_4)_2$			×	
Datolite	$H\ Ca\ B\ SiO_5$			×	
Fluorite	$Ca\ F_2$				×
Calcite	$Ca\ CO_3$	×	?	×	×

A.—Diopside and Chlorite Rocks.—The rocks here grouped together are somewhat complex in mineral composition and vary to a notable degree from point to point. They form, nevertheless, a very characteristic group of which the members can be recognised at first sight in the majority of instances. The different members of the group occur together at several places in the Comstock region, and some of them have been found at Anderson's Creek, near Beaconsfield. The following description of the salient features of these rocks will serve to indicate the mineralogical composition of the rocks under discussion, although, for want of space, the description of each type is brief.

(a). Diopside Rock.—This type consists usually of medium-grained to fine-grained crystalline aggregates of white or grey colour. The structure is sometimes columnar, and in some cases the columnar aggregates attain notable dimensions. These columnar portions occur in veins, traversing the parts which are of finer grain; and the columns, which are sometimes divergent, are arranged in directions which are in a general way perpendicular to the directions of the veins.

To the naked eye little else than diopside is visible in the bulk of the rock mass. Grains and aggregates of garnet and vesuvianite may at times be detected, and sometimes irregular patches of apple-green to yellowish serpentine. With the latter there is usually chromiferous magnetite of rhombic dodecahedral habit. Occasional specks and films of pyrite, chalcopyrite, galena and blende are visible.

In thin section the main mass of the normal rock is seen to be built up of hypidiomorphic granular diopside, with greenish-yellow garnet and vesuvianite. The diopside is the earlier mineral to crystallise. The serpentine appears to be truly authigenic. It has an ill-defined internal structure as revealed between crossed nicols and surrounds the magnetite and garnet.

(b). Chlorite Rock.—This group comprises several different members, the outward appearance of which is somewhat variable. They possess a habit which is sometimes massive and sometimes schistose, and they are disposed in veins which are closely associated with the diopside rock at more than one point in the vicinity of the Heemskirk granite *massif*. The most prominent constituent is chlorite, the hexagonal plates of which are at times as much as two inches in diameter. The colour is a rich green in unweathered specimens. The serpentine in the rock varies in colour from olive green to pale green, and is disposed in veins or throughout the mass of the rock surrounding the other constituents. A light greenish to yellowish brown mica—probably phlogopite—is a prominent constituent of certain bands of the rock, and the plates of this mineral are sometimes as much as an inch in diameter. They are difficult to distinguish macroscopically from the chlorite in many cases. Greenish or yellowish vesuvianite is sometimes visible to the naked eye, and garnet has been seen in clear hyacinth red trapezohedra.

The microscopical characters of these rocks vary considerably. The prominent constituent—chlorite—is not constant in character. Its colour is usually very pale green to very pale brown, according to the direction of the vibration of the transmitted light. The polarisation colours and optical character measured with respect to elongation are most often those of clinochlore. Yet, intergrown with this member of the chlorite family, or occurring in separate crystals, is another of the chlorites, probably pennine, with deep Berlin blue interference tints and positive elongation. Diopside occurs in small disseminated idiomorphic crystals, or aggregates of crystals, with hypidiomorphic outlines arranged in bands. The serpentine possesses no constant characteristics of internal structure. Vesuvianite is abundant in almost every variety. It is usually granular or euhedral, and shows the characteristic zoned and segmental structures. In one type it assumes a skeletal form with quadratic outlines being intergrown with optically continuous chlorite. The mica has ragged outlines. The normal order of crystallisation for the group is vesuvianite, diopside, phlogopite, chlorite, serpentine.

B.—Axinite-Actinolite-Calcite and Garnet-Vesuvianite-Actinolite Rocks.—The members of this group are best developed in Tasmania in two parts of the North Dundas district. The principal occurrence, and that which has best been exposed by mining operations, is that on the Colebrook Hill. A number of smaller developments are known in the part of the North Dundas tinfield which lies to the south-west of the Colebrook mine. With these occurrences the following description is concerned. A related occurrence would seem to be that of the Mt. Ramsay bismuth mine, in which the non-metallic gangue minerals are amphibole and fluorite[1]. In this material axinite was detected by the late Professor Ulrich. This occurrence has not been investigated officially by the geological survey, but the specimens obtained from it display undoubted genetic affinities with the rock of the Colebrook Hill.

(a). Axinite-Actinolite-Calcite Rock (Limurite).—The specimens to be obtained from the Colebrook mine show no essential features of difference from those of the Boulder mine, and the following description applies to both.

The rock is of very variable appearance and is commonly banded. The colour is usually violet or greenish, according to the predominance of axinite or actinolite, but is sometimes green and white when calcite carrying bands of actinolite is abundant. Bands of slate are often to be seen in the mass of the rock. Quartz may often be recognised, and, rarely, danburite and datolite. The grain is very variable, and so are the proportions of the component minerals.

The metallic minerals characteristic of the group are pyrrhotite, pyrite, arsenopyrite, chalcopyrite, with minor amounts of galena, blende, and tetrahedrite. Bismuth has also been detected in small quantities. These metallic minerals are either disseminated through the mass or are restricted to bands or lenses, or, again, they may entirely take the place of the non-metallic minerals which belong to the same composite whole.

The microscopical characters of the non-metallic portions are, as may be expected, very variable in different specimens. The axinite is always in idiomorphic or hypidiomorphic plates, which are often large. It shows the same undulose extinction as has been noted by Prof. Lacroix for the axinite of Arbizon and Montfaucon.[2] Actinolite appears in somewhat variable forms—stellate aggregates, sheaves, or separate acicular crystals, and in some cases forming more massive crystals, of which the borders are corroded. Colourless pyroxene is common in small, stout idiomorphic prisms, of which the outlines are at times corroded. Interstitial calcite and quartz are common and may locally predominate. Nests of radiating tufts of chlorite with negative elongation are fairly common.

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1 *Vide*: W. F. Petterd, "Catalogue of the Minerals of Tasmania," 1910, pp. 17, 74, 131, 132.
2 *Bull. Carte Géol. France*, No. 71, p. 59.

The order of crystallisation is actinolite, pyroxene, axinite, quartz, chlorite, and lastly calcite.

(b). Garnet-Vesuvianite-Actinolite Rock.—Traversing the bed of Gormanston Creek (in the North Dundas tinfield) at a narrow angle is a broad banded vein rock of variable composition, which is undoubtedly genetically allied to the limurite. A great portion of the vein is composed of felted actinolite, with which appear bands or lenses of unreplaced slate and strong bands of garnet or vesuvianite rock. Small axinite veins have been seen in immediate proximity to the lode.

Pyrrhotite, haematite, chalcopyrite, sphalerite and sometimes galena have been observed in association with the non-metallic minerals.

The actinolite shows features of similarity with that of the last sub-group, but the type here described is separated from the limurite on account of the presence of the garnet and vesuvianite. The brown garnet is not abundant, but the vesuvianite rock is in places massive. To the unassisted eye it has the appearance of massive garnet rock.

In thin section, however, the vesuvianite is at once recognisable. It forms large crystals of negative sign, with the zones and sectors characteristic of the species. The massive portions are most markedly zoned where they have projected into druses and the crystal terminations appear. Sometimes skeletal crystals are visible, enveloping minerals which fill the veins traversing the massive vesuvianite. Epidote, with pale brownish to greenish yellow pleochroism tints, forms large euhedral crystals or small anhedral grains. It is enveloped in the vesuvianite or projects into the cavities, which were filled at a later stage.

The later veins are of complex composition. Small euhedral crystals of colourless fluorite are visible in some. Calcite is common in the form of allotriomorphic plates, sheaves, divergent blades, or small granules intermingled with quartz. The quartz fills the interstices between the other minerals in single crystal plates or granular aggregates. Chlorite is occasionally visible in nests of divergent fibres which have the positive elongation and intense Berlin blue interference colours of pennine.

The normal crystallisation order is : Epidote, vesuvianite, fluorite, chlorite, calcite, quartz.

The association of this rock with the limurite of Arbizon has been noted by Prof. Lacroix[1].

III.—The Mode of Occurrence of the Contact Rocks.

The rocks thus classified and described occur in the immediate vicinity of the Devonian *massifs* of north-western Tasmania. They are found enclosed within the boundaries of either the sedimentary rocks invaded by the granitic magma or pre-granitic igneous rocks of basic composition.

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1 *Loc. cit. supra*, pp. 56, 57 and 60, 61.

The chlorite rocks described—Group A, Sub-Group (b)—are found at Anderson's Creek, near Beaconsfield, actually within the boundaries of the serpentine and pyroxenite of that district. The particular varieties observed are those of massive habit and complex mineralogical composition—serpentine, clinochlore and pennine being the dominant constituents. To the occurrence of this type within the basic igneous rock boundaries the author would attach special significance.[1]

The remaining groupings are almost invariably found within sedimentary *terrains*, but without exception in the immediate vicinity of basic igneous rocks either identical with or closely related to those which have been observed at Anderson's Creek. And the chlorite rocks themselves also occur thus in more than one observed locality together with the other types.

Looking firstly at the broader features of occurrence of these contact rocks within the sedimentary boundaries one cannot but be struck with certain outstanding facts :—

(*a*) The composition of the sedimentary rocks themselves is in no case that which might be expected when the high content of lime and magnesia in the aggregates under discussion is borne in mind. The sediments comprise no limestones nor any other highly calcareous rocks, as far as is yet known. They are somewhat variable in character, but the variations are only those which commonly exist between the normal non-calcareous slates and sandstones of a great sedimentary group. The contact rocks of different types occur, sometimes side by side, within sediments of the same or different characters.

(*b*) The neighbouring masses of basic igneous material are at no place more than a few chains distant from the observed developments of the contact rocks. These basic rocks are sometimes in large excess over the exposed acidic rocks with which the contact rocks are found, and sometimes are entirely dwarfed by the later acidic *massifs*.

(*c*) The acidic rocks are exposed at the present surface to very different extents in the localities from which the contact rocks have been recorded. Thus, the Heemskirk *massif* is a large outcrop of plutonic rock occupying a considerable area. At Anderson's Creek there are numerous intrusions of granite with aplitic and pegmatitic affinities within the serpentine, but no one of them is of large size. At North Dundas the place of the more deeply-seated types is taken by the intrusive equivalents—granite porphyry and quartz porphyry.

(*d*) The acidic intrusions themselves and the surrounding rocks also bear evidence of having been affected during

1 It would appear that the occurrence is not an isolated one. Similar surroundings are indicated for the occurrence of these minerals elsewhere. *Vide*: H. A. Miers, "Mineralogy," 1902, pp. 422, 495, 499, 505.

the final stages of consolidation, by issuing vapours and solutions rich in mineralisers. Thus at Heemskirk and North Dundas boron and, to a less degree, fluorine have attacked the minerals produced during the earlier stages of consolidation and the invaded rocks. At Anderson's Creek veinlets of scapolite within the aplite and pegmatite are attributable to the passage of chlorine through these masses.

Turning now to those features of occurrence which concern the contact rocks themselves, a number of other important facts present themselves for consideration.

These rocks are here called "contact rocks" for the reason that they are, in some cases at least, characteristic of the contact metamorphic aureoles which surround granitic invasions, and also for the reason that they are, in the opinion of the author, certainly to be regarded as genetically related to the observed acidic rocks of the regions in which they occur; yet certain reservations with regard to the use of the term must be made[1].

It is undoubtedly necessary to make these reservations, for the reason that contact rocks are usually regarded as being zonally arranged with some marked degree of regularity about the igneous rock causing the contact metamorphism and conformably with its boundaries.

In those cases which are here under discussion no such arrangement of the contact rocks is to be observed. In fact, the particular contact rocks here described are to be regarded as arranged radially rather than tangentially with respect to the igneous masses to which they owe their origin. Nevertheless, since they are in essential particulars identical with rock types which are known to be found in other parts of the world within the zones of contact metamorphic aureoles, as the result of the alteration of calcareous sediments by the operation of the emanations from acidic magmas, the name of contact rocks cannot be denied to them.

The predominant structural feature of these rocks is the lenticular or tabular form. That is to say, the contact rocks all have a vein-like habit, when the whole of the mass of any development is taken into consideration. And, where they are developed within sedimentary boundaries, the veins or lenses do not always coincide with the bedding planes of the enclosing rocks.

It is particularly to be noted that these remarks apply only to the rocks which are here being dealt with. There are other contact rocks of more normal type surrounding the granite at its immediate border, where the border has been observed, constituting the normal tangentially-disposed aureole. The contact rocks with which we are here specially concerned are found in the form

1 It would perhaps be better if some modification of existing nomenclature were universally adopted. Joseph Barrell, in writing of the geology of Marysville, Montana (*U.S.A. Geol. Surv. Prof. Paper* No. 57, pp. 116 *et seq.*), uses the word "metamorphism" in treating of cases wherein no change of composition in the altered rocks other than the expulsion of gas and water has taken place and "metasomatism" where some alteration in composition is produced by igneous emanations. The contact rocks here discussed are considered to have been produced by the "metasomatism" of Barrell.

of lenses and veins within this metamorphic aureole to the north of Trial Harbour. But they are not limited by the narrow zone in which the rocks of more normal type occur. The rocks of all the groupings mentioned in this paper extend far beyond the immediate contact zones into the rocks which surround the acidic igneous masses.

Their vein-like habit is accentuated by the fact that the several component minerals are often to be seen arranged in well-defined bands, in precisely the manner in which the constituents of mineral veins so frequently occur.

Even more significant are the occurrences of metallic minerals in the contact rocks of both groups at Comstock, Colebrook and North Dundas. When the ore-bodies of both the Comstock and Colebrook districts are examined, it is very noticeable that there are all degrees of inter-association of the metallic ores and the non-metallic minerals rich in lime and magnesia. The association is that of synchronously deposited components of one aggregate, and not that of the accidental admixture of the ingredients of two or more phases or epochs of deposition.

IV.—Hypothesis with Regard to Origin.

Since the form and surroundings of the various rock-types described appear not to be consonant with a derivation from calcareous sediments by the operation of magmatic emanations from the acidic reservoirs upon them, we must look elsewhere for the source of the very considerable lime and magnesia contents of the rocks.

It has been pointed out that the acidic magma of the Devonian period of intrusion is, wherever developed in western Tasmania, especially characterised by a content of mineralising agents. To the agency of these mineralisers, when they have been freed from the magmatic hearths, we must certainly refer the genesis of these contact rocks.[1] A Devonian granitic invasion has been claimed by the author to affect a zone which extends certainly from Heemskirk to Middlesex, and possibly even to Anderson's Creek. Along this zone all the rocks here shortly described are situated.

But the granite cannot reasonably be supposed to have provided the calcareous and magnesic content of these contact rocks. It is true that soda-lime felspars are present in the granite ; but it is also true that there are only the most sparing traces of lime-bearing minerals in the veins which are contained within the granite borders. Fluorite is undoubtedly rare within these boundaries.

Turning to the other facts known with respect to the occurrence of the contact rocks, we are confronted with the constant recurrence of the basic igneous rocks, which are certainly com-

1 This suggestion has long since been made for the limurite grouping. *Vide*: W. H. Twelvetrees "On the Nomenclature and Classification of Igneous Rocks in Tasmania." *Proc. A.A.A.S.*, Hobart, 1902, p. 305.

petent sources of lime and magnesia. Their presence, according to the hypothesis here proposed, provides the solution of the problem.

There is a constant difference of age between the basic and acidic igneous rocks to which reference has been made in this paper. The acidic types are of invariably later date, and are known to penetrate the basic ones in several localities.

It is of equal importance to note that the two invasions are coincident at several points (three at least)[1] along a well-defined axis of intrusion which had already been affected by much earlier igneous activity.

The magmatic emanations issuing from the acidic reservoir hearths and ascending towards regions of lower pressure have inevitably in many cases passed through the basic igneous rocks surrounding the acidic types. The relation of topographical development to original structure determines the actual phenomena of occurrence at the surface. At Anderson's Creek, erosion has removed the rocks surrounding the basic masses, and we see these in juxtaposition with the granite. In other places we find at the surface the contact rocks with which this paper deals traversing a complex of sedimentary rocks and the acidic and basic igneous masses which have penetrated them. There can be little doubt but that, with deeper erosion in such localities, features of occurrence for the contact rocks closely comparable with those now to be observed at the surface at Anderson's Creek would be visible at Comstock and North Dundas.

The point which it is desired to make is that the fissures or paths whereby the emanations from the granitic magma have ascended cannot but traverse the basic igneous rocks through some portion of their subterranean course, even where they are now seen at the surface to lie within the boundaries of rocks which have a sedimentary origin.

It is to the chemical reaction of the emanations from the acidic magma hearths upon the walls of fissures which traverse the basic rocks that the author would ascribe the greater part of the lime and magnesia contents of the contact rocks here described.

It is true that the contact rocks are found beyond the limits of the basic rocks, but such occurrences appear to the author to invalidate the hypothesis in no respect whatever. It is supposed that the magmatic emanations have acquired by a process of chemical assimilation a certain amount of the material of the wall-rocks of their conduits. If this assimilation took place before the issuing material came to rest, the transference of part of the igneous rock matter may have been sufficiently pronounced to carry the dissolved material beyond the limits of the rocks whence it was derived.

1Heemskirk, North Dundas and Anderson's Creek.

The variability of the contact rocks at any point will, upon this hypothesis, depend upon three main factors :—

(i.) The character of the acidic emanations.

(ii.) The variations of temperature and pressure along the conduit.

(iii.) The composition of the basic rocks traversed.

Of these factors, the first is most readily disposed of with regard to one group. It is probably the most potent influence in determining the type of the resultant contact rock. The presence of boron in the emanations is undoubtedly necessary for the creation of the limuritic type. What other mineralisers are predominant in the creation of the other types is not so clear.

The influence of the second factor cannot yet be said to have been determined in any detail.

The effect of the third factor can be investigated only by means of detailed analytical work, which has not yet been begun.

In connection with the hypothesis here advanced, it may be of interest to observe that a certain amount of collateral evidence may be cited.

If, as the author believes, the peculiar contact rocks here mentioned are formed by the assimilation of material from the basic rocks by the magmatic emanations issuing from the acidic magma hearths, it is logical to enquire whether the basic rocks themselves exhibit throughout their mass signs of the operation of these emanations, and whether other veins (apart from those with which this paper deals) in the neighbourhood of the basic rocks exhibit mineralogical characteristics which may indicate the derivation of some part of their contents from these rocks.

The basic rocks which attained their *mise en place* at a date slightly earlier than that of the acidic types are of extremely variable character in all the observed localities in which they have been observed. Perhaps the most widely distributed rock type is serpentine, though gabbros, norites, and pyroxenites, together with varieties into the composition of which amphibole largely enters are also common. The serpentine rock exhibits some differences of character at different points ; and although often almost entirely composed of serpentine itself it shows in places the presence of carbonated minerals and chlorite in addition. In the North Dundas district calcite, dolomite, and chlorite have been recorded [1] At Dundas a new mineral—stichtite—allied to pyroaurite[2] is found in the serpentine in veins, blebs and irregularly-shaped masses. The serpentine both at Anderson's Creek and North Dundas is traversed by numerous veins of asbestos and magnetite, in which these minerals are arranged in threads or columns at right angles to the fissures, which they fill after the manner of crustified veins. The presence of the acidic rocks in the immediate vicinity of these occurrences may be of causal significance.[3] It is at least possible

1 Vide: *Geol. Surv. Tas.*, Bulletin No. 6, p. 23.

2 This mineral was formerly supposed to be Kämmererite. *Vide*: W. F. Petterd, "Catalogue of the Minerals of Tasmania," 1910, pp. 167-170.

3 Compare the observations of J. A. Dresser in Eastern Quebec: "Economic Geology," Vol. IV., 1909, pp. 130-140.

that the whole process of serpentinisation—with the attendant development of such minerals as chlorite, stichtite, asbestos, fibrous or columnar magnetite, and occasional calcite or dolomite—may be ascribed to the influence of the magmatic emanations given off from the whole surface of the cooling acidic magma of later date. Or, in other words, the water of hydration wherewith the basic rock types have been converted into hydrated varieties may have been of magmatic origin. In support of this suggestion may be cited one peculiarly interesting occurrence. Near the summit cutting on the Comstock tramway in Zeehan a mineral vein has traversed a serpentinised basic (mica-gabbro) dyke in which asbestos veins occurred. The asbestos veins have been converted into veins of ferriferous dolomite in which the original structure is preserved. The mineral veins in this district being all ascribable to a single period of deposition, which immediately succeeded the acidic invasion, and when there was apparently still a considerable thickness of superincumbent rock above the point where deposition took place, it is significant that the asbestos had already been formed when the mineralisation occurred. In view of this known occurrence—to which will probably be found analogous examples as the geological survey of Tasmania proceeds—the serpentinisation appears to be due to juvenile not to meteoric waters.

How far amphibolitisation is a concomitant process with that of serpentinisation is not yet apparent. While it is possible that in some cases the amphiboles may have been developed in the basic masses by processes akin to those which have controlled the deposition of members of the amphibole family in the mineral veins at Mt. Ramsay and North Dundas, the problem demands much more detailed investigation in the field than that which it has yet received.

Turning from the consideration of the basic rocks themselves to that of the mineral veins located within their boundaries or in their immediate neighbourhood, we find several phenomena which have some bearing on the questions here discussed.

At the Adelaide Mine in Dundas, which is situated in immediate proximity to a considerable development of serpentine, some very magnificent crystals of crocoite have been obtained from the oxidised portions of the lode. These occur in the weathered part of a lode of which the primary constituents are dolomite, sphalerite, galena, pyrite, and a curious green mineral which appears to be a chromiferous sericite. This same green mineral has been found also at the Spray Mine and the Colonel North Mine at Zeehan.

The magnetite ore of the Comstock region carries traces,[1] and the iron ore of Anderson's Creek carries appreciable[2] quantities of chromium.

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1 *Vide*: G. A. Waller, "Report on the Iron and Zinc-Lead Ore Deposits of the Comstock District," 1903, p. 9.

2 *Vide*: W. H. Twelvetrees, "Report on the Mineral Resources of the Districts of Beaconsfield and Salisbury," 1903, p. 26.

In the immediate neighbourhood of the serpentinised mica-gabbro dyke of the Summit Cutting, Comstock tramway, Zeehan, to which reference has been made above, nickel has been detected in pyritic lode matter.[1] Nickeliferous pyrrhotite is known to occur at two other places in the North Dundas district.[2]

Niccolite has been found at the Five Mile[3] and also in the Zeehan field[4] in association with silver lead ore.

It will serve no useful purpose to multiply these examples, all of which appear to the author to support the view that the chromium and nickel contents of certain lodes are ascribable to the chemical action of the ore-depositing solutions upon adjacent basic igneous rock masses.

Enquiry along the lines here indicated leads inevitably to the consideration of the origin of the iron content, in addition to that of the nickel and chromium, of such ore-bodies as those mentioned. With respect to this question the author cannot here say more than that he believes only a portion of the iron to have been derived from the basic rocks themselves.

V.—Conclusion.

The acceptance or rejection of the hypothesis here advanced would seem to depend primarily upon the more detailed observation and explanation of the field occurrences of these rock types in the north-western part of Tasmania along the axes of igneous invasion which have some geological persistence. But much collateral support may be adduced from any other regions in which the sites of basic and acidic invasions have been coincident. The time interval between such invasions of igneous material is a matter of no significance. The acidic invasion must needs be the later, and the liberation of magmatic vapours and solutions from the acidic magma hearths is essential.

The evidence which may be claimed to have bearing on the whole question is such as may establish in any region the existence of lateral secretion by juvenile or magmatic waters, whether the material secreted give substance to metallic or non-metallic products.

It is to be expected that such evidence will in most cases have reference to the metallic ores, since the activity of so many geologists is directed towards the investigation of the ores of the valuable metals. The author would, however, venture the opinion that the detailed study of the alteration of basic igneous rock material by acidic intrusions of later date will afford much information of scientific value, the economic importance of which will not be negligible.

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1 *Vide*: G. A. Waller, "Report on the Zeehan Silver-Lead Mining Field," 1904, p. 83.

2 *Vide*: G. A. Waller, "Report on the Ore Deposits (other than those of tin) of North Dundas," 1902, pp. 65, 66.

3 *Ibid.*, p. 60.

4 *Geol. Surv. Tas.*, Bulletin No. 8, 1910, p. 52.

17.—THE FAULTING DUE TO THE LATE TERTIARY UPLIFT IN EASTERN AUSTRALIA.

By E. C. ANDREWS, B.A., F.G.S.

18—PRE-CAMBRIAN AREAS IN THE NORTH-EASTERN PORTION OF SOUTH AUSTRALIA AND THE BARRIER, NEW SOUTH WALES.

By D. MAWSON, D.Sc.

[PLATES XV., XVI.]

At the Adelaide (1907) meeting of the Australian Association for the Advancement of Science I communicated a paper defining the age as Cambrian of a series of sedimentary rocks flanking the older schistose and gneissic areas of the Barrier Ranges, N.S.W. In places this series was noted to be highly metamorphosed, thus complicating the work of distinguishing older formations. Several sections in the Barrier Ranges were noted which strongly favoured a pre-Cambrian age for the major portion of the granite and metamorphic belt. More conclusive, however, is the data furnished in the neighbouring portions of South Australia, where the stratigraphy is similar. Evidence is now available to show that there are larger areas of pre-Cambrian rocks in the north-eastern portion of South Australia, even crossing the New South Wales border in the vicinity of Broken Hill.

In a recent thesis[1] on this area I have distinguished the predominant formations as the "Torrowange Series" (Cambrian) and the "Willyama Series" (pre-Cambrian). The object of this contribution is to place on record the two sections shown in the accompanying plates. The evidence incorporated therein definitely determines the existence of pre-Cambrian areas and assigns that age to the Willyama Series.

The first of these sections (Plate I) refers to the neighbourhood of Olary. This is in South Australian territory, at no great distance west of Broken Hill. In this vicinity I have followed the junction of the Cambrian and pre-Cambrian rocks for many miles. The section given is semi-diagrammatic, illustrating the stratigraphy near Bimbowrie head station, some 15 miles north of Olary. There a syncline of Cambrian sediments lies between and rests upon a pre-Cambrian basement. This syncline is about $3\frac{1}{4}$ miles across.

The pre-Cambrian terraine consists chiefly of a ternary granite of medium grain size, and of gneissic and schistose products resulting from the dynamo-metamorphism of the same. Even the least altered granite shows the effects of stress when examined in microscope sections. Basic ilmenitic pegmatites and acid beryl-bearing pegmatites are features of the pre-Cambrian areas. Somewhat

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1 Now in process of publication.

altered doleritic intrusions are found in both the newer and the older series.

The Cambrian basin comprises an immensely thick series of breccias, conglomerates, and true glacial tillite ; with these are associated repeatedly recurring grits, sandstones, slates and calcareous beds. A single granite boulder in the tillite outcrop measures 22 feet in length. Overlying the pre-Cambrian granite at the Boolcoomatta head station is a granite breccia several hundred feet in thickness. This breccia is composed of fragments of the underlying granite. As is the case in the region near Adelaide, ilmenite grains are abundant in these basal Cambrian beds, in some places becoming so concentrated as to form bands of almost pure ilmenite rock.

The second section (Plate II) refers to an area lying west of Lake Frome, near the mining district of Yudnamutana. Here I have determined a belt of pre-Cambrian rocks surrounded by steeply dipping and undulating Cambrian sediments. The section is a semi-diagrammatic representation intended to make clear the salient geological features.

The pre-Cambrian rock types are here more varied than at Olary. Granite, gneiss and schist predominate. Notably in this locality there is an effusive equivalent of the granite. This is a striking quartz porphyry, in which the quartz idiomorphs are of a faint bluish tinge. Another allied rock is a felspar porphyry with porphyritic pink orthoclases. Amongst these igneous rocks are bands varying from a few inches to several hundred yards in width of micaceous schists, owing their origin, apparently, to pneumatolitic alteration of portion of the igneous rock itself. These schists may be composed either exclusively of mica, or more usually mica accompanied by a greater or less proportion of blue or colourless corundum, pleonaste, or magnetite. Large nodules of black tourmaline are often met with, and when this is the case there is frequently a noticeable proportion of yellow monazite. Veins of coarse white apatite are also known in the mica belts. At the largest of these outcrops, that between Mt. Pitts and Mt. Painter, a transition to a very tough cordierite, sillimanite, corundum schist takes place. Several miles south-east of Mt. Painter the schists are more usually types suggestive of the metamorphism of sedimentary rocks. The sedimentary origin is quite obvious in the case of a very thick quartzite series met with in the neighbourhood of the rock hole on Arkaroola Creek, where the latter takes a sudden turn across the strike of the beds. This quartzite is light grey in colour, fine-grained and compact. The bedding is distinctly marked by fine dark lines caused by concentration of ilmenite grains along the bedding planes. Beautifully ripple-marked surfaces are frequently exposed on the cliff faces.

Intrusive basic igneous rocks are of common occurrence in this pre-Cambrian series. These are partly coarse and fine grained amphibolites and less altered uralitised dolerites and basalts. The latter were observed to be amygdaloidal at an outcrop on the Arkaroola Creek, near the quartzite to which reference has been made. About one mile south-west of Mt. Painter there is an extensive outcrop of very coarse amphibolite in which huge crystals of clove brown sphene are abundantly scattered; individual crystals have been got several pounds in weight.

Undoubtedly the neighbourhood of Mt. Painter has, in pre-Cambrian times, been the scene of great igneous activity, both acid and basic effusive and plutonic types of that age are there represented. There has been, also, post-volcanic activity to a marked degree. This is evidenced, firstly, by pneumatolite metamorphism producing the micaceous corundum and spinel-bearing belts above noted; secondly, by ore and quartz reefs such as result from geyser action; these latter occur on a truly magnificent scale. The most notable of these extends through Mt. Painter itself, its great hardness determining the relief. This reef is specially notable on account of the uranium ores which it contains.

Flanking these pre-Cambrian highlands are undulating plains and hills composed of Cambrian sediments. On the north-west side the basal beds are well exposed between the Daly mine and Freeling Heights. Coarse boulder conglomerates are here conspicuous. Amongst the boulders are fragments of the quartz porphyry occurring massive in the adjacent pre-Cambrian series. As usual elsewhere, also, ilmenite and magnetite grains are abundant amongst the finer material. Above are grits, slatey, and calcareous beds. An immense thickness of these is exposed in the Flinders Range, to the west, as already shown by Mr. W. Howchin.[1] The Cambrian glacial till horizon outcrops at intervals to the west, for instance, at "The Red Hill," near the Wheal Turner Mine, at Muller's Hill, and in the vicinity of the Mt. Rose Copper Mine. At Muller's Hill I picked up seven distinctly glaciated pebbles in a few minutes.

Mr. W. Howchin[2] has already drawn attention to intrusions of a basic magma in the Cambrian strata of the Flinders Range. Large intrusions of this nature are met with at Yudnamutana and at the Daly and Stanley Mines. These are genetically connected with workable copper deposits.

Intrusions of normal granite into the Cambrian sediments have not been observed, though a great dyke-like tongue of an acid character, situated two miles south of Umberatina, extends east and west for several miles. This has resulted from the crystallisation of a magma highly charged with gaseous products. This deduction is evidenced partly by the porosity of the rock,

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1 *Proc. A.A.A.S.*, Adelaide, 1907.
2 *Loc. cit.*

and more directly by the great abundance of liquid and gaseous inclusions in the adularia felspar which comprises the greater part of the rock. The fabric of this rock in the major part of the outcrop is typical of entectic crystallisation. Besides a little quartz and a predominance of adularia, the constituents include some sphene and rather abundant tourmaline ; the latter often in graphic intergrowths.

The south-east margin of the pre-Cambrian area, where examined on Arkaroola Creek, is flanked by a coarse breccia consisting chiefly of boulders and angular masses of the adjacent pre-Cambrian quartzite.

In both the localities described there is a marked difference in the vegetation and topography of the Cambrian and pre-Cambrian areas. The latter are much more rugged and the outcrops more rocky. These rocky hills support abundant scrubby vegetation, such as acacia and mulga ; even mallee and pine trees are met with on the more elevated ground.

The low undulating hills and plains country, more typical ot the Cambrian areas, support abundant herbage and salt bush ; whilst scrub growth is less conspicuous.

EXPLANATION OF PLATE XV.

Figs. 1 and 2 of plate are illustrations of the typical appearance of Cambrian as distinct from pre-Cambrian outcrops in the Yudnamutana district. In the former the absence of vegetation is not truly natural, being the outcome of long-continued overstocking and the rabbit pest.

REPORTS OF THE RESEARCH COMMITTEES.

On (*a*) Alkaline Rocks ; (*b*) Glacial Phenomena ; (*c*) Structural Features of New Zealand.

ALKALINE ROCKS OF AUSTRALIA.

Resolutions carried, Brisbane, 1909 :—

(*a*) That a Committee of the Geology and Mineralogy section be appointed to investigate the alkaline rocks of Australasia, consisting of Professors David and Marshall, Dr. H. I. Jensen and Professor Skeats (Dr. Jensen, Secretary).

(*b*) That a sum of £50 be set aside for the further investigation into the nature and origin of the alkaline rocks of Australia.

1.—REPORT OF ALKALINE ROCKS RESEARCH COMMITTEE.

By H. J. JENSEN, D.Sc., Secretary of the Committee.

ALKALINE rocks being plentifully represented in all the eastern States of Australia, and research in many parts being desirable, it was decided not to allocate the grant for any one single locality, but to assist anyone pursuing such work.

The regions in Queensland known to be partly of alkaline rock and requiring investigation were :—

(*a*) The Main Range, Ipswich district.

(*b*) Gladstone district.

(*c*) Yeppon, near Rockhampton.

In New South Wales :—

(*a*) The Barrigan Tinguaites.

(*b*) Mounts N. and S. Obelisk (head of Clarence River), and other hills south of Mt. Wilson in the McPherson Range.

(*c*) Some rocks of alkaline nature were subsequently discovered by Mr. Benson near Murwillumbah.

Victoria and Tasmania :—

Many localities in Victoria ; Port Cygnet in Tasmania, and so on.

In addition, it was known that alkaline and sub-alkaline rocks occur in several Pacific Islands, and Professor Marshall, with his students, volunteered to undertake investigations in these remote regions.

In Queensland Mr. R. A. Wearne was willing to continue his work ; in Victoria Professor Skeats, Mr. Summers, B.Sc., and several of Professor Skeats' students were available.

In New South Wales and Tasmania no one was found desirous of taking up this class of work.

The Committee accordingly recommended a grant of £20 for Professor P. Marshall's party, £10 for Mr. H. L. Summers, B.Sc., and £10 for Mr. Wearne.

The recipients of these grants have all done good work. The results of Professor Marshall's work have already partly appeared in several papers in the Transactions of the New Zealand Institute (Geology of Raratonga and Aitutaki, and Geology of Mangaia.) He also furnishes an abstract report appended to this.

The result of the work of Professor Skeats' party appears in an abstract report appended, and Mr. Wearne read before this meeting a paper entitled "Notes on the Alkaline Eruptive Rocks of West Moreton, Queensland."

Of the £50 grant only £40 has been voted up to the present, but the work of the Committee will probably continue.

FIG. 1.—PRE-CAMBRIAN COUNTRY, ARKAROOLA CREEK.

FIG. 2.—CAMBRIAN COUNTRY, NEAR OLARY.

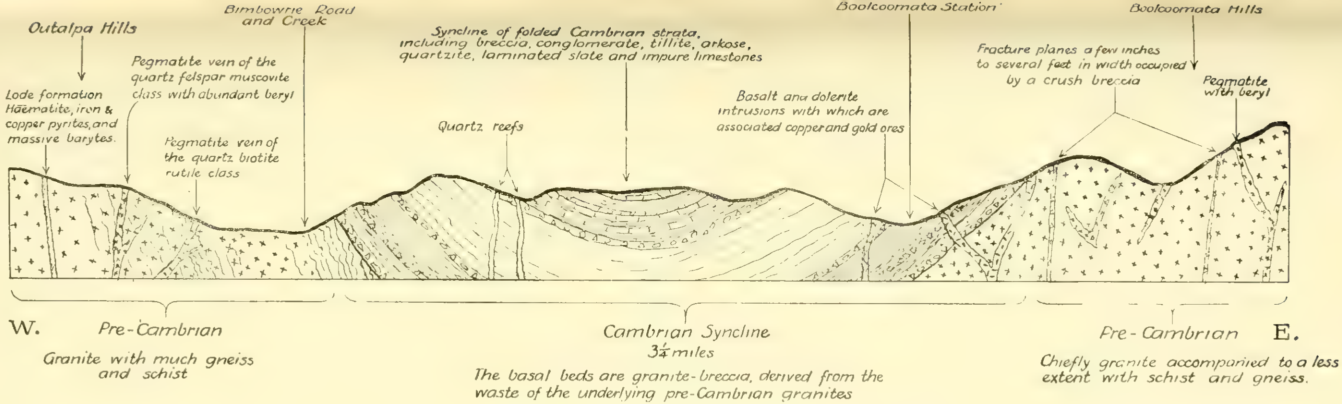

FIG. I.—GEOLOGICAL SKETCH SECTION, NEAR OLARY, S.A.

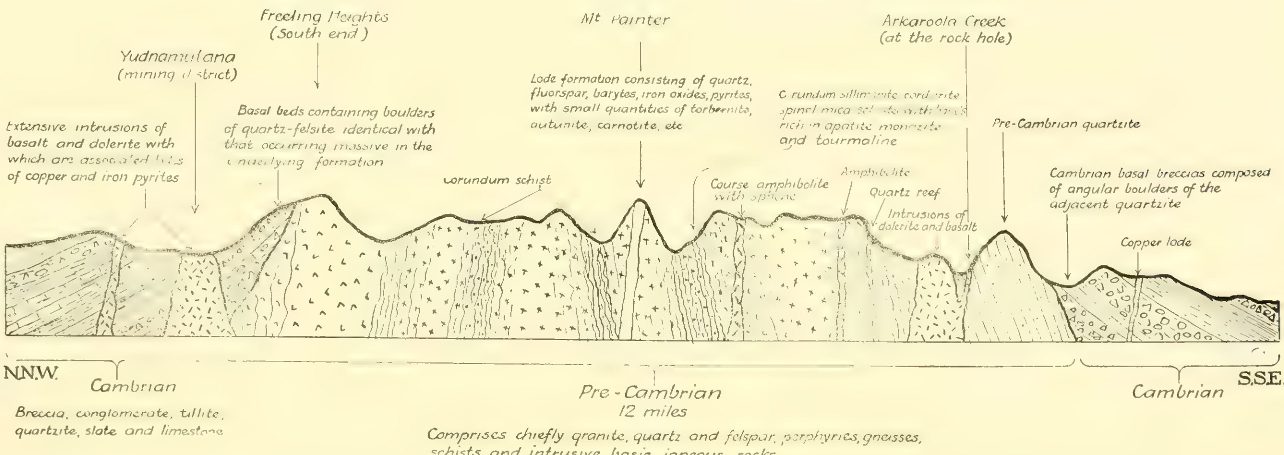

FIG. 2.—GEOLOGICAL SKETCH SECTION FROM YUDNAMUTANA TO ARKAROOLA CREEK.

The separate reports detail what has been done in Victoria and New Zealand. Mr. Wearne's work in Queensland is fully accounted for in his paper. I have now only to state what other observations have been made on alkaline rocks.

In 1909 I went down the South Coast as far as Bega on a soil collecting trip. At the foot of Mount Dromedary occurs a complex of basic igneous rocks of great interest, comprising quartz-diorite, monzonite, orthoclase gabbro, essexite and other species. At Brogo occurs a similar but smaller complex. Dr. Woolnough has also informed me that he has had anorthoclase-granite from Dromedary. I believe that these basic sub-alkaline rocks are the plutonic equivalents of the hypabyssal orthoclase-diorites of Milton, and of the volcanic sub-alkaline lavas of the Kiama-Jamberoo area. As we pass from the geosyncline of the Sydney basin towards the geanticline of Eden-Monaro and Gippsland we get rocks of a more and more deepseated origin exposed by erosion. Not having done any detailed work, I only propose to indicate the problem.

Early in 1909, Mr. Benson discovered alkaline riebeckite trachytes at Murwillumbah. On a later visit I observed a dyke of alkaline trachyte in the same locality. As Dr. Woolnough finds the great bulk of the rocks of Mt. Warning to belong to a different family, it would be interesting to find the relations of the alkaline rocks there to the other rocks.

Recently Professor R. A. Daly published an interesting paper on the possible origin of alkaline rocks, in which he suggested that they are differentiated from a normal magma which has been fluxed by coming into contact with limestone. The theory is a fascinating one and very plausible on physical, chemical and metallurgical grounds, but it fails altogether in the Australian region from the standpoint of field geology. Professor Daly makes it appear that there are limestones in proximity to the Warrumbungles, Glass House Mts., and Nandewars which is not the case, while the best instance he could have chosen in support of his theory is omitted, namely, the alkaline and sub-alkaline rocks of the Kiama-Jamberoo area. To make this theory apply to Australian regions he will have to assume mixture with deepseated limestones not outcropping in the volcanic regions, an assumption just as impossible of direct proof in most localities as the one which I made in outlining my theory, and which he condemns on grounds of insufficient evidence. I believe that future research will prove my theory well-founded and applicable in many regions, and Daly's applicable in others, and a compromise between them in most. Workers on alkaline rocks will do well to look for evidence for and against each. The minerals and inclusions of alkaline rocks will furnish the best clues. The artificial preparation of the minerals of alkaline rocks would also be helpful.

2.—SUMMARY OF WORK ON THE ALKALINE ERUPTIVES OF S.E. QUEENSLAND.

By R. A. WEARNE.

RESEARCH work on the alkaline eruptives was carried on in the following areas :—

1. MAIN DIVIDING RANGE, near Cunningham's Gap.

MT. MATHESON (2660 ft.) was found to be the main focus of the trachyte eruptions of this district. It is composed of trachyte very similar in character to the comendite of Jensen from Mt. Edwards, surrounded by tuffs and huge masses of trachyte agglomerate.

MTS. SPICER & MITCHELL (4000 ft.) The section exposed on the escarpment of Mts. Spicer and Mitchell was found to consist of alkaline trachyte, tuffs and breccia for a thickness of 1500 ft. surmounted by 1000 feet of olivine basalt.

2. MT. ALFORD (2200 ft.), about 7 miles to the east of the Main Range, was found to consist of andesites and quartz-diabases, intruded by rhyolite dykes.

GLENNIE'S PULPIT, on the north-western front of Mt. Alford, was found to be the plug of a rhyolite centre of eruption which intrudes the andesites of that mountain.

3. MT. GREVILLE (2700 ft.) was found to consist of grorudite intruded by decomposed basalt dykes.

4. MT. MAROON (3300 ft.) was found to consist of rhyolite

5. MT. BARNEY (4300 ft.) was found to consist of rhyolite intruded by basalt and dolerite.

Volcanic Sequence.

The volcanic sequence was found to be—

1. Trachytes.
2. Andesites and Dacites.
3. Rhyolites.
4. Basalts.

(1) Andesite intrudes trachyte at the Main Range.
(2) Rhyolite intrudes trachyte at the Main Range, near Cunningham's Gap.
(3) Rhyolite intrudes andesite at Mt. Alford.
(4) Basalt intrudes rhyolite at Mt. Barney.

Age of Eruptions.

The age of the volcanic eruptions was found to be Trias-Jura contemporaneous with the uppermost portion of the Walloon stage of the Ipswich coal measures.

Proofs.—(1) Water-worn trachyte pebbles were found imbedded in Trias-Jura conglomerate of the Walloon stage at Laidley Valley and Mt. Flinders. (2) Volcanic tuff containing Trias-Jura plant imprints (*Taeniopteris Daintreei*) was found associated with basalt at the "Hip Roof," a meridional razor-back between the Little Liverpool Range and the Main Range, near Toowoomba.

3.—REPORT ON DISTRIBUTION OF ALKALINE ROCKS IN THE PACIFIC.

By PROFESSOR P. MARSHALL.

As a member of the Alkaline Rocks Research Committee it was arranged that I should as far as possible study the distribution of alkaline rocks in the Pacific Islands.

I was able to visit Raratonga and Mangaia in the Cook Group, and Tahiti, Raiatea and Huaheine in the Society Group.

The petrographical descriptions of the rocks collected appear in a separate paper submitted to the Geological Section.

As a summary of general results of my work it may be stated that alkaline rocks have a wide distribution in the Central Pacific. They certainly occur at Raratonga, Aitutaki, Raiatea, Huaheine, Tahiti, Savaii, Upolo and Tutuila. The aspect of Moorea, Tahaa and Borabora, when compared with Raiatea and Huaheine, strongly suggests that these islands also are crowned with phonolite lava flows, but no specimens have yet been obtained from them. In Mangaia Island I found no volcanic rocks except highly decomposed basalts ; specimens sent to me from Atiu by Major Large are also basaltic.

At Tahiti there is a great variety of alkaline rocks both plutonic and volcanic. It is highly desirable that this large island should be fully explored by geologists. At present we do not know the relations of the plutonic to the volcanic types. Ellis has mentioned granite from Maupiti and a quartz-felspar rock from Borabora. A specimen of gabbro was given to me by Frère Alain as from the island of Raiatea, so it is evident that work of an important nature is to be done in these islands. Future researches may throw much light on the antiquity of land areas in the Central Pacific.

My discovery of the rocks at Arue corresponding with the hauynophyre of Lacroix I regarded as of great interest, and it was eight months later that I found that the distinguished French petrologist had received specimens of a similar rock from other parts of the island, destitute, however, of the hornblende.

In Raratonga, Huaheine and Raiatea the alkaline rocks are far later than the decomposed basalts upon which they rest, and I could find no rocks of other kinds on their surface. This appears to me to prove that the alkaline rocks are the latest eruptives of this area, but still of great age, for denudation has entirely destroyed all signs of the craters from which these immense lava flows issued.

In each of the islands visited the alkaline rocks were closely associated with extremely basic effusives. Some of these are so basic that Lacroix refers them to a species of picrite. Whether the different species of rock in Tahiti have resulted from differentiation is a question for the future. Lacroix evidently thinks this is the case, though he admits the incomplete nature of the collection. The constant association of the two main types mentioned in the islands visited truly supports this view.

4.—ALKALINE ROCKS OF THE COOK AND SOCIETY ISLANDS.

By PROFESSOR P. MARSHALL, M.A., D.Sc., F.G.S Otago University, Dun., N.Z.

[PLATES XVII -XIX.]

As a member of the Committee appointed to investigate the alkaline rocks of Australasia it was arranged that I should as far as possible study the distribution of these rocks in the Pacific. I was able to visit Raratonga and Mangaia Islands in the Cook Group, and Tahiti, Raiatea and Huaheine in the Society Group. At Raratonga I stayed for six days—February 15th to February 22nd, 1910 ; at Tahiti part of two days—February 25th and 26th ; at Raiatea part of two days—February 24th and 28th ; at Huaheine, a few hours on February 27th ; at Mangaia, a few hours on March 3rd. This time, of course, did not allow of a complete inspection of any of the islands, though Raratonga and Mangaia were traversed more widely than the others. The following notes will give an idea of the distribution of alkaline rocks in these islands :—

TAHITI.—The time at my disposal did not allow of a visit to the Papenoo Valley, and I can, therefore, add nothing to the descriptions of plutonic rocks given by Lacroix. Frère Alain, Principal of the Brothers School at Tahiti, kindly gave me specimens of rocks that he had gathered there. These specimens are rolled pebbles. They include nepheline syenite, mica syenite, tinguaite and theralite, which agree satisfactorily with the specimens described by Lacroix. In one specimen the hornblende is almost entirely replaced by irregular plates of biotite, while the pinkish augite is surrounded with a green mantle ; the sphene is surrounded by a black border of magnetite.

Lacroix has lately described a hauynophyre from the Papenoo Valley and from Vairao. I found a similar rock in great quantity at Arue, six miles south-east of Papiete along the coast. In general it answers well to the description of the Papenoo specimen, for not only is the hauyne in moderately large crystals, but in small ones as well, and black inclusions are crowded on the margin. There is also this difference, hornblende is present in considerable quantity in my specimens, though in those of Lacroix " mais l'amphibole y manque toujours." There is also a small quantity of felspar, but I cannot identify the species. Lacroix observes that the glass, which is very abundant, is heterogeneous, varying from brown to colourless. In all my specimens it is colourless, and the question arises whether such an abundance of colourless glass could form the unindividualised residue of such a rock. To test the nature of this material some of the powdered rock was warmed with dilute nitric acid. It was found that 68·90 per cent. of the rock passed into solution. The dissolved matter contained $SiO_2$33·87, $Al_2O_3$16·48, $Fe_2O_3$3·12, CaO 1·47, TiO_2·56, alkalies 10·20, H_2O·3·20.

When allowance is made for the hauyne and iron oxide dissolved, the remaining matter has the probable composition SiO_2 32·57, Al_2O_3 15·88 ; alkalies 9·30, H_2O 3·20, or a percentage composition of SiO_2 53·1, Al_2O_3 26·9 ; alkalies 15·0, H_2O 5·3. This approaches quite closely to the composition of Analcite SiO_2 54·5, Al_2O_3 23·2, soda 14·1, H_2O 8·2. Such chemical treatment as that employed does not dissolve glass, and the chemical effect certainly suggests that some easily decomposed isotropic mineral, probably analcite, forms the base of the rock. A bulk analysis gave the following result :—

	1	2	3	4
SiO_2	48·64	49·52	48·70	42·46
Al_2O_3	17·04	19·40	19·12	18·49
Fe_2O_3	3·32	2·08	2·40	3·35
FeO	6·14	5·15	4·77	6·31
CaO	5·79	6·51	5·25	8·70
MgO	2·58	2·12	1·54	3·64
K_2O	3·02	3·85	3·45	4·58
Na_2O	7·16	7·15	7·83	7·12
TiO_2	2·06	3·30	2·37	
Cl_2	·20	·15	·13	·52
H_2O	3·20	·50	2·80	2·31
SO_3	·04	·41	·83	2·44
	99·21	100·14	100·19	99·92

1. Hornblende type from Arue.
2. Lacroix type I. from Papenoo, *Bull. Geol. Soc. de France*, 1910, p. 115.
3. Lacroix type II. from Vairao.
4. Melfi, Rammelsberg, *Zeitschr. d.d. Geol. Gesell*, XIII., p. 273. 1896.

It will be seen that my analysis shows a negligible quantity of sulphur and a distinct amount of chlorine. This indicates that the blue isotropic mineral is sodalite, not hauyne, as it was identified by Lacroix, whose analysis gives a higher percentage of sulphur. The rock contains a considerably higher per centage of SiO_2 than those quoted by Lacroix from other localities, and more than the amount in the additional analyses collected by Rosenbusch (" Elemente de Gesteinlehre," 2nd ed., p. 372). On the other hand it is too basic for the ordinary rocks with sodalite. Even the phonolitic types are much more acid. The lowest silica percentage that I can find recorded in a sodalite-bearing rock is in that from Mopanui (Dunedin, New Zealand), which has 56.40 per cent. of silica, and another related rock from the same locality 55.66. Lacroix, making use of the American classification, places his hauynophyre in the Essexose sub-rang, where it is associated with rhombporphyry, theralite, essexite and phonolite.

TAHAA.—The only rock obtained from this island came from Rei Point, on the north-east side. It is an extremely coarse dolerite. The earliest mineral to form was olivine, but the grains are usually rounded; they are often stained with limonite. Irregular grains of brownish augite and crystals of felspar (labradorite) constitute the rest of the rock except for rather numerous crystals of menaccanite. There is said to be a large outcrop of this rock, which is of a light grey colour.

Huaheine.—A dense greyish-green rock. It consists mostly of nepheline. Some of the crystals, though small, are distinctly idiomorphic; they are associated with a quantity of irregular ægerine, which almost surrounds them and forms irregular patches. These patches are embedded in a fine-grained clear matrix, which is composed of granular allotriomorphic nepheline. In the clear matrix there are small grains of magnetite often with cossyrite or katoforite; or the amphibole may occur alone in angular grains in the clear matrix.

The rock forms conspicuous lava flows crowning Pahiraia, and apparently other hills such as Tahateao. An analysis showed that it had the following composition:—

SiO_2	59·04
Al_2O_3	16·21
Fe_2O_3	1·04
FeO	2·64
CaO	1·93
MgO	·24
K_2O	6·59
Na_2O	9·78
H_2O	1·60
TiO_2	·76
Cl_2	·22
	100·05

A basalt occurs largely as boulders in the stream, but it could not be found *in situ*. It contains much coarse and idiomorphic olivine, a little idiomorphic augite, felspar that is probably labradorite, in small and ill-defined crystals. There is a great deal of dusty magnetite and minute granular augite between the felspars.

Boulders of a highly vesicular rock with large inclusions of olivine were very common. This rock appears to correspond with the felspathic picrite of Lacroix. The olivine masses are granular, and are embedded in a coarse ground mass consisting mainly of augite with microlites of labradorite and ilmenite.

Raiatea.—Mt. Tapioi.—A dense greyish-green rock without conspicuous phenocrysts. In section it is seen that about nine-tenths of the rock consists of felspar in crystals, which are occasionally 1 m.m. long, cracked transversely and often bent. The ægirine is very pale green, with an extinction angle of 40-45 degrees; magnetite is quite abundant and is often associated with the pyroxene. A little apatite in relatively large prisms. The small quantity of nepheline that is present is slightly decomposed and much cracked. It is intercalated between the felspar prisms, and quite allotriomorphic. The rock agrees closely with that described by Lacroix from Vairao in Tahiti. The composition of the rock is given on the following page. (Pl. xviii., fig. 2 and Pl. xix.).

A lava flow of this rock crowns the top of Mt. Tapioi, which is 968 feet high. The lava flow is nearly 200 feet thick, and has a characteristic steep escapement. It rests on phonolitic scoria and was almost a horizontal flow. Beneath the phonolite scoria, which is 50 feet thick, there is basalt completely decomposed into red clay. (Fig. 1).

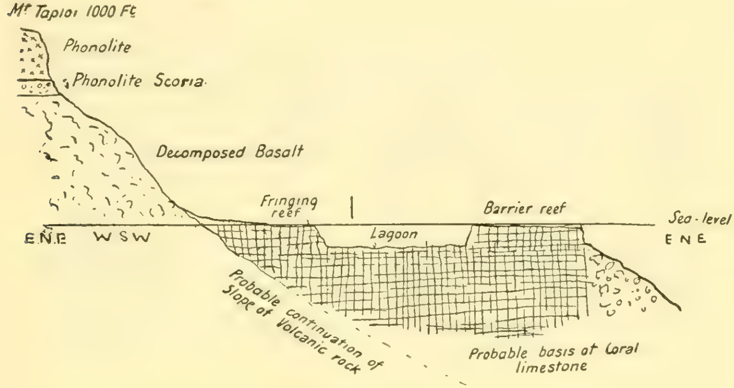

FIG. 1.
GEOLOGICAL SECTION MT. TAPIOI, RAIATEA.

A fine-grained basalt occurs south of the harbour of Avarua. It outcrops at the sea-level. It contains a few phenocrysts of labradorite. The greater part of the rock is extremely dense, and consists mainly of microlites of labradorite with small crystals of olivine stained yellow with limonite and minute grains of a colourless pyroxene. There is a great deal of magnetite.

Another mile further south the ordinary coarse basalt or dolerite so common in the Society Islands crops out at the sea-level, but its relation to the other rocks could not be made out.

The following is the composition of the phonolite from Mount Tapioi, compared with that of rocks from other South Sea localities :

	1	2	3	4	5	6
SiO_2	60·20	59·04	60·50	66·19	57·42	54·60
Al_2O_3	17·86	16·21	18·20	17·45	18·83	17·48
Fe_2O_3	1·10	1·04	1·34	2·95	4·89	5·72
FeO	2·02	2·64	1·89		3·56	1·02
CaO	3·60	1·93	1·18	1·16	1·75	3·10
MgO	·32	·24	1·75		·59	1·44
K_2O	5·94	6·59	4·45	4·90	5·46	5·61
Na_2O	6·36	9·78	7·25	5·55	6·23	9·32
H_2O	2·46	1·60	2·30	1·61	2·36	1·56
TiO_2		·76	·92			·80
Cl_2		·22				
	99·86	100·05	99·78	99·81	101·09	100·65

1. Summit of Mt. Tapioi, Raiatea, Society Islands.
2. Boulders at Fare Harbour, Huaheine, Society Islands.
3. Vairao Tahiti, Society Islands, Lacroix.
4. Alkali-Trachyte, Tafagagai, Tutuila, Samoa, Weber.
5. Signal Hill, Dunedin, New Zealand.
6. Nephelinite, Black Rock, Raratonga, Cook Islands.

A comparison of these analyses with those quoted by Rosenbush (" Elemente de Gesteinlehre," 2nd edition, p. 292) shows that the South Sea phonolites are somewhat higher in silica and lower in alumina than the average phonolite ; the difference, however, is not great.

RARATONGA.—I have previously recorded a nephelinite from Muri Point and from Black Rock. (Pl. xvii. fig. 1, xviii. fig. 1). A visit to the island showed that the alkaline rock occurs over a wide area. It was actually found *in situ* on the summit of Maungatea, and here it contains a large quantity of an isotropic mineral, which is probably sodalite. All the lower slopes of Maungatea are formed of a much decomposed basalt which has weathered into a red soil. This rises to 500 feet above sea level. On it there is a thick mass of nephelinite breccia 200 feet thick. (Pl. xvii., fig. 2). On this rests the nephelinite lava, which, however, on this hill is not thick. The nephelinite at the west side of Maungatea is associated with the porphyritic basalt that is found so frequently in the island, and is very similar to the common rock type of the Society Islands. The dense covering of vegetation on the summit of the hill prevented me from arriving at any definite conclusions as to the relative age of the rocks, though it appeared probable that the porphyritic rock was intrusive into the nephelinite. This is rendered likely by the occurrence of the porphyritic basalt *in situ* at the bottom of the neighbouring valley of the Avatiu. It also forms the crest of Hikurangi, the sharp spur of which is I believe a dyke of this rock that penetrates the nephelinite breccia, which is well exposed on the north-east face of the hill. The heavy rain experienced on this hill, however, interfered with geological work.

Nephelinite breccia is also exposed in great thickness on the south side of the Avatiu valley, and the solid rock is exposed in many places in the hills on the south-west side of the island. A glassy basalt was found on the shore of the Ngatangiia stream and a dyke of dense basalt on the north spur of Hikurangi, while blocks of a coarse tinguaitic rock were found in the village of Avarua. This rock contains much anorthoclase, but its origin could not be found.

The structure of the island appears to be as follows :—

(1) The lowest rock a fine grained, but much decomposed basalt, 500 ft.

(2) Nephelinite breccia, 200 ft.

(3) Nephelinite lava, 100 ft.

(4) Intrusive masses and dykes of a coarse basalt or dolerite

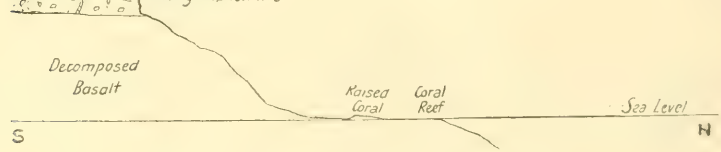

FIG. 2.—GEOLOGICAL SECTION, RARATONGA.

FIG. 1.—MT. MANGATEA, COOK GROUP.

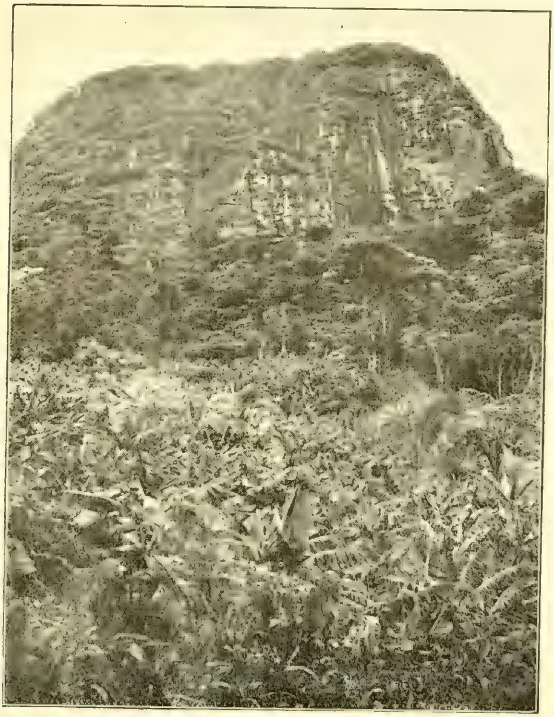

FIG. 2.—MT. MANGATEA, SHOWING BRECCIA PRECIPICE.

From this account it will be seen that alkaline rocks have a wide distribution in the Central Pacific. They certainly occur at Raratonga, Aitutaki, Raiatea, Huaheine, Tahiti, Savaii, Upolu and Tutuila. The aspect of Moorea, Tahaa and Bora-bora when compared with Raiatea and Huaheine strongly suggests that these islands also are crowned with phonolite lava flows, but no specimens have yet been obtained from them. On Mangaia Island I found no volcanic rocks except highly decomposed basalts. Specimens sent to me from Atiu by Major Large are also basaltic.

At Tahiti there is a great variety of alkaline rocks, both plutonic and volcanic. It is highly desirable that this large island should be more fully explored by geologists. At present we do not know the relation of the plutonic to the volcanic types. Ellis has mentioned granite from Maupiti and a quartz felspar rock from Bora-bora ; a specimen of Gabbro was given me by Frere Alain as from the island of Raiatea, so it is evident that work of an important nature is to be done in these islands. Future researches may throw much light on the antiquity of land areas in the Central Pacific.

My discovery of the rock at Arue which corresponds with the hauynophyre of Lacroix I regarded as of great interest, and it was only eight months later that I found that the distinguished French petrologist had received specimens of a similar rock, destitute, however, of hornblende, from the other parts of the island.

In Raratonga, Huaheine and Raiatea the alkaline rocks are much younger than the decomposed basalts on which they rest, and I could find no rocks of other kinds on their surface. This appears to me to prove that the alkaline rocks are the products of the latest eruptions of this area, but still of considerable age, for denudation has entirely destroyed all signs of the craters from which these immense lavas issued. In each of the islands visited the alkaline rocks are closely associated with extremely basic effusives. Some of these lavas are so basic that Lacroix refers them to the class of picrites. Whether the different species of rocks in Tahiti have resulted from mamatic differentiation is a question for the future. Lacroix evidently thinks this is the case, though he admits the incomplete nature of the collections. The constant association of the two main types mentioned in the islands visited truly supports this view.

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EXPLANATION OF PLATES XVII.—XIX.

Pl. XVII.—(1) Mt. Maungatea, Cook group, from the wharf, Raratonga Island; (2) upper 200 feet of Mt. Maungatea, showing precipice of breccia.

Pl. XVIII.—(1). Black Rock, on west side of Raratonga Island; the rock is nephelinite. (2). Mt. Tapioi, Raiatea Island, Society group; the top of the mountain consists of phonolite lava.

Pl. XIX.—Phonolite rock on Mt. Tapioi, Raiatea Island; the surface of the rock is channelled by the tropical rainfall.

5.—REPORT ON RECENT WORK ON THE ALKALI ROCKS IN VICTORIA.

By PROFESSOR E. W. SKEATS.

SINCE the Brisbane meeting (1909) Mr. Summers and I have nearly completed our investigation of the field relations and petrographic characters of the interesting series of alkali and other rocks of the Mount Macedon district. The results will presently be published by the Geological Survey of Victoria. As the result of a grant of £10 from the Association, Mr. Summers has been enabled to spend one of the University vacations in the Western District of Victoria supplementing previous observation on the alkali rocks of that area, which he and I made jointly in 1908. He has obtained much additional information, which in the form of a paper he is presenting at the present meeting of the Association. Much yet remains to be done, especially in the Omeo, Noyang and Mt. Senister districts in Eastern Victoria before our knowledge of the alkaline rocks of Victoria can be regarded as resting on the firm foundation of combined observation in the field and research in the laboratory.

GLACIAL PHENOMENA COMMITTEE.

See Adelaide volume, 1907, p. xxix.

Reappointed Brisbane, 1909 :—

The Committee to consist of: Professor T. W. E. David, B.A., F.R.S.; Professor P. Marshall, M.A., D.Sc.; Mr. E. G. Hogg, M.A.; Mr. G. Sweet, F.G.S.; Mr. A. Gibb Maitland, F.G.S.; Mr. B. Dunstan, F.G.S.; Mr. R. M. Johnston, F.G.S.; Mr. W. H. Twelvetrees, F.G.S.; Mr. W. Howchin, F.G.S.; Mr. G. A. Waller; Mr. R. Speight, M.A., F.G.S.; Mr. A. E. Kitson, F.G.S. (Professor David, Secretary.)

Reports have been submitted by Messrs. W. Howchin (South Australia), A. Gibb Maitland (West Australia), and R. Speight (New Zealand), as follows :—

FIG. 1.—NEPHELINITE, RAROTONGA

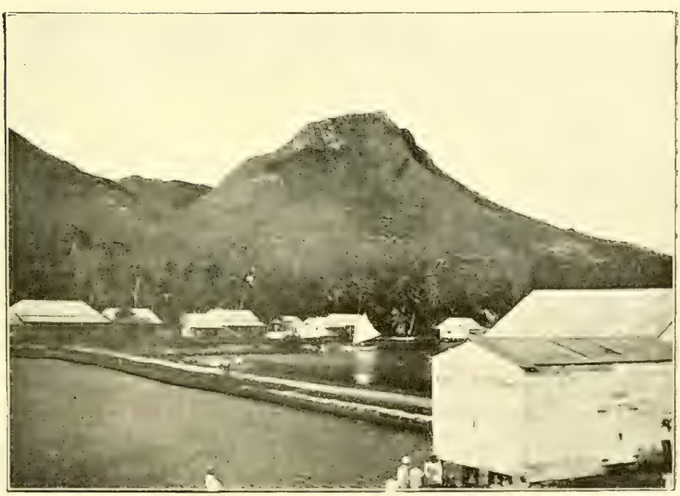

FIG. 2.—MT. TAPIOI, RAIATEA.

Plate 19.

Phonolite Rock, Mt. Tapioi, Raiatea.

1.—CAMBRIAN AND PERMO-CARBONIFEROUS GLACIATION.

By W. HOWCHIN, Secretary of the Committee.

The last report of the South Australian Glacial Research Committee was presented at the Adelaide Meeting of the Association held in 1907. In the interval further explorations have been made and additional data secured in the elucidation of the glacial phenomena pertaining to the two great Ice Ages of South Australia.

1. *Cambrian Glaciation.*—In 1908 a paper on "Glacial Beds of Cambrian Age in South Australia," was published by Mr. Howchin.[1] In this paper the evidences of a Cambrian glaciation of South Australia was given in detail and fully illustrated, and therefore the ground covered in the paper need not be recapitulated in this report. Attention, however, is called to the interesting and extended discussion which took place in London on the reading of the paper and the unanimous acceptance of the evidences by the noted glacialists who took part in the discussion.

What has been done since then has been chiefly in the discovery of further outcrops of the beds. By numerous traverses across the strike it has been proved that the Cambrian glacial beds outcrop at intervals of a few miles, in repeated foldings, over a vast area, from a few miles north of Adelaide to the latitude of Port Augusta, and from thence eastward into New South Wales. Also northward from Port Augusta at many points in the Flinders Ranges and as far north as the Willouran Ranges, near Hergott. The Cambrian glacial till is, therefore, one of the most persistent horizons in South Australian geology. Reference will be made to only one or two new localities which possess special interest.

The nearest outcrop of the glacial beds to Adelaide, on its northern side, is in the *Kapunda district.* To the south of Adelaide, in the Sturt Valley, the tillite is developed in great thickness, but is cut off by a series of faults, near the Viaduct Gully, on the Adelaide and Melbourne railway. North of this point the beds are lost to sight under the effects of block-faulting, on a large scale, and by the thick cover of alluvium which forms the Adelaide Plains.

The glacial beds reappear in another disturbed area 50 miles from their outcrop in the Sturt and 44 miles north of Adelaide. Block faulting has brought them again to the surface and given the beds a more east and west direction. The lie of the country is indicated by the quartzites which immediately overlie the till, and are in strong relief. About four miles west of Kapunda these quartzites form the crest of the Camel's Hump Range, which has a general north and south trend, but at Hawker's Creek, near Mr. Hazel's homestead, the beds swing round towards the east, forming conspicuous outcrops, and cross the Freeling and Kapunda railway a little north of Ford's Railway Station. The till overlies the

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1 *Quart. Journ. Geol. Soc.*, LXIV, pp. 234-259, and plates XIX.-XXVI.

quartzites and can be followed on the inside of the curve made by the altered strike of the quartzite ridge. In this district the glacial till is rotten and has weathered down in most places to a soil possessing good agricultural qualities.

Near Mr. Hazel's house, in Sections 134 and 137, Hund. of Kapunda, huge blocks of harder tillite rise above the cultivated ground having the appearance of monoliths. Large granite boulders occur both free and *in situ* in the till. One that was dug out measures 4 feet 6 inches, by 3 feet 6 inches, by 3 feet. The till near Hazel's is light-coloured and, amongst other erratics, contains numerous angular fragments of a dark-coloured crypto-crystalline limestone. Near the upper limits of the till are grits and quartzites, which are quarried.

The glacial beds cross the River Light, and are well exposed in a railway cutting, about a mile and a-half north of Ford's Railway Station. Here the beds are about half-a-mile in width, varying in texture from a fine-grained sandstone to coarse grits. The erratics are not very numerous in this exposure and occur mostly in groups or pockets. One granite example, seen in the fifth cutting from Ford's, measured 3 feet in length.

In superior order, the Tapley's Hill slates are met with on the northern side of the glacial outcrops, and these continue over an extensive peneplain of agricultural country for a distance of 24 miles to Eudunda, where the glacial beds once more appear in a return fold. The town of Kapunda is situated on the Tapley's Hill slates and the once famous Kapunda Copper Mine was worked in the latter.

At *Eudunda*, 21 miles north of Kapunda, the glacial beds occur in a relatively flat country and exhibit only slight relief in the physical contours, so that outcrops have to be looked for in small quarries or in the sides of the creeks. The Eudunda township is built on these beds, which follow a north-westerly and south-easterly strike along the flanks of a low range which makes the division between the Hundreds of Julia Creek and Neales. The outcrop was followed in a south-easterly direction for seven miles, when, in its passage into the Hundred of Dutton, the strike once more becomes due north and south, which is the prevailing strike of the country. This outcrop is interesting as being on the most easterly scarps of the hill country overlooking the plains of the River Murray.

Mount Remarkable is the most prominent elevation of the southern Flinders' Ranges, over 3,000 feet in height, and rises abruptly from the plains which extend for many miles on its eastern side. The Mount is a well-defined horst, as it is circumscribed by important faults on all sides accompanied by wide zones of brecciated fault-crush rock. The main mass of the Mount consists of quartzite, but on its western side the Cambrian glacial till makes an important feature. At the northern end of the Mount the glacial beds are cut out by the intersection of faults, but they widen in their outcrops as they extend towards the southern end, and at the extreme end of the ridge, which is abruptly truncated, they are cut off by a transverse fault accompanied by much breccia. The beds are overlain by Tapley's Hill slates, Brighton limestones and purple slates and quartzites, in their natural order, forming the ranges between Mount Remarkable and the coast.

The glacial beds reappear on the south side of Mount Remarkable and cross the main road a little east of the Gorge Hotel.

On the ranges west of Mount Remarkable, severe faulting, in places, has brought the glacial beds once more to the surface. Very fine exposures of the till with large erratics occur in Waterfall Creek, a tributary of Baroota Creek. The beds are of great thickness and form a series of steps in the bed of the creek, which has a rapid descent, with some fine waterfalls from which the creek takes its name.

Scores of outcrops of the Cambrian till have been noted, covering thousands of square miles, but for the most part they possess features in common, and do not call for specific descriptions. Striated erratics have been obtained from all outcrops of the beds where attention has been given to their collection. My colleague, Dr. Douglas Mawson, has recently discovered undoubted evidences of the Cambrian till in the western parts of New South Wales, and will publish his results shortly.

2. *Permo-Carboniferous Glaciation.*—Since this Committee presented its last report an entirely new and extensive area of Permo-Corboniferous glaciation has been discovered and, in part, described.[1] It includes the plateau country lying to the east and north-east of the Hindmarsh Valley, bounded by the Willunga Ranges, Bull's Creek Range, and the Strathalbyn Range, on the north; Currency Creek on the south, and the River Murray Plains on the east. It is an area that may be roughly estimated to comprise 240 square miles, and is continuous with the still more extensive glacial area on its western side, including the Hindmarsh and Inman valleys, the Cape Jervis Peninsula, from Myponga on Gulf St. Vincent, round the Cape to Port Elliot, on the southern coast, over which glacial deposits of Permo-Carboniferous age have already been determined and described.

The new area for these deposits is so uniform in physical features, as well as distinctive in character, that it may be regarded as a physiographical province. The higher portions of the plateau are about 1,000 feet above sea level, with a gradual slope to the east. Pre-Cambrian inliers, with rounded contours, rise above an undulating sandy country covered with a dwarf, desert-like scrub. The drainage, which is insignificant, finds its outlet mainly along flat-bottomed valleys occupied by swamps.

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[1] "Description of a New and Extensive Area of Permo-Carboniferous Glacial Deposits in South Australia," by W. Howchin. Trans. and Proc. Roy. Soc., S.A., vol. XXXIV., 1910, p.231.

The geological formation of the country explains its peculiar physical features. The old Permo-Carboniferous valleys have been choked with thick accumulations of glacial waste—a stiff, tenacious, blue clay being characteristic of the lower portions, and a gritty, more or less argillaceous sandstone, with scattered pebbles and conglomerates the upper.

The upper set of beds form ridges, 200 feet and 300 feet above the valley bottoms, and as they are soft and easily disintegrated they yield much free sand, which forms a poor soil and subsoil. This sandy country is very absorbent of rain, which latter, after penetrating the porous beds, finds its way down to the clay level and makes a seepage along the valley bottoms and thereby creates swamps. A swamp vegetation has grown in many places sufficiently long to form a black peaty mass many feet in thickness.

On the rises, the glacial sandstones, highly charged with grit and pebbles, are sufficiently indurated to make good road-metal, and are used throughout the district for this purpose.

The present lines of drainage are superimposed on the older Permo-Carboniferous system, with which they have no relation. Glacial sandstones form the present watershed between the east and west, and the older valleys of Permo-Carboniferous erosion have not been sufficiently unloaded to show the main lines of drainage pertaining to the older system.

Mount Observation, an inlier of Cambrian rocks, roughly divides the great glacial basin into two parts. On the southern side is the Mount Compass and Nangkita sub-basin, which has its drainage outlet by the Black Swamp, and on the northern side is the sub-basin of Giles Creek and the River Finniss. With the exception of that part of the River Finniss which flows through Mount Observation, in a deep gorge, the whole of the drainage of the area is practically over glacial deposits.

In the lower portion of the Finniss basin the glacial sandstone is compact, fine-grained, and free working, and has been extensively used for building purposes locally, and, to some extent, in Adelaide.

Near the northern limits of the area, on the Bull's Creek road, 4½ miles from Strathalbyn, and within the valley of Giles Creek, an important exposure of glacial till is seen in a road-cutting. The erratics are varied, of large size (up to four feet in diameter), and many of them glaciated.

The evidences for the glacial origin of the deposits in this wide area may be briefly stated :—

(*a*) The beds are continuous and lithologically identical with those on the western side of the area, in which the glacial features are most pronounced.

(*b*) The presence of erratics foreign to the district. These are not usually so large as those frequently met with in the Inman valley and other localities on the western side, but they are characteristic.

(*c*) Many of the erratics are distinctly ice-marked under the forms—faceted, soled, striated, and polished.

(*d*) The fine-grained sandstones of the lower Finniss exhibit a peculiar grain in the stone, both macroscopically and microscopically. In place of regular bedding planes, there are strong corrugations, as though the sediment had been subjected to a ploughing action at the time of its deposition, some of the sandstones are so markedly curved in the grain that they are rejected for building purposes. Even the fine-grained portions, in which no distortion can be recognised in the quarry, develop similar features under weathering.

(*e*) Microscopically, the sandstones have a very distinctive character, quite unlike ordinary waterworn sand grains. The granular fragments are all intensely sharp, often mere splinters, and even the finest grains have the same features, corresponding to a "rock-flour." The greater induration of these glacial freestones has probably arisen from the interlocking, under conditions of pressure, of the angular fragments of which the rock is composed.[1]

Yankalilla, Normanville and Second Valley.—The great glacier which filled the Inman Valley, travelling westwards to unite with the still greater ice-sheet of the Valley of St. Vincent, passed over the Bald Hills and spread itself over the plains of Yankalilla, Torrens Vale, and the present coastal districts between Myponga and Cape Jervis.

On the north side of Yankalilla glacial deposits are found in most of the sheltered situations, as in the Carrickalunga Creek and in the valleys intersecting the Archæocyathinæ limestones.

Going south, along the coast, the glacial beds can be seen on the landward side of the Normanville Gorge, with a large granite boulder on the saddle between the Great and Little Gorges, and extensive washouts in glacial till in the paddocks.

Interesting road cuttings in the till occur near the residence of Mr. E. C. Kelly (Anacotilla), and at Poole's Flat, about one-and-a-half mile further south, there is a remarkable display of very deep washouts in the till, exposing numerous erratics, many of which are strongly glaciated. These washouts have led during the past season to a landslip of agricultural ground that covers an area of more than three acres in extent.

At Second Valley, from near the coast to the marble knob near the hotel, the superficial beds consist of glacial drift exposed in washouts. In the western angle of Section 1568, near the old district road which runs parallel with the coast, are two large boulders of granite, each 3 feet by $2\frac{1}{2}$ feet, and a round boulder of dolomitic limestone 2 feet in diameter. The drift passes over the saddle into Poole's Flat, already described.

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1 For a more detailed description of these beds, with illustrations, see Howchin's paper (*loc. cit. ante.*)

At Rapid Bay, south of Second Valley, is another patch of morainic material with several groups of granitie erratics, some of which measure six feet in length.

Victor Harbour District, lying at the entrance to the Inman Valley, contains some very striking glacial features. Rosetta Head (The Bluff), a prominent granite headland, near Victor Harbour, formed a ridge of resistance to the ice-sheet, which came in from the south. The granite obstruction led to an ice-fall and an over-deepening of the glacier bed, as well as a great accumulation of morainic material on its leeward side.

King's Point, the next prominent headland, situated about two miles further to the west, presents similar features. West Island is a fragment of the old granitic barrier, now separated from the headland, and presents a roche moutonnée contour. The headland is about a quarter of a mile in extent and is a very typical glacial moraine, so modern in its appearance that it seems difficult to believe that it dates back to Palæozoic times.

This district has been recently mapped and described, and therefore need not be further dealt with in this report.[1]

2.—WESTERN AUSTRALIA—PERMO-CARBONIFEROUS GLACIAL DEPOSITS.

By A. GIBB MAITLAND.

SINCE the date of my last report some further evidence regarding the occurrence of Carboniferous glacial deposits in Western Australia has been obtained, which will be briefly recapitulated :—

Lyndon River, Lat. 23 S.—In the year 1907, while examining the neighbourhood of Windalyia, on the Lyndon River, a hurried visit was paid to the country in the vicinity of Tchugareywurdoo Pool to examine the boulder bed, the existence of which had been previously noted.[2]

The boulders consist of a great variety of rocks, and many of them covered with glacial striæ. The boulder bed wherever exposed is in every way identical with that on the Gascoyne, the Minilya, etc., to which reference has already been made in an earlier report. The stratigraphical position beneath the fossiliferous limestone of Carboniferous age shows it to be identical with the glacial con-

1 See paper on "The Glacial (Permo-Carboniferous) Moraines of Rosetta Head and King's Point' South Australia," by W. Howchin, *Trans. and Proc. Roy. Soc. S. Aus.*, vol. XXXIV., 1910, pp. 1 to 12. Plates I to XVII.

2 *Geol. Surv. Bull.* 26, Perth, 1907, p. 12.

glomerate of the Arthur and the Minilya Rivers.[1] The limestone, which forms a well-marked ridge, to the west of the boulder bed, occupies a considerable area of country in a N.W. and S.E. direction and dips at a comparatively low angle to the south-westward. The *debris* of the boulder-bed also covers a very wide expanse of country in this latitude.

The occurrence at Tchugareywurdoo Pool marks the northern limits of this glacial conglomerate in this portion of the State, which has now been proved to extend for a distance of about 200 miles between the Lyndon and the Wooramel Rivers (Lats. 23 to 26).

Fairly full details, illustrated with photographs, sections, and a map, will be found set out in *Geol. Surv. Bull.*, 33, pp. 8 to 23, and need not be repeated.

Irwin River.—In my presidential address on Recent Advances in the Knowledge of the Geology of Western Australia[2], delivered to the Association in Adelaide in 1907, it was pointed out that the carboniferous rocks of the Irwin River Valley contained associated with the Marine Series a boulder bed, the *debris* of which strewed the surface for a considerable distance, while no ice-scratched boulders had at that time been detected, its glacial origin was suspected.

The recently completed geological survey of the Irwin River coalfield has added considerably to our knowledge of the Carboniferous series, and has resulted in the discovery of a glacial boulder bed of some importance.

Wherever exposed, the boulders forming the bed consist of a heterogeneous collection of granite, gneiss, quartzite, basic lavas, etc., many of them being beautifully glaciated.

The *debris* of the boulder bed occurs more or less regularly along a general N.W. direction over the whole area of the coalfield, and marks a very important geological horizon, extending for about twenty-four miles along the surface.

This Irwin River boulder bed does not appear to be exactly at the base of the Carboniferous series as developed in this latitude, and is in all probability the southern extension of that occurring in the valleys of the Lyndon, Lyons, Gascoyne and Wooramel Rivers, which are described in *Bull.*, 33, q.v.

The Carboniferous rocks of the Irwin River Valley do not occupy any very large area, but are covered by a considerable thickness of Jurassic rocks, which dip generally to the southward.

Full details of these glacial deposits and associated rocks, illustrated by geological maps, sections and photographs, will be found in *Geol. Sur. Bull.*, 38, and hardly need repetition.

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1 *Geol. Surv. Bull.* 33, Perth, 1909, pp. 8-22.
2 *Austr. Assoc. Adv. Sci.*, 11th meeting, Adelaide, 1907, p. 146.

3.—REPORT ON GLACIATION PROBLEMS IN NEW ZEALAND

By R. SPEIGHT, M.Sc., F.G.S.

The following is a brief summary of the results of investigation during the last two years into the problems of New Zealand Glaciation.

The first work to be noted in point of time is that resulting from the expedition to the Auckland and Campbell Islands organised by the Philosophical Institute of Canterbury, notice of which has already been given by Dr. Marshall to the last meeting of the Association. In the volume which has recently appeared containing the scientific results of the expedition both Marshall and Speight have concluded that the islands were subjected to a glaciation of moderate intensity, a conclusion based on the presence of undoubted lateral moraines, accumulations of huge angular boulders in the lower part of the river valleys, glacier cirques, hanging valleys, and glaciated landscapes, but no evidence was found of icesheet conditions obtaining over the area. No decided reason can be assigned for the glaciation, though there are signs that the land was formerly higher, but not sufficiently high to account for all the phenomena.

In Bulletin No. 6, N.Z. Geological Survey, dealing with the Geology of the Mikonui Subdivision, Morgan describes the physiographical features of a section of Westland stretching from the sea to the crest of the Southern Alps, and discusses the features and age of the glacial deposits of the area. He concludes that there was a glaciation in Late Cretaceous or in Early Tertiary times, and that the most recent glaciation commenced in the late Pliocene, and after rea hing a maximum in the Pleistocene gradually waned till the present. Morgan agrees with Haast in attributing the extension of the glaciers to the former larger size of the snowfields, and he concludes that as the valleys were eroded deeper the fields became smaller and the glaciers shrank in consequence, a result probably accentuated by a slight lowering of the land.[1]

In the same volume there are several papers by Park, in which he maintains that there was a Pleistocene Ice Age in New Zealand corresponding with that which occurred in the Northern Hemisphere. This opinion was first advanced by him in Bulletin No. 7, N.Z. *Geol. Survey* (Geology of the Queenstown Subdivision, 1909), where he maintained that the South Island was subjected to a glaciation from an icesheet of Polar origin, that the ice came down to the seacoast near Dunedin, but that it did not extend any further north than Cook Strait. He followed this up with papers, controversial and otherwise, showing that these conditions extended to the North Island, a conclusion based chiefly on the reported discovery by him of glacial till in the valley of the Hautapu River, a tributary of the Upper Rangitikei, about thirty miles to the south of Ruapehu. He has subsequently in his "Geology of New Zealand" recorded the

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1 In *Trans. N.Z. Institute,* Vol. XLII., 1910, in a paper entitled "Geological Notes on the West Coast Sounds," Speight gives a reference to the landscape features of the Fiord Region, which depend on ice action.

finding of moraines in the Waimarino Forest to the west of Ruapehu. On account of these discoveries he has extended the limits of the Pleistocene Glaciation much further north so as to include the greater portion of the mountain axis of the North Island stretching from Wellington to near East Cape. He explains the landscape features in the neighbourhood of Wellington as due to glaciation, and supposes that a great glacier once occupied the site of Cook Strait and produced the special land forms to be seen in its vicinity. It may be remarked here that in the same volume Bell attributes these features in the immediate vicinity of Wellington to the results of great crustal movements, notably faulting. Park has also recorded the existence of huge moraines in the valleys of the Awatere and other rivers on the east coast of Marlborough.

The whole matter of this remarkable extension of the glaciers as postulated by Park is most difficult to handle in a short report, but it must be said that his views are quite at variance with the mature opinions of former geologists of standing and wide experience, such as Haast, Hector and Hutton. Both Park's observations and his interpretation of them have been strongly criticised by Marshall on geological grounds, and his conclusions have been criticised by Thomson on botanical grounds, in the same volume of the Transactions in which Park's papers appear. Cockayne has also a short note to the same effect in his report on the Botanical Survey of Stewart Island. These two botanists have maintained that the present distribution and ecological requirements of the indigenous plants could not possibly result if Park's Ice-sheet hypothesis is granted. It must be observed, however, that he is not altogether consistent in that at times he looks upon his ice covering as due entirely to elevation of the land, and his hypothesis then amounts merely to an extension of the present glaciers far farther than ever has been demanded by other geologists of considerable experience. At other times he apparently regards the ice covering as a true ice-sheet and as an extension of the Polar ice cap which crossed the sea to the south of New Zealand. These two positions are hardly tenable at the same time.

Judging from my own observations in the middle district of the South Island, Park's conclusions are not founded on satisfactory evidence, and his recent map, which shows the whole of Canterbury as covered with ice, cannot be accepted as correct. There is no proof whatsoever that glaciers came out any further on the plains than was recorded by Haast, if indeed they came as far, and Banks Peninsula was certainly not covered by ice. The loess of the Canterbury Plains is not a boulder clay except in so far that it has been formed by the grinding action of glaciers on stones contained in their mass or on rock over which they have passed, the fine powder resulting therefrom being subsequently distributed over the land by river and wind action.

His conclusions as regards the glaciation of all the central portion of the North Island appear to be based on somewhat slender evidence.

To sum up the whole question as it stands at present, it must be stated that Park's contention cannot be regarded as satisfactorily maintained, and unless other evidence is forthcoming his hypothesis must be considered untenable.

At the beginning of this year two parties visited the head waters of the Rakaia and Rangitata Rivers on the eastern side of the Southern Alps, and as a result of their work a substantial modification must be made in the accepted size of the glaciers in that locality. Those at the head of the Rangitata are much larger than represented on maps, while the Lyell Glacier is much smaller and cannot exceed five miles in length. Till the recent investigations our knowledge concerning the Lyell Glacier was based entirely on the report made by Haast in 1866, and the country is still almost unknown.

The Geological Survey Department has just issued a report on the Franz Josef Glacier with letterpress by the Director, Dr. J. M. Bell, and a map by R. P. Greville. The map is excellent, and the report gives a concise account of the main features of this interesting glacier. A special feature is the record of observations on the movement of the ice, which show that either this is not as great as has formerly been supposed or that the rate is changing. The speed varies from ·79 to 1·240 feet per day at various stations, the observations ranging over a period of 134 days. At present one portion of the terminal face is rapidly advancing.

An interesting fact is pointed out by Cockayne in his list of plants near the glacier, viz., that the Alpine plants have followed the ice down from the higher levels, and the statement made originally by Haast and widely circulated in geological literature, that the terminal face is in the midst of subtropical vegetation, is not altogether correct, as it contains a very important alpine element.

4.—REPORT ON THE STRUCTURAL FEATURES OF NEW ZEALAND.

By R. SPEIGHT, M.Sc., F.G.S.

(Committee appointed Hobart meeting, 1902.)

The chief recent work bearing on the evolution of the structural features of New Zealand has been done by the Geological Survey, which has published from time to time reports in the form of Bulletins dealing with isolated areas, primarily interesting on account of the occurrence of minerals of possible economic value. The first seven of the Bulletins were referred to by Dr. Marshall in his report to the last meeting of the Association.

In Bulletin No. 8 ("Geology of the Whangaroa Subdivision, Hokianga, North Auckland"), J. M. Bell and E. de C. Clarke give a thorough report of the features of part of the North Auckland Peninsula. The oldest rocks of the area (Waipapa series), of probable late Palæozoic or early Mesozoic age, consist of argillites, greywackes, cherts, quartzites, and crystalline limestones, which are much jointed, faulted and fractured, and with an occasional approach to schistosity. Two detached areas are dealt with, both folded into anticlinoria, the inland one with a general E.N.E. to W.S.W. trend, and the coastal one with a W.N.W. to E.S.E. trend, the two directions meeting at an angle ; but the authors express an opinion that if the superincumbent more recent rocks were removed the two directions would be found to merge into one another.

The trend of the Auckland Peninsula does not correspond with either of the axes of these anticlinoria, but the whole structure and arrangement of the series is somewhat obscure. The overlying beds (Kaeo series) of late Mesozoic age consist of sedimentaries which have not been acutely folded, but have been subjected to a considerable amount of faulting and displacement. Owing to the marked variation of the strike the direction of the folding is uncertain, but certain beds exhibit a persistent N.S. direction in the northern part of the area, while in the southern part others exhibit a E.N.E. to W.S.W. direction, corresponding with that of the Waipapa series. These two great sedimentary series are overlaid by volcanic rocks, chiefly andesites and dolerites ; intrusive gabbros of uncertain age also occur.

The presence of granite boulders in a conglomerate at the base of the Kæo series, taken in conjunction with the occurrence of similar rocks in conglomerates in other parts of the North Island—for example, near Kawhia (Park), near Cape Palliser (Sollas and McKay), and the more recent discovery of normal and gneissic diorites in the same locality (Adams)—is interesting as indicating the close proximity of a continental area in Mesozoic times. Where this land lay is uncertain ; but the present writer has urged in a recent paper on the petrology of the Kermadec Islands that a land mass probably existed in Mesozoic times to the north of New Zealand, with connections to the north with a former Pacific continent and south to New Zealand itself.

In the northern peninsula extensive faulting has taken place since Miocene times ; the major faults recorded have an E.N.E. to W.S.W. direction—one with a throw of five hundred and another with a throw of three hundred feet. These and others have caused considerable fracturing of the former tableland or elevated peneplain, which has resulted in the formation of block mountains of no great height.

Dr. Bell has also published (*Trans. N.Z. Inst.*, vol. xlii, 1910) some account of the geology of the extreme north of the island. This is largely a restatement of McKay's views as recorded in the Geological Report for the year 1892-3 (published 1894) ; but there is a specially interesting announcement of the presence in the extreme north, near Cape Maria van Dieman, of basic rocks—harzburgites, lherzolites and serpentines, which are related petrologically to the Milford Sound peridotites. This find is specially interesting, taken in conjunction with the occurrence of a broken band of similar rocks extending up the western side of the Southern Alps to Nelson and its reappearance again in New Caledonia. The prevailing strike of the beds in the far north is, according to Clarke, N.N.W. to S.S.E.—that is, in the direction of the general trend of the peninsula. It is, according to Hector, also the trend of the mineral veins of Cape Brett, to the east of the Bay of Islands. The direction of the main axis of folding in the Coromandel Peninsula is, however, slightly more to the east. In Bulletin No. 10 (Geology of the Thames Subdivision) Fraser notes that the main direction of folding in the pre-jurassic rocks is nearly parallel to the trend of the Hauraki Peninsula, that is with the more northerly of the two main lines of folding which are evident in New Zealand. The quartz lodes of the area are, however, generally parallel to the Ruahine-Southern Alps line of folding with its prevailing N.E. to S.W. direction. In the same Bulletin reference is made to the main faults of the area ; and the author endorses the generally accepted statement that the Firth of Thames is a down-faulted area or "graben," and that other main faults of the locality are connected with it in origin. He also concludes that the rocks of the area have been subjected to a tilting towards the south-east on an axis running north-east.

Bulletin No. 9 (The Geology of the Whatatutu Subdivision) deals chiefly with the tertiaries on the east coast of the North Island, to the north of Gisborne. The beds here are fairly flat and slightly folded ; the axes of the anticlines that have been recorded run generally north-east and south-west, though with occasional local variations. Reference has been made earlier to the finding of boulders of plutonic and gneissic rocks in a conglomerate in the locality.

In Vol. XLII, *Trans. N.Z. Inst.*, 1910, Dr. J. M. Bell again refers to the formation of Wellington Harbour, and shows from physiographical evidence that earth movements have taken place within fairly recent times on a line running north-east up the western side of the harbour, resulting in a differential movement giving a throw of at least 500 feet to the south-east. He has also suggested the probable existence of other faults running in approximately parallel directions ; but the available evidence in support of his hypotheses is at present somewhat uncertain.

Bulletin No. 11, by E. J. H. Webb, deals with the Mount Radiant sub-division in West Nelson, north of the Buller River. The oldest rocks, which are poorly developed, are of probable Ordovician age, and are folded along a N.W. to S.E. line. They are penetrated by granite intrusions of post-Ordovician and pre-Miocene age, and overlain by Miocene sandstones, breccias, grits and limestones, and later detrital deposits. The present physiographical features of the area seem to be determined by a series of faults which have produced sets of high level and low level blocks. The main fault lines follow a N.N.E direction, and the largest fault has a relative downthrow to the west of at least 4,000 feet. The coast line is also probably determined by the presence of another large parallel fault. The effects are, however, complicatod by a cross set of faults. The conclusions of the author are generally in support of McKay's theory of the presence of a series of great earth movements which are responsible for the landscape features of this part of New Zealand, an opinion which is virtually endorsed by Morgan in his Bulletin on the Mikonui sub-division of Westland. In this publication Morgan reports the occurrence of a great thrust plane at the western edge of the Serpentine belt, with a series of parallel and related minor displacements. He concludes that the thrust which produced the Southern Alps came from the east, and that to the west are sedimentaries which are folded in a direction at right angles to the general trend of the Alps. From this he apparently concludes that there was a range to the west of the present coastline in early tertiary times and that the anomalous folding of these beds is the folding of a partly submerged block of country. In connection with this observation of a strike at right angles with the direction prevailing in the Alps, it may be mentioned that directions corresponding to this are to be observed on the Canterbury side of the range (Cox, Geological Report, 1884, page 25) ; another marked variation in strike is also recorded by him on page 28 of the same report. His first observation has been confirmed by Capt. Hutton and the present author. The latter observation serves to show that beds in undoubted sequence show a marked range of variation in strike over small areas, so that deductions as regards direction made from a variation in strike of the Greenland series, as recorded by Morgan, must be taken with great caution.

The observations conducted by the present writer in the Arthur's Pass Tunnel show that the beds cut by the tunnel vary from a direction parallel with it—that is, N. 8° W. to N. 23° E. in a distance of about half a mile. The beds are faulted in directions approximately parallel to the latter direction, with very occasional cross faults. The amount of throw in each case it was impossible to determine, as the beds are very monotonous and the tunnel cuts at a small angle the axis of an anticline. It was pointed out by Dobson that the direction of the folds of this part of the Southern Alps is not parallel to the general direction of the range, but about N. 15° E. Although the range has a general north-easterly trend, the folding is in places remarkably discordant with it.

Papers dealing with the geological structure of the south of New Zealand have been published by Finlayson and the present author. The former describes the different vein systems of Central Otago, and concludes from their distribution and general orientation as follows :—" The fissures are evidently due to compression forces, as they have all the typical features of compression veins, described by Emmons." In his opinion they were caused " by a tectonic force acting from west to east and south-east, with its greatest intensity at the head of Lake Wakatipu, in the near vicinity of the belt of igneous rocks which were intruded during the Jurassic mountain formation. Such a compression movement would conceivably extend its area of effect—and would gradually diminish in intensity as it passed towards the coast."

In a short paper on the West Coast Sounds the present author refers briefly to the structure and petrology of the rocks of that little-known area.

Dr. Marshall furnished to the last meeting of the Association a brief report on the general conclusions of the members of the recent expedition to the Southern Islands of New Zealand. It may be mentioned here that this expedition found undoubted signs of former extension of a continental area in that region, but no evidence as to the date of this extension, although there is undoubted evidence of the existence of shallow water near the Campbell Islands in Miocene times, the existence of an old shore line or large river on the Auckland Islands at a time previous to the pouring out of the basalt flows of which the islands are chiefly constructed, and also fairly sound evidence that these eruptions, even in their early stages, were subærial and not submarine.

Section D

BIOLOGY

ADDRESS BY THE PRESIDENT:

F. M. BAILEY, F.L.S.

Government Botanist, Brisbane.

[The text of the address was not available at the time of going to press.]

PAPERS READ IN SECTION D.

1.—SOME EXAMPLES OF PRECOCIOUS BLOOMING IN HETEROBLASTIC SPECIES OF NEW ZEALAND PLANTS.

By L. COCKAYNE, Ph.D., F.L.S.

The flowering of plants at an earlier stage of development than the so-called "normal" is, as Diels[1] has very clearly shown, a matter demanding close investigation. Of especial interest is the early blooming of strongly heteroblastic species, *i.e.*, those whose juvenile form is markedly different to that of the adult, particularly when the former stage of development is prolonged for a number of years.

Although a good deal is now known regarding the occurrence of heteroblasty in New Zealand plants, the information is much scattered, while but little has been published as to the blooming of the juvenile stage. It seems well then to bring together some of the leading cases of this latter phenomenon, so that they may be at the disposal of students of evolution.

Two aspects of the subject under consideration present themselves :—1. The juvenile and adult forms are present *at the same time* on the one individual—the juvenile below and the adult above, or the former as reversion-shoots, perhaps in any part of the adult. 2. The adult stage is altogether suppressed in some individuals. This last-named series is evidently the more important, since if such a juvenile form flowers, it is to all intents and purposes a distinct species from the adult, and would be so considered by any

1. "Jugendformen und Blutenreife im Pflanzenreich." 1906. See also Goebel, "Organography," Part 1, pp. 145-146 and 153-155.

botanist unacquainted with the "normal" plant. Further, such a plant might very well become, as Diels has suggested,[1] the starting point of a new line of descent.

A striking shrubby growth-form, which is extremely common in many parts of New Zealand, is the divaricating. It is distinguished by the very frequent branching at almost a right angle, so that a close, entangled, usually stiff twiggy growth results. It occurs in various families (*e.g.—Pittosporaceæ, Rutaceæ, Icacinaceæ, Rhamnaceæ, Elaeocarpaceæ, Violaceæ, Araliaceæ, Cornaceæ, Myrsinaceæ, Rubiaceæ, Compositæ*), and in genera which may also exhibit altogether different growth-forms. But, especially important from the standpoint of this paper is the fact that the divaricating-form affords a most excellent example of convergent epharmony, various members, generically distinct, not only looking exactly alike, but growing associated together in certain xerophytic montane and subalpine stations. Now this growth-form is not merely confined to shrubs, but is an early stage in the development of certain trees, which are thus xerophytic shrubs for sometimes several years and afterwards mesophytic trees. The following are trees of this class :—*Hoheria angustifolia, H. sexstylosa, Plagianthus betulinus* (Malvacaceæ) ; *Pennantia corymbosa* (Icacinaceæ) ; *Sophora microphylla* (Leguminosæ). So far as the above species of *Malvaceæ* go, I have never seen actual juvenile shoots blooming, but *Plagianthus divaricatus*, a well-marked halophytic species, is always a shrub. *Pennantia corymbosa* has occasionally flowering juvenile shoots, but these occur on the persistent shrubby form still at the base of an adult tree. So, too, with *Sophora microphylla*, but in this case there is the variety *prostrata*, which comes true from seed, is confined to xerophytic stations, blooms freely, does not grow into a tree,[2] and is, most certainly, the fixed juvenile form of *S. microphylla*, though its flowers are smaller and its pods slightly different from those of that species.

The shrub-stage of the above trees, *S. microphylla* excepted, might well be considered non-epharmonic, and its origin bound up in the phylogeny of the species, as indeed it probably is, to some extent. But, on the other hand, the earliest seedling state is not xerophytic, and the succeeding shrub-stage may well be an advantageous growth-form for a plant of dry soil, or wind-swept station, in its early years. Afterwards, as a mesophytic tree, and a member of a forest, it would better cope with the quite different environment.

In the case of *Sophora prostrata*, a plant of a xerophytic station, an ontogenetic origin may perhaps be assumed, the habitat favouring the shrub-rather than the tree-form. At the present time, in certain stations, shrub and tree grow side by side as might be expected were the above supposition true, but in the most xerophytic stations *S. prostrata* alone is present. In the case of the other trees cited, their present habitats do not justify the theory of

1. *Loc. cit.*, p. 109.
2. Wind-swept examples of *S. microphylla* must not be confused with this plant.

a recent origin of the shrub-stage. Such, more probably, arose gradually during a former dry period, when it may have gained, in some cases, an independent existence, as shown by its sometimes blooming, and its resemblance to the divaricating shrubs. At the present time the mesophytic conditions favour the tree-form and a reversion has taken place, while in course of time, if this view is correct, the shrub-stage should be suppressed altogether; in fact there are examples in the flora of early hardly or non-divaricating shrubby stages of certain trees of this class.

As for the divaricating shrubs themselves, nearly all are more or less heteroblastic. *Pittosporum divaricatum*[1] (Pittosporaceæ) and, to some extent, *Corokia Cotoneaster* (Cornacaceæ) remain juvenile in the shady forest, though just on its outskirts both are intense xerophytes—*i.e.*, both forms are epharmonic. Probably the forest form blooms, but my notes have nothing on this head. *Aristotelia fruticosa* (Elaeocarpaceæ), a shrub ecologically equivalent to the last-named, has a most remarkable series of distinct leaf-forms when juvenile, at which stage it not only flowers at times, but may also occasionally remain fixed, as in an example noted by me near the base of Mount Torlesse, Canterbury. In such a case the difference between the almost spiny small entire-leaved xerophytic adult and the fixed juvenile form, with its much larger frequently pinnatifid leaves, is indeed striking.

The whipcord Veronicas of the cupressoid growth-form pass through a very distinct juvenile stage with hygrophytic leaves, which is epharmonic, since, in the first place, the low stature of the early seedling and the shelter it receives from other plants, etc., bring it under very much more humid conditions than those of the adult; and, in the second place, the juvenile form will persist for a long period if cultivated in moist air and feeble light. Also, the adult form is exceedingly plastic, and various stimuli will rapidly bring about the formation of reversion-shoots.

So far as fixed juvenile forms go amongst these cupressoid Veronicas, Mr. T. F. Cheeseman made the important discovery of a "variety" of *Veronica tetragona* growing in fair abundance on the dry pumice and scoria of the subalpine volcanic plateau of the North Island, of which plant he writes: "Probably it is an intermediate state between the juvenile stage and the fully matured one, but if so *it must persist for many years*."[2]

A distinct species of Veronica, bearing the garden name of *V. cassinioides*, reputed as having been first collected in S.W. Otago, appears to me to be without doubt a permanent juvenile form, intermediate between the early pinnatifid and adult scale-leaved stages of the whipcord Veronicas, the adult of which is probably extinct. A closely allied plant has recently been collected on the Garvie Mountains by Mr. D. L. Popplewell, but not in flower, and it may turn eventually into the cupressoid stage.

1. This is in part *P. rigidum* Hook.f., but differs so much from the type that I am separating them. It is the shrub dealt with by me in *Trans. N.Z. Inst.* 33; pp. 264, 265, 266, 1901, and my conclusions therein cited by Diels, *loc. cit.* p. 66-69.
2. *Trans. N.Z. Inst.* 40; 281, 1908. (Italics mine.)

A somewhat different case to any of the preceding is that of *Parsonsia* (Apocynaceæ). The two New Zealand species of this genus, as I have already shown,[1] undergo a remarkable series of changes in leaf form during their ontogeny, but these cannot be referred to the effect of the environment; they are hereditary merely, and not epharmonic at the present time. In the liane, *P. heterophylla*, I have seen a reversion-shoot to bloom freely, though this is probably not a common occurrence. In *P. capsularis*, on the contrary, the very narrow-leaved intermediate stage frequently blooms, and in a montane variety this stage remains fixed, this variety or species extending over a considerable area and growing both under xerophytic and mesophytic conditions. The case of the two species of *Weinmannia* (Cunoniaceæ), is somewhat similar to that of Parsonsia in so far as the juvenile form is not epharmonic. Both species (*W. racemosa*, *W. sylvicola*) show a reduction in leaf-form in the adult stage, that of the former being simple, but the latter being always more or less compound; in fact, since the flowers, etc., are virtually the same in both species, *W. sylvicola* may be considered a fixed juvenile form of *W. racemosa*. Further, both species can remain at an earlier juvenile stage as shrubs with compound leaves, and bloom abundantly, but in this case their station is not the rain-forest, but the more xerophytic heath.

The case of *Dacrydium intermedium* (Taxaceæ) is of considerable interest, and recalls that of the xerophytic whipcord veronicas. This tree, like so many of the New Zealand taxads, has a juvenile form very distinct from that of the adult. It has drooping branches which bear long, narrow, spreading pointed leaves. These pass by gradual gradations into the short, thick, rhomboid, imbricating reduced leaves of the adult, which are closely pressed to the branch. In Stewart Island[2] the adult form is not always reached, and juvenile flowering and fruiting trees are quite common, and form the variety *gracilis* of T. Kirk.[3]

The so-called variety *serratum* of the mesophytic small forest-tree, *Nothopanax Edgerleyi* (Araliaceæ) is evidently a fixed and flowering juvenile form of the latter, and its leaves are more hygrophytic, a condition of affairs which may be referred perhaps to the relation of the seedling to the moist forest floor. The variety *trifoliatum* of *Pseudopanax crassifolium* (Araliaceæ) may also perhaps be considered a fixed earlier stage of development.

The herbaceous plants do not furnish nearly so many cases of discontinuous stages of development as do the ligneous: two, however, seem worthy of mention. The celebrated mountain lily (*Ranunculus Lyallii*), distinguished from all other members of the genus but one by its peltate leaves, has seedling reniform leaves, the peltate form arising, I am virtually in a position to demonstrate, through concrescence of the basal lobes. Be this as it may, occasional adult flowering plants are encountered in which peltate

1. *Rep. A.A.A.S.* 11; 486, 1908.
2. Cockayne, L.: "Report on a Botanical Survey of Stewart Island," p. 17, 1909.
3. "Forest Flora," p. 224, 1889.

leaves are absent, while there are other cases where both leaf forms are present on the same plant. The last case has probably no epharmonic significance, but in the xerophytic *Anisotome filifolia*[1] (Umbelliferæ) the effect of a change of environment is very striking. This species when growing on subalpine shingle-slip has much cut filiform leaf-segments. These in the seedling are much broader,[2] but the plant also grows under mesophytic conditions, in which case the seedling form persists, although the plant flowers freely.

This last case is the strongest, so far as the cases given in this paper go, in support of a possible ontogenetic origin of certain species, since the question of a reproduced ancestral form, which could with much reason be argued for most of the former examples, may be here put on one side, the relation between breadth of leaf and variation in aridity of station being so well marked.

2.—THE XEROPHYTIC CHARACTERS OF THE FLORA OF THE HAWKESBURY SANDSTONE.

By A. G. HAMILTON.

The general aspect of the flora of the Hawkesbury sandstone is very characteristic. Wherever that formation occurs, even in detached outliers, the flora can be recognised at a glance. The plants are shrubby and small, very twiggy, the leaves hard and leathery, and there is a general scragginess which is unmistakeable.

Schimper[1] sums up the characters of xerophilous plants as below :—

1.—Reduction of leaf surface.
2.—Diminution of intercellular spaces.
3.—Augmentation of vessels and sclerenchyma.
4.—Increased length of palisade cells.
5.—Increased thickness and amount of cutin in the outer walls of the epidermis.
6.—Sinking of the stomates.
7.—Increased number of air-containing cells.
8.—Supply of water-storing cells.

He also mentions wax and other protective substances on the surface of the leaves, hairiness, thorniness, and the power of altering the position of the pinnæ in the pinnate leaved plants.

Henslow[2] mentions in addition the secretion of ethereal oils, tannin and certain hygroscopic salts as features in xerophytes.

Almost all these characters appear in the plants of the Hawkesbury flora, and in most instances several of them are found in the same plants. They are particularly noticeable in the endemic Australian plants ; indeed I think it would be safe to say that every one of these exhibits one or more of the xerophilous structural characters.

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1. *Anisotome filifolia* (Hook. f.), Cockayne *comb. nov.*—*Ligusticum filifolium* Hook. f., in "Handb. N.Z. Flora," p. 95, 1864.
2. See Cockayne, *Trans. N.Z. Inst.* 33 ; fig. 38, pl. 12.

With regard to the first character above—reduction of leaf surface—it is extremely common, and in all degrees of completeness up to complete loss of leaves. In the following natural orders it is very noticeable: Dilleniaceæ, Rutaceæ, Euphorbiaceæ, Leguminosæ, Myrtaceæ, Santalaceæ, Proteaceæ, Thymeleæ, Epacrideæ, and Coniferæ. The leaves may be of normal shape but very small, or may be needle-like (some Hakeas) cupressoidal (*Exocarpus*, *Callitris*), spinescent, phyllodineous, or dissected (*Trachymene*, *Petrophila*, *Isopogon*, *Lomatia*, *Actinotus*). Where the leaves are mere vestiges (*Casuarina*) or entirely absent (*Viminaria*, *Sphærolobium*) the work of photo-synthesis is done by the stems in the earlier stages of growth. Sections of these show that the histological characters of leaves are assumed by these stems.

In *Bossiæa* the stems are flattened; in *Amperea*, *Exocarpus*, *Callitris*, *Omphacomeria*, *Leptomeria* and *Choretrum* they are angular, and in *Sphærolobium* and *Viminaria* they are round. Seedlings of the latter plant bear small elliptical leaves, the earliest broadly elliptical with short petioles, and the later leaves very narrow with long petioles. Then the switch-like branchlets grow out of the centre. Seedlings of *Bossiæa scolopendria* also have elliptical leaves growing alternately on narrow branches. Sometimes in a wet season the ordinary flat branches produce leaves.

The second character—diminution of intercellular spaces—is very marked in microscopic sections of the leaves and stems of all these plants; and the third—the augmentation of vessels and sclerenchyma—is a notable feature, particularly in the leaves of Hakeas and Banksias. The veins frequently show a great deal of thick walled fibre, and in the needle bushes there are radial columns of sclerenchyma. See paper on the structure of the leaf of *Banksia serrata*,[3]

The palisade tissue is usually much modified. As Schimper points out, the cells are greatly lengthened, but in addition there are often two or three rows of cells. This is best seen in the flat-leaved Hakeas, *Lomatia*, *Eucalyptus*, etc.

Almost every plant shows a remarkable thickening of the outer wall of the epidermis, which is in some cases as thick as the palisade cells which it covers. In many plants there are two or three layers of epidermal cells. In that case only the outer wall is thickened, the inner one being rather below the normal in thickness.

The sinking of the stomates is a very common feature. The most usual method is not so much a sinking of the stomates as a protection afforded by the rolling backward of the edge of the leaf. This is well seen in *Boronia ledifolia*, *Ricinocarpus pinifolius*, *Banksia ericifolia*, *B. spinulosa*, and many of the Leguminosæ. The midrib fills up nearly all the space between the two edges of the leaf, so that there are only two narrow slits running the whole length of the leaf. These are defended by hairs growing in the grooves. The hairs are thick-walled and tapering to a sharp point. In some there is a bulbous base to the hair, and it is remarkable that this form of hair occurs in rolled leaves of plants belonging to widely separated natural orders. In *Dillwynia ericifolia* and *D. floribunda* there is a thickening of the margins, so that there is a V-shaped groove on the under side, and through a twist in the leaf this runs in a spiral direction. The groove is lined with thick-walled tapering hairs.

True sunken stomates are found in the flat leaved Banksias. On the under side of the leaf there are numbers of cavities or crypts of a hemispherical shape or spherical with a narrow mouth. The cavities are lined with hairs having a bulbous base crowned by a fine curled hair or cilium. There are many of these in each crypt, and the fine cilia are fitted into a plug projecting from the mouth of the cavity.[3] In all the flat-leaved Banksias I have sectioned, including a number from West Australia, the hairs have this form. The stomates are very large and there are from sixteen to twenty in each crypt. Each crypt is margined by a vein. The palisade is very close and there is a patch of open spongy tissue surmounting the roof of each cavity. The same structure is found in *Nerium Oleander*, but the hairs are not the same type, and the crypts occur on both sides of the leaf. There is an approach to crypt formation in *Ficus macrophylla*, and in an Italian paper, the reference to which I have unfortunately mislaid, the authors describe crypt structure in certain tropical figs.

In *Casuarina*, the stomates are on the sides of grooves running along the branchlets from node to node. The grooves are lined with thick-walled branching hairs. There is a differentiation between the base and the extremity of the hairs, the extremity staining readily and deeply with saffranin, while the base remains uncoloured. The palisade tissue is small in quantity and lies in the lobes between the grooves. Between it and the epidermis a thick layer of sclerenchyma is interposed and a wedge of the same runs down the centre of the palisade.

The increased number of air-containing cells I have not noticed except in the epidermis of some of the plants.

Water-storing cells are found in *Portulaca*, *Claytonia*, *Rhagodia* and *Mesembryanthemum*.

The section of wax and other protective substances on the surface is extremely common. It is generally the young leaves which are protected in this way. *Eucalyptus corymbosa* has the young foliage coated with rubber.[4] *Dodonæa* has its leaves coated with a viscous substance which persists when the leaf is full grown.

Hairiness is not a general adult character. *Actinotus* shows it in a marked degree. *Metrosideros glomulifera*, *Callicoma* and some others have the underside of the leaf, where the stomates occur, covered with hairs. In the former the hairs often disappear with age. Hairiness is much more common on the younger leaves. Several of the flat-leaved Banksias and some of the flat-leaved Hakeas show it. The young shoots are so thickly covered with golden brown hairs that they look like chenille or fur.

Bursaria and *Citriobatus* have spinescent branches. Pungent pointed leaves are found in several Daviesias, some Acacias, *Mirbelia* and *Oxylobium trilobatum*, the terete leaved Hakeas, *Lambertia*, *Xylomelum* (on the young leaves), and most of the Epacrideæ.

Tannin filled cells are frequently found in the Proteaceæ and Leguminosæ, particularly in the Acacias.

In the first-mentioned order it is usual to find the outer epidermal cells filled with this substance.[3] Henslow says it has been suggested that tannin is hygroscopic.[2] The presence of ethereal oils is well known in the Rutaceæ, Myrtaceæ, some of the Labiatæ and the Coniferæ. Henslow points out that desert plants are notoriously aromatic, and mentions the suggestion that as a screen of vapour from ethereal oil is opaque to heat rays, the secretion of these oils may be of service to dry climate plants.

The only Hawkesbury plants secreting hygroscopic substances are the Chenopodiaceæ.

References to Literature;

1. Schimper; "Plant Geography," Clarendon Press.
2. Henslow; "The Origin of Plant Structures, Int. Sc. Series."
3. Hamilton; "On the Structure of the Leaf of *Banksia serrata*." Proc. Aus. Ass. Adv. Sc., Vol. xi.

3.—RECORDS OF AUSTRALIAN BOTANISTS.

(FIRST SUPPLEMENT).

By J. H. MAIDEN, Government Botanist and Director of the Botanic Gardens, Sydney.

(WITH FOUR PLATES.)

I have already published the following papers on deceased Australian botanists. They will be referred to by the figures in heavy type :—

(**1**) "Records of Australian Botanists" (A. General, B. New South Wales), Journ. Roy. Soc., N.S.W., xlii., 60 ; (**2**) "Notes on South Australian Botanists," in Journ. Aust. Assoc. Adv. Sci., Adelaide Meeting, 1907 ; (**3**) "Records of Victorian Botanists," Vict. Nat., xxv., 101 ; (**4**) "Records of Tasmanian Botanists," Journ. Roy. Soc. Tas., 1909 ; (**5**) "Records of Western Australian Botanists," Journ. W.A. Nat. Hist. Soc., 1909 ; (**6**) "Records of Queensland Botanists," Journ. Aust. Assoc. Adv. Sci., Brisbane Meeting, 1909 ; (**7**), "Records of the Earlier French Botanists as regards Australian Plants," Journ. Roy. Soc., N.S.W., xliv. 123.).

Atkinson, Caroline Louisa Waring. *See* (**1**), p. 83.

For an account of her father, James Atkinson, senr., of Oldbury, *see* Burfitt's "Founding of the Wool Industry of Australia," 2nd edn., p. 60.

BAUDIN'S Expedition. *See* (7), p. 132.

For a note on the collections brought home by Baudin's Expedition, which included "four cases of dried plants, three large casks of specimens of timber, two boxes of seeds, and sixty tubs of living plants," *see* Scott's "Terre Napoléon," p. 248.

BEHR, HANS HERMANN, Dr. *See* (2), p. 173.

He published the following :—

(1) "Flora of the Vicinity of San Francisco." San Francisco, 1888.
(2) "Botanical Reminiscences." *Zoe*, 2, pp. 2-6, 1891.
(3) "On the Poisonous Plants indigenous to California."

Miss Alice Eastwood, of San Francisco, a distinguished botanist, who suffered so severely in the San Francisco fire, wrote to me as follows: —

"Dr. Behr was born August 18, 1818, at Coethen, in the German duchy of Anhalt, and died March 6, 1904, in San Francisco.

"In 1844 he went to Australia by the advice of Alexander von Humboldt and Karl Ritter. He lived among the natives, studying their language and habits, and published results in Virchow's *Archives*, *Linnæa* and *Nature.* He also studied insects and plants and described new species, which were published in Germany. He was a devoted friend of Ferdinand von Mueller, and because of the friendship von Mueller sent him piants from Australia, which were thus introduced into California. He returned to Germany in 1847 (from Australia)."

BENNETT, GEORGE. *See* (1) p. 84.

Soon after his death his widow published an 8vo. pamphlet of seven pages for private circulation, entitled "George Bennett, M.D., F.R.C.S., F.L.S., F.Z.S., &c.," giving the fullest details of his activities, including notes on his botanical labours.

BONPLAND, AIMÉ.

See "Aimé Bonpland, Médecin et Naturaliste, Explorateur de l' Amérique du Sud, sa vie, son œuvre, sa correspondence, avec un choixde pieces relatives à sa biographie, un portrait et une carte." Par Dr. E. T. Hamy. (E. Guilmoto, Paris), 1906. 8vo. pp. xcvi., 300 ; contains no references to Australian plants.

BRONGNIART.

See "Eloge de M.M. Alexandre Brogniart et Adolphe Br ngniart, membres de l' Académie des Sciences," par M. Dumas, Secretairè perpétuel. Lu dans la Séance publique annuelle de l' Academie du 23 Avril, 1877. 4to, pp. 40.

BUNCE, DANIEL. *See* (3) p. 103.

He died 2nd June, 1872, having been Curator of the Botanic Gardens, Geelong, for 10 or 12 years. He was son-in-law of John Batman. In Mr. A. C. Neate's "A Peep into the Geelong Botanic Gardens" ("Geelong Advertiser," 11th November, 1905) is an account of this worthy, with notes from official records.

DAMPIER, WILLIAM. *See* (5), p. 13. *See* also Banks' Journ. (Hooker) xlvi.

Figures of the Western Australian plants collected by Dampier and the oldest Australian plants in existence are reproduced from Dampier's work in the "Western Mail" (Perth) Christmas Number, 1898.

There is a paper, "Remarks on Plants collected by the Voyager Dampier," by Prof. Lawson, in *Journ. Bot.* xi., 348.

DECAISNE, J.

The *Flore des Serres*, tome xxiii., contains a portrait, a biographical notice by Planchon, also "discours" by M. M. Frémy, Ph. Van Tieghem, Bouley, P. Duchartre, Barral, Lavallée, Henri de Parville, P. P. Depérain, C. E. Bertrand. The whole extends to 37 pages and includes (pp. 16-20) a valuable list of Decaisne's works.

DE MOLE, MISS FANNY ELIZABETH (1835-1866). *See* (2), p. 174.

Born in England 1st March, 1835, died at Burnside, South Australia, 26th December, 1866. Came to Australia for the benefit of her health, arriving in Adelaide in the ship "Albemarle" in February, 1856. Owing to the state of her health she could not go far in the search for specimens, and accordingly most of the plants depicted in her work were collected at Burnside. The object of the book was to raise funds for the enlargement of St. Bartholomew's Church, Norwood, S.A., her brother-in-law, the late Rev. J. S. Jackson, M.A., being Rector at that time.

I am indebted to Mr. G. E. De Mole, of Fullarton, S.A., for the above particulars concerning his sister.

DESFONTAINES, R. L.

See "Notice historique sur la vie et les travaux de M. Desfontaines," par M. De Candolle. From the "Bibliotheque Universelle," Geneva, Feb., 1834. 8vo., pp. 32. Contains a valuable list of his works.

DIETRICH, AMALIE (1822-1891). *See* (6), p. 376.

I am indebted to Mr. Ernst Betche for the following details of this remarkable woman; he extracted them from "Charitas Bischoff; Lebensbild, Amalie Dietrich," published in Berlin, 1909.

Amalie Dietrich was born in 1822 in Siebenlehn, a small mountain village in Saxony; her father, Gottlieb Nellen, was a saddler, and she was the youngest child of five. Three of the other children died quite young, and she had only one brother living. Her brother learnt the trade of his father, went as a travelling journeyman when he was about 18 years old, as it was the custom with artisans at that time, and married in Bucharest, Roumania, his master's daughter.

Amalie and her mother met the naturalist, Herr A. W. S. Dietrich, in the mountains when they were gathering mushrooms for sale and for their own use (mushrooms were always and are still an important article of food in the poor mountain districts of Germany), and he explained to them the difference between poisonous and wholesome mushrooms, and showed them where they could get plenty. Herr Dietrich had settled recently in Siebenlehn, and was the wonder of the small township. His father was a lawyer and was the descendant of a family of botanists. Salomo Dietrich, who immigrated from Bohemia to Germany in 1688, was the first botanist of fame in the family, and since then there had always been at least one member of the family a reputed botanist. A. W. S. Dietrich was a well educated man, and started life as a chemist and druggist, but gave up his profession in order to make a living by lecturing and teaching all branches of Natural History and selling collections. He was an enthusiast, but made a very poor living. He became a friend of the saddler's family, and Amalie fell desperately in love with him, took a passionate interest in Natural History, chiefly in Botany, and Herr Dietrich became her instructor. Finally they married in 1846 or 1847, very much against the wishes of her father and mother (Cordelia).

The couple had very little to live on, but the father sold his house and garden for 300 thaler (900 shillings) and gave the money, together with all his little savings, to his son-in-law, and they all four lived together. The mother managed the household with much pinching and many deprivations on the part of the female members of the family, till the mother died. It is very sad to read the details of the household. He was an utterly selfish man, who never gave a thought to the comfort of his willing wife, and she considered him as her master and teacher, and willingly slaved for him. The only daughter, Charitas, was born in 1848, and the mother of Frau Dietrich died in 1852. After that confusion reigned in the household. Amalie Dietrich had apparently neither inclination nor skill as housewife or cook, and they had to hire a housekeeper, but could not afford it. They commenced hawking their botanical collections, walking many hundreds of miles from township to township, and she was the beast of burden who carried the packs on her back. Afterwards they bought a dog and dog-cart, and she and the dog drew the cart ; but Herr Dietrich stayed at home after a couple of hawking journeys, and left all that work to Frau Dietrich. The hawking seems to have paid little in proportion to the hard work. The author gives no details about her income, but she mentions in one case that Amalie Dietrich brought home 48 thaler after a five months' journey—*i.e.*, about £7 4s—and that was hailed as a prosperous journey. Herr Dietrich wanted at once to buy the many-volumed illustrated Botanical Dictionary of David Dietrich (one of his ancestors), but she refused. Soon afterwards Herr Dietrich pretended to go to Berlin to collect money, but did not return, and informed her afterwards that he had accepted a position as teacher. He sent her some months later £12 or £13, and she used the money to go with her child to Bucharest to visit her brother. Her brother had settled in Bucharest, and was a prosperous artisan—a glove-maker. He and his wife received them kindly, and she stayed with them more than a year. Amalie Dietrich was so unconventional and so slovenly and careless in dress that she constantly jarred on the feelings of her sister-in-law, who was scandalised about everything she did. When she commenced collecting plants and snakes and insects, etc., the latter bundled her collections out of the house and told her she would not have such rubbish in the house. She tried to get positions to make her own living, but failed to hold the positions she got, and decided to return to Germany. Charitas was then about six years old. She returned to Germany in 1858, got reconciled with her husband, and commenced the old life again. Every summer she made hawking journeys with the dog-cart under terrible hardships. In 1860 she broke down on one of the journeys and was for many weeks in a hospital at Haarlem, in Holland. (This shows the extent of her walking trips.) When she returned after six months without money she found the house empty; her husband had again taken up a position as teacher to the sons of a German Graf. When he left Seibenlehn he told his about nine years old daughter to get a position somewhere, and left her to shift for herself. Some compassionate people took care of her and gave her board and lodging for what work she could do. Amalie Dietrich saw her husband, returned him her ring, and continued the collecting and selling on her own account. When she went hawking she left the child with people who would board her for what work she could do.

At last there came a lucky turn in her life. In 1862 she met a Dr. Meyer, a rich merchant, in Hamburg, who took a great interest in botany. He and his wife bought all her collections, and recommended her to Cæsar Godeffroy. She must have had at this time a good reputation in Germany, because she got excellent letters of recommendation from Dr. Willkomm, Reichenbach, Garke and Leunis, all persons whose names stand high in science. These letters of recommendation secured her an appointment as collector for Godeffroy. No mention is made of the terms of the engagement, but they must have been liberal because she could provide for the education of Charitas before she left.

Amalie Dietrich left Hamburg in the sailing vessel "La Rochelle" on March 15th, 1863. She said farewell to her husband, who was indignant that such an offer had been made to his wife and not to himself. The "La Rochelle" carried 450 steerage passengers, emigrants to Australia. The modest woman was much surprised at Godeffroy's generosity in providing her with a cabin to herself; she had been so much used to roughing it that she would have thought it quite natural to travel steerage.

From this part on the book consists of letters from Amalie Dietrich to Charitas, from Charitas to her, and from Godeffroy to her, but, unfortunately, the letters seem to have been more or less compiled. Anybody who knows Australian life and the flora can see that the letters as published are written by a person who has not seen Australia. The author of the book, Charitas Bischoff, is probably her daughter Charitas Dietrich. She knew, of course, the life of her mother, but she apparently did not preserve all her letters, and more or less reproduced them from memory, but the letters probably correctly show her movements in Australia. She wrote letters to her daughter from Brisbane, August, 1863; Rockhampton, April and October, 1864, February, 1866; Mackay, November, 1867; Lake Elphinstone, March, 1868; Mackay, February, 1869; Bowen, September, 1869; October, 1870; Melbourne, April, 1871 (met Baron von Mueller); Tongatabu, February, 1871.

She returned to Europe in May, 1873, and was met by her daughter Charitas at Hamburg. She had hoped to spend the rest of her life with her daughter, but was disappointed to hear that Charitas was engaged to a pastor (presumably Bischoff) on the border of Denmark and Germany, and would soon marry. Amalie Dietrich refused to live with her daughter and son-in-law. She accepted a position in the Museum Godeffroy, and lived for 13 years in the Museum. When the collections were transferred to the Municipality of Hamburg a position was given to her in the botanical museum of Hamburg, and she was paid by the municipality. The business of Godeffroy was converted into a company, "Die deutsche Handels und Plantagen Gesellschaft" (about 1880, probably after the death of Cæsar Godeffroy). The money spent on science by the rich merchant as a hobby was not spent by a company, and the Museum Godeffroy ceased to exist.

She died in 1891, aged 69, when on a visit to her daughter in Rendsburg, having caught a cold on the journey.

The portrait of Amalie Dietrich is copied from the work in question.

FERGUSON, W., took up the position of Superintendent or Curator of the Botanic Gardens, Melbourne, on 1st January, 1870, and continued until 30th June, 1872.

Interim arrangements for the control and management of the Gardens, Domain and Government House Gardens were made and continued until 1st July, 1873 (F. Pitcher).

On that date Mueller and Luehmann were restricted to the Department of the Government Botanist, while Mr. W. R. Guilfoyle was appointed Director of the Botanic Gardens.

See HEYNE, E. B. (below).

FRANCIS, GEORGE W. *See* (2), p. 174.

There is a stone obelisk to his memory in the Adelaide Botanic Gardens, with a gunmetal plate encircled with ivy and laurel, and bearing this inscription :—

"In remembrance of the late G. W. Francis, Esq., F.L.S., F.H.S., first Director of this Garden, by whom it was planned and laid out in the year 1855."

The portrait of him in the Museum of the Adelaide Botanic Gardens is reproduced in "The Garden and Field," Adelaide, December, 1907, p. 487.

GUNN, RONALD. *See* (4), p. 15. *See* also (*a*) "Contributions towards a Flora of Van Dieman's Land, from Collections sent by R. W. Lawrence and Ronald Gunn, Esq., and by Dr. Scott," by W. J. Hooker in Hooker's Journ. of Bot., i. 241 (1834); (*b*) "Contributions towards a Flora of Van Dieman's Land chiefly from the Collections of Ronald Gunn, Esq., and the late Mr. Lawrence," by Joseph Dalton Hooker, M.D., R.N., London Journ. of Bot., ii., 399 (1840).

Gunn was appointed Secretary of the Tasmanian Society (Hobart) on 4th June, 1844. *See* Tas. Journ., ii., 317.

Incidentally I may refer to an account of the foundation of the "Royal Society of Van Diemen's Land for Horticulture, Botany and the Advancement of Science." The Botanic Garden, Hobart, was founded at the same time. *See* Tas. Journ., ii., 348.

I am indebted for the portrait of Ronald Gunn, which is reproduced (and which is the only one I have ever seen). to his niece, Miss Louisa C. Gunn, of Launceston, Tasmania.

HEYNE, E. B. *See* (3), p. 108.

Mr. F. Pitcher, of the Botanic Gardens, Melbourne, points out that I am in error at p. 109 in stating that Mr. Ferguson "succeeded him," Mr. J. G. Luehmann having been his successor. Mr. Pitcher writes :—

> Mr. Ferguson did not appear on the scenes for a long time after Mr. Luehmann had become clerk and assistant to the Baron. In fact, Mr. Ferguson was appointed to act in the distinct position of curator rather than as assistant to the Baron.
>
> Mr. Heyne resigned in January, 1869, probably about the 17th or 18th of that month, and was succeeded by Luehmann.

HUSSEY, MISS JESSIE L. (1862-1899).

Born at Port Eliot, South Australia. 5th June, 1862. Became totally deaf in 1889, and her health otherwise impaired. In 1893 commenced collecting algae of the southern coast of South Australia for Mueller. who sent them to Agardh. who named two new species of her collecting after her, viz., *Crysymenia Husseyana* and *Pachyglossum Husseyanum*. She was an indefatigable and careful collector and corresponded with many algologists in Europe and America. She also collected phanerogams. and, shortly before her death, which took place in March, 1899, she offered her herbarium, consisting of 2.000 plants, as a gift to the Adelaide Museum.

JUSSIEU, ADRIEN DE. *See* (7), p. 137.

Add to the list :—

"Mémoire sur l'Opercularia, genre de plantes voisin de la famille des Dipsacées." Par A. L. Jussieu, Ann. du Muséum, iv., 418 (1804). With figures of *O. aspera, sessiliflora, hyssopifolia, ligustrifolia, ocimifolia.*

LABILLARDIERE, J. J. H. DE. *See* (4), p. 20, and (7), pp. 127, 128. Add to list :—

Extrait d'un Mémoire lu à la classe des sciences physiques et mathématiques de l'Institut, le 19 Messidor an 13 (8 Juillet 1805), par M. Labillardière. Ann. du Muséum xiii., 451 (1805).

" J'ai nommé *Candollea* le nouveau genre que je propose," etc. Figs. of *C. pilosa, C. glauca, C. serrulata.*

See also " Sur le gere (genre) *Candollea.*" Note by M. Labillardière (confusion with *Stylidium*). Ann. du Muséum, vii., 400 (1806).

See also " Eloge historique de J. Julien de Labillardière," par M. Flourens, Secrétaire perpétuel. (Lu à la Séance publique du 11 Sept., 1837), pp. xxi.-xxxi., with a list of his works at pp. xli., xlii. (Vol. xvi. *Ann. du Mus. d' Hist. Nat.*, 1837).

LAWRENCE, R. W. *See* (4), p. 20.
See " Notes on an excursion up the Western Mountains of Van Dieman's Land," by R. W. Lawrence, Esq., of Formosa. Hooker's Journ. of Bot. i., 235 (1834).
See also GUNN, RONALD.

LUEHMANN, J. G., *See* (3), p. 110.
He commenced duties as clerk and assistant to Baron von Mueller on 22nd February, 1869. He was a bachelor at the time, and for a considerable period resided at the Herbarium.

MACARTHUR, WILLIAM. *See* (1), p. 111.
The accompanying portrait is from the " Sydney Mail " in November, 1882, and is an excellent one.

MCWILLIAM, JAMES ORMISTON (—1862). *See* (1), p. 114.
Sir Norman MacLaurin, M.D., Chancellor of the Sydney University, himself a surgeon in the Navy as a young man, kindly gave me particulars concerning Dr. McWilliam, and clues which I followed up.

The Secretary to the Admiralty kindly informed me as follows :

James Ormiston McWilliam, C.B., M.D., R.N., entered the Navy as Assistant Surgeon 8th October, 1829. Was Senior Medical Officer in the Niger Expedition, 16th September, 1840, to 29th November, 1842, and published a work on that expedition.

Served in " Forfarshire," 29th May, 1843, to 10th July, 1844, and in " Hyderabad," 24th September, 1844, to 2nd September, 1845, both ships being employed in Australian waters. He died on the 4th May, 1862.

Following is the title of the work referred to :—

" Medical History of the Expedition to the Niger during the years 1841-2, comprising an account of the fever which led to its abrupt termination." Plates 8vo. London, 1843.

He obtained the Blane medal—a much coveted distinction for naval officers. There is an account of him in the "Dictionary of National Biography."

MAXWELL, G. *See* (5), p. 20.

He lived at Albany, W.A., for many years.

Mr. William Dunn, who knew him well, gave me the following particulars concerning him when I was last at Albany.

He lived and died at a cottage near Middleton Beach, on the right hand on the last descent from Albany. The property belongs to Mr. Affleck now. It used to be a reserve for the native school, and the ground about it was cultivated by the natives. The building itself was erected as a native school.

He was buried in the Church of England Cemetery at Albany; there is no headstone. He was in very low water during the last few years of his life, and died almost penniless. He used to sell birds, insects, flowers, seeds, etc., to the passengers (chiefly those of the P. & O. boats of the old days) who visited King George's Sound.

He was always a wanderer. He was a great bushman, and many rich families possess good land discovered by him, who, however, never did any good for himself. He lived in his cottage or hut by himself, and Mr. Dunn and others used to keep an eye on the old man, following him up whenever they missed him. He suffered greatly from his eyes.

There is no doubt that he performed yeoman service in bringing under notice the vegetation of King George's Sound, the Stirling Range, and the western part of the Bight. The seeds he collected caused many public and private collections to be enriched, whose owners probably never heard of him.

MOQUIN-TANDON, H. B. A.

See "Eloge du M. le Professeur Moquin-Tandon," prononcé par M. H. Baillon, à la seance de rentrée de la Faculté de Médecine, le 3 Novembre, 1864. 4to, pp. 34, with a full list of his works at pp. 23-34.

See also "Université de Montpellier, L' Institut de Botanique Notice," par Ch. Flahault (1890), p. 49.

OLDFIELD, AUGUSTUS FREDERICK. *See* (4), p. 24, and (5), p. 22.

He was author of a paper "On the Aborigines of Australia." By Augustus (Frederick) Oldfield, Esq. (read February 9th, 1864), pp. 215-298 (? *Roy. Geog. Soc.*, but I cannot trace the paper).

He botanised in the country about the Murchison River, West Australia, in 1858-9.

Mr. E. D. Oldfield has presented to me many of his brother's manuscripts, mostly written on paper bearing the water-mark of 1864. What he has written shows him to have been a competent linguist, a mathematician, but especially a biologist in both branches of zoology and botany. He was evidently a man of very broad reading, and it is a pity he published nothing in regard to the Australian flora. I give two specimens from his copious manuscripts, showing that he was not a mere collector.

In all my wide wanderings in Australia I discovered but a single plant of *Emblingia calceoliflora*, a form hitherto found by none but myself. As it grows on the sandy shores of Western Australia, different portions of which have been examined by various naturalists, beginning with Dampier, who made the first botanical collection in New Holland, and including La Billardiere, Rob. Brown, Gaudichaud, Hugel, A. Cunningham, Preiss, J. Drummond, P. Walcot, and many other collectors, and as it covers many square yards with its long prostrate branches, and therefore is a plant not liable to be overlooked, the probability is that the individual found by me was the only existing member of its species, and, as far as is yet known, of its genus also, while from the circumstance that it was growing on a spot over which cattle were continually grazing, it is to be feared that that solitary individual has been destroyed. Now, are we to consider such an individual as the first or the last of its species ? As a plant nearly allied to it, the *Capparis spinosa* is very abundant in the vicinity, perhaps the former supposition is the more correct, and if hereafter the plant in question—or congeners with it—should be found more plentifully, not only in Australia, but also in India, wherein the *Capparis spinosa* is also indigenous, we should be somewhat justified in assuming that it originates from the last-mentioned plant. Many other examples of strictly local plants might be cited to give weight to the foregoing hypothesis of the origin of species, such as *Scaevola chenopodiacea*, *Chloanthes atriplicina*, etc., of each of which probably not half-a-dozen individuals exist, but these will suffice to show the probability of the birth of new species.

On the other hand, there are forms which are continually being detected in widely separated, and in some instances well-examined localities, and which therefore appear to be nascent forms. As an example may be cited that delicate little fern, *Gymnogramma leptophylla*, which has been successively discovered in Eastern and Western Australia, New Zealand, Tasmania (in two spots only), North and South Africa, extra-tropical South America, in a few localities on the northern shores of the Mediterranean, on the mountains of India, in the north of Spain, and lastly in the Channel Islands. Should this fern be really a nascent form, it would be highly interesting to determine to which species it owes its birth, for we should then have an example of a form verging on extinction. But we need not expect to see the parent species at once disappearing ; such a process must extend over a considerable period, for all the individuals of the parent species in a given locality may not be of the same age, nor may they all be equally precocious, or it may be, and most probably is, that the new form is a reversion. However, all this may be, this much is certain, that some variety or other of the common Brake (*Pteris aquilina*) is found in every locality in which the fern in question has yet been discovered, and should the *Gymnogramma leptophylla* still continue to be detected in countries to which it has hitherto been a stranger, and should the *Pteris aquilina* still be found in those new localities—a condition almost sure to be fulfilled, since the Brake is almost cosmopolitan—then will there be great probability, not only that the former fern is a nascent form, but also that it owes its birth to the latter.. (Pp. 437-441.)

Notwithstanding the discreet nature of their individualism—a condition determined perhaps by the forces inherent in the vegetable elements being unable to combine so intimately as those proper to the animal elements—plants are not exceptions to this law, for we find that when the blending of individuals is most complete, the evidences of life—manifested by spontaneous motion—are very apparent, as in the compound-leaves of many *Leguminosæ*, those of *Biophyllum*, etc. In the case of the genus *Stylidium* the concretion of individuals is more perfect than in most other plants, the *column* consisting of the united stamens and style, all very highly organised bodies as compared with their homologues in orchids, in which family the column has no evident motion, though, as might have been expected from the concrete nature of the individualism of their flowers, many orchids evince irritability, as in *Caleana*, *Pterostylis*, etc., where the *labellum* is very sensible. In consequence of the concrete nature of the individualism of the column of *Stylidium*, the resultant forces are more localised—and therefore intensified—than in most other plants, residing entirely in a gland (the analogue of the nervous-ganglion of animals) situated at the base of the column, and the irritation of this gland by any foreign substance causes the whole column to jerk quickly from one side of the flower to the other, for which reason the Australian colonists call this plant (of which there are many species) " Jack-in-the-box." The fronds also of *Cycads* (at least according to my observations on two species of *Macrozamia*) evince the concrete nature of their individualism by nightly assuming that state which Linnæus called *the sleep of plants*." (Pp. 474-6 under Chap. VI.—*Life*.)

Mr. H. Stuart Dove, of Cunninghame, Victoria, has politely forwarded me some personal reminiscences of Mr. Oldfield's declining days, when, quite blind, he used to live in a cottage in Merton-road, Wandsworth, London, consoled by a portion of his herbarium, a specimen of which his visitors would describe as well as they could to the sightless man, and he would then give the botanical name and particulars concerning it.

PLANCHON, J. E.

See " Université de Montpellier, L' Institut de Botanique." Notice, par Ch. Flauhault " (1890), p. 54.

SCHOMBURGK, RICHARD. *See* (2), p. 176, 181.

There is an obituary notice in Proc. Roy. Soc., N.S.W., xxv, 3, and a portrait in " The Garden and Field," Adelaide, December, 1907, p. 487.

SCOTT, THOMAS, Dr. *See* (4), p. 26.

See GUNN, RONALD.

STIRLING, JAMES.

Acting Government Geologist of Victora for some years; C.M.G. He died at Riverside, California, in 1909, and there is an obituary notice of him in the Melbourne " Age " for 5th August, 1909.

He travelled extensively for geological purposes in the Victorian Alps, and wrote on the plants, most of which were determined for him by Mueller. His papers include :—

(*a*) " Notes on the Flora of Mount Hotham " (Vict. Nat. iv, 72), and the following in Trans. Roy. Soc., Vict. :

(*b*) " The Phanerogamia of the Mitta Mitta Source Basin and their Habitats" (Part i. in xix., 1; Part ii. in xxi. 29).

(*c*) " The Cryptogamia of the Australian Alps" (Part i. in xxii., 49).

Helichrysum Stirlingi, F. V. M., commemorates him.

SWAINSON, WILLIAM. *See* (**3**), p. 113.

Mr. A. Hamilton, Director of the Dominion Museum, Wellington, N.Z., obligingly writes to me :—

In sorting a number of books that have been packed away in the library for some time, and which formerly belonged to Mr. Swainson, I have found three manuscript notebooks and a quantity of manuscript on the same sized paper relating to his celebrated report on the Eucalypts and the Casuarinas. I see in your address* that you suggest that Mueller may have lost the manuscript notes. Possibly there was another copy of these. What I have seem to be the originals. The first MSS. book is entitled " Rough Notes on the Eucalyptidæ, Dandenong, March, 1853, William Swainson," and contains apparently the description of about 42 species. The second one is entitled " Rough Description of Cassuarinæ of Port Philip, September, 1881, vol. 2, William Swainson." I see he adopts the spelling Cassuarinæ all through. The third one continues the description of Casuarinæ from No. 171 to apparently 225. Besides this there are descriptions of other Tasmanian Casuarinas in loose manuscript. There is perhaps no very great interest attached to this now, but I thought you might like to make a note of where they are at present. We have besides a large number of his beautiful sketches of birds, which have hardly ever been surpassed. Also some old botanical works, many of which were presented to him when he was in Sicily by some Italian botanists.

TATE, RALPH. *See* (**2**), pp. 171, 177, 181, 186.

I have come across a list of Tate's botanical papers, in his own handwriting, dated 31st August, 1892. Any subsequent papers can be readily traced.

(1) *Journal of Botany* (1866).

1. Flora of the Shetland Islands, 1866.

(2) *Intellectual Observer* (1866).

2. Review of the Flora of Ireland, 1866.

(3) *Royal Society of South Australia* (1880-1892).

3. Census of the Flora of South Australia, 1880.
4-5 *Id.* Supplements, 1881, 1882.
6. Census of the Cryptogamic flora of South Australia, 1881.
7. New Dilleniaceous plants, 1882 (In conjunction with Baron von Mueller).
8. New Rhamnaceous plant, 1882
9 Botany of Kangaroo Island, 1883.
10. Miscellaneous botanical contributions, 1881.
11. Winter-flowering state of *Hypoxis glabella*, 1882.
12. Plants of South Eyre Peninsula, 1883.
13. Plants of South-east of South Australia, 1883.
14. Plants of North-east part of Lake Torrens basin, 1883.
15. Diagnoses of New Plants (in conjunction with Baron Sir F. von Mueller), 1883.
16. Additions to the Flora of South Australia, 1883.
17. Descriptions of New Species, 1884.
18. Diagnoses of New Species (in conjunction with F. v. M.), 1885.
19. Diagnosis of a New Species of *Caladenia*, 1 pl., 1886.
20. Diagnoses of New Species (in conjunction with F. v. M.), 1887.
21. Flora of Port Lincoln district, 1888.
22. Plants of the Lake Eyre Basin, 1888.
23. Botany of Southern Yorke Peninsula, 1890.

* *Proc. Linn. Soc. N.S.W., XXVI,* 797.

24. Botany of the Tietkens' Expedition, with diagnoses of New Species (in conjunction with F. v. M.), 1890.
25. Revision of the Flora of Kangaroo Island, 1889.
26. Census of the Phanerogamic and Vascular Cryptogamic Flora of South Australia, 1889.
27. Botany of the Elder Exploring Expedition (in conjunction with F. v. M.). In preparation.

(4) *Australian Association for the Advancement of Science* (1888).

28. Influence of Physiographic Changes in the Distribution of Life in Australia. (Presidential Address before Section D), 1888.

(5) *Linnean Society of New South Wales* (1892).

29. On the Relationships of the Florulas of Lord Howe and Norfolk Islands. In preparation.

Mr. W. Botting Hemsley writes to me that Tate was a contributor to his "Outlines of the Flora of Sussex" before he left for Australia.

There is a "Notice of William Hann's Expedition to Northern Queensland" with Tate as botanist, 26th June, 1872. *See* Trans. Roy. Soc., N.S.W., 1873, p.10.

There is an obituary notice of Tate in Vict. Nat. xvii, 88.

THOZET, ANTHELME. *See* (**6**), p. 382 ; (**7**), p. 153.

The Curator of the Australian Museum, Sydney, has placed at my disposal three letters from M. Thozet, dated 3rd March, 5th and 22nd April, 1859, on botanical subjects.

He sends some local wood specimens, numbered and botanically named, provisionally, as "I hear the Sydney Museum will soon put before the public an Herbarium." They correspond to herbarium specimens sent to the Botanic Garden. (Perhaps these found their way to Mueller.) "The box containing the specimens is made from Leichhardt's wood (*Nauclea Leichhardtii.*)"

WALTER, CARL. *See* (**3**), p. 114.

Mr. Ernst Betche informs me that Mr. Walter told him that he came out to Australia with Baron von Huegel. *See* (**5**). If that be a fact, then Mr. Walter was older than I surmised.

Walter was a photographer, and is stated to have been engaged by Baron von Huegel as professional photographer, and remained in Australia when von Huegel returned.

Walter was an excellent collector. I first made his acquaintance in 1866, just before he went to Croajingolong. He collected afterwards in the Eclipse Expedition, also in New Britain and Samoa. He carried a huge old-fashioned camera and his "tucker-bag" the whole distance to Croajingolong and back, some 400 miles, and when roads in these parts were unknown. I have collected *Prostanthera Walteri* in the very spot where Walter collected it so long ago, and also *Nageia alpina*, which everyone but yourself seems to have missed. (C. French, in letter to me.)

WILHELMI, CARL. (*See* (**2**), p. 179.

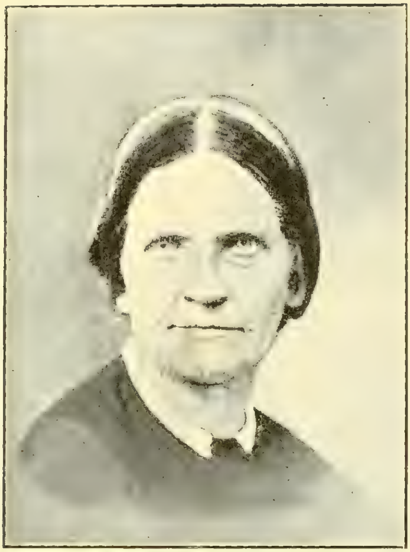
Mr. D. Henne informs me that Wilhelmi returned to Dresden, his native city, in 1865. Mr. H. F. Eaton, of London, formerly in the Victorian Civil Service, informs me that he died in Dresden.

Mrs. Wilhelmi was a niece of the celebrated traveller, Frau Ida Pfeiffer.

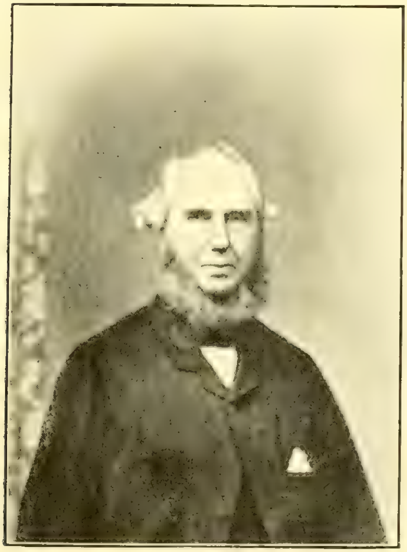
With reference to Wilhelmi's labours amongst the Port Lincoln aborigines, there used to be an aboriginal station at Poonindi, 10 miles north of Port Lincoln, on the Tumby-road, but it has been broken up for some years, and the few remaining blacks are at Tumby.

I am indebted for the portrait of Wilhelmi to his colleague at the Melbourne Herbarium, Mr. Henne, botanist of Landsborough's Expedition.

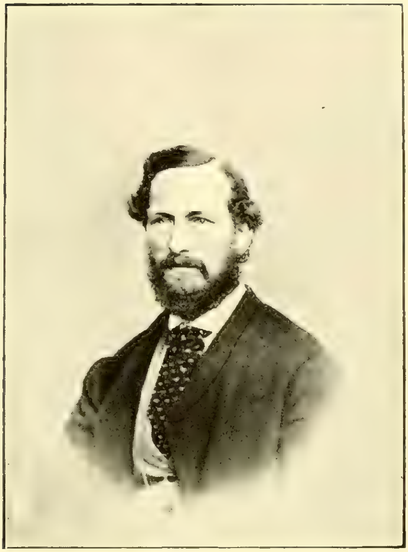
Following is a list of the botanist already referred to :—



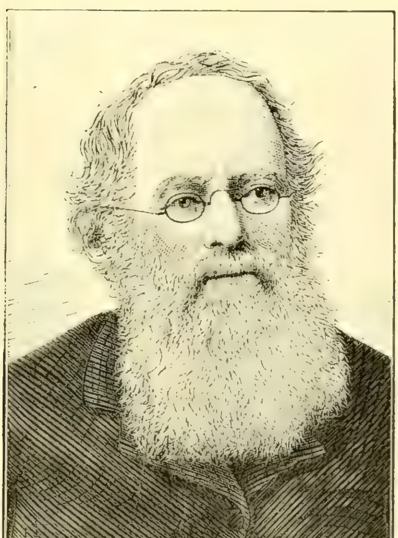
AMALIE DIETRICH
(1822-1891).



RONALD GUNN
(1808-1881).



CARL WILHELMI.



SIR WILLIAM MACARTHUR
(1800-1882).

EXPLANATION OF PLATES.

Portraits of AMALIE DIETRICH
RONALD GUNN
WILLIAM MACARTHUR
CARL WILHELMI.

4.—THE CINNAMOMUMS OF AUSTRALIA.

By RICHARD T. BAKER, F.L.S., Curator of the Technological Museum, Sydney.

HISTORICAL.

THE genus *Cinnamomum* has now been before the botanical world for nearl· 200 years, but was definitely established by Blume in 1825, in *Bijdr.* 568, where some half-dozen species are described—all from Java and Malaya.

As botanical knowledge extended it was found that the genus had representatives in India and Ceylon, and Hooker in his "Flora of British India" enumerates 26 species, with a large number of synonyms, many of which will no doubt be restored to specific rank when systematised on a broader base than morphology permits.

The genus also extends through the Malayan Archipelago, China and Japan, where its greatest economic product has been its camphor.

The first record of the genus in Australia was made by Baron von Mueller in 1865-6, Fragm. V, 165, under the name of *C. Laubatii*, from material obtained from Sea View Range, Rockingham Bay, Queensland, and this name was repeated in 1870 by Bentham in the Flora Australiensis, vol. v, p. 303, but placed as a synonym of *C. Tamala*—the locality being Mueller's.

Its next specific identification was in 1892, when material which was thought to be *Beilschmiedia obtusifolia*, was pointed out to be a *Cinnamomum*. In this connection Bailey (Bot. Bull., v. 25) states that "Professor D. Oliver, of the Kew Herbarium, to whom I sent [1]*specimens of the bark* for the museum, and also herbarium specimens, hinted at the probability of its being a Cinnamomum." Perfect material coming to hand, Bailey later gave it its true systematic position under the name of *Cinnamomum Oliveri, loc. supra.*

(1) The italics are mine.

In the same Bulletin Bailey records the occurrence from imperfect material of another *Cinnamomum*, and suggests the name of *C. propinquum*, from its near resemblance to *C. Wightii* and *C. ovalifolium*.

R. T. Baker (Proc. Linn. Soc., N.S.W., 1897, p. 275) records two from N.S.W., viz., *C. Oliveri* and *C. virens*, the latter being a new species, and a figure is given in each case, the first for any Australian Cinnamomum.

Bailey (1901) in his "Queensland Flora," Part IV, 1308, gives full descriptive records of the three species—*C. Oliveri*, *C. propinquum*, *C. Tamala*, for Queensland.

In 1906 Professor Ewart in Proc. Roy. Soc., Vict., vol. xix (new series), Pt. II, under *Persea Baileyana*, F. v. M., reviews the specific rank or stability of the species of Cinnamomums so far recorded for Australia, and suggests—(1) the suppression of the specific rank of all these species; (2) the placing of them as variations of *C. Tamala*, and finishes up by proposing the abolition of the name *Persea* altogether (or Australia)—a would-be slaughter of the innocents indeed.

Economics.

As the Cinnamomums fill an important place in the economic botanical world, some attention has been given to their products both in Queensland and at the Technological Museum, as well as in other parts of the world.

In the working out of these economics it need hardly be stated that the chemist has had much to do, and the Australian species have received some attention at his hands, as shown by the following bibliography :—

K. T. Staiger found the bark "contained a tannin similar or identical with cinchona tannin ; the amount, 7½ per cent. One ton of the dry bark yielding 770 oz. of oil." (Bail. Bot. Bull., No. 5, p. 25.)

Dr. Lauterer records the discovery of a dextro-rotatory camphor in the leaves and bark of a young tree (Proc. Roy. Soc., Q., Dec. 15, 1894, p. 22).

He also gives his own analysis of the bark, which yielded 4.57 per cent. tannin, and adds under his remarks on the essential oil of the bark, that "it contains about 2 pro mille of the essential oil" (*idem loc.*).

In a paper on the Cinnamomums of N.S.W., by R. T. Baker, Henry G. Smith gives the results of a fairly exhaustive research on the oil of the bark of *C. Oliveri* (Proc. Linn. Soc. N.S.W., 1897, p. 277.)

At the time of obtaining this oil from the bark, some was also obtained from the leaves, which was rich in the camphor of commerce, but no investigation was made further with this oil.

Systematic.

Turning again to the systematic side of these trees, Bentham (Flora Australiensis, vol. v) states, under *C. Tamala* :—

"These specimens appear to me to agree perfectly with E. Indian ones of the fertile tree, accurately described by Roxburgh, who gives it as a native of various mountains of the Indian Continent. The Australian specimens have only very few of the flowers fully out, and no fruit. In Indian ones the fruiting perianth has six short truncate lobes, the upper portion of the lobes being alone deciduous. There are several other Indian Cinnamoma described as species which, as observed by both Miquel and Meissner, are very difficult to distinguish in all their various forms from C. *Tamala*, and may be hereafter united with it ; but even then, as far as I have been able to ascertain, Hamilton's specific name of *Tamala* will have to be retained as the oldest."

And Ewart, *loc. cit.*, states :—

"The specimens in the National Herbarium are marked *Probably Cinnamomum Tamala*, Nees, in the handwriting of von Mueller, and queried *Cinnamomum virens*, R. T. Baker, by R. T. Baker. One specimen of *C. virens* is marked by R. T. Baker as very close to *C. propinquum*, Bailey, which Bailey considers to be closely allied to *C. ovalifolium*, Wight, Ic. 125. A type specimen of *C. propinquum*, Bailey, agrees closely with the figure of *C. albiflorum*, Nees (*Laurus cassia*, Roxb.) in Wight, Icones 140, and this species is an accepted synonym for *C. Tamala*, Nees. This disagreement of experts probably results from the fact that all these 'species' are so closely connected with *C. Tamala* by intervening forms as to render it advisable to extend the boundary of this species so as to include *C. virens*, Baker, *C. propinquum*, Bailey, and *C. oliveri*, Bailey, of which plant we have specimens from the same locality (Lismore) as *C. propinquum*."

(In this connection I would like to say that I was writing from memory when going over this material at Melbourne, and had not my original specimens with me).

It will be seen that both these conclusions, although made at the extremities of the earth, are founded upon morphological data alone, and in the case of Bentham on imperfect material, so that from our present knowledge it would appear he was hardly justified in synonymising Mueller's *C. Laubatii* under *C. Tamala* on such evidence only, for in his own words it is upon that he based his results.

[*The Occurrence of C. Tamala in Australia.*—To my mind there is no justification for the inclusion of this species as Australian. Hooker, in his "Flora of British India," vol. v, p. 128, gives the locality for this species as "Tropical and sub-tropical Himalaya, from near the Indus to Bhotan, altitude 3-5000ft., ascending to 7800 in Sikkim ; Silhet and Khasia Mountains, altitude 3-4000ft.," published 1890, and the Index Kewensis, published later, gives no additional localities.

There appears to be no record of its occurrence between the Himalaya and its reputed Australian habitat, Rockingham Bay. Now, as these localities are so far apart, it certainly would be remarkable if the trees were specifically identical. Through the kindness of Professor Ewart I have been able to see the original specimen from Rockingham Bay, Queensland, and named by Mueller *C. Laubatii*, to which is added another label by Mueller, *i.e.*, *C. Tamala*, var. ex. Benth.]

Bentham, speaking of this latter specimen, states, *loc. cit.*, "it only had a few flowers and no fruits." In the absence of such important diagnostic characters as fruits, bark, timber, and what in these days of phyto-chemistry, is most important—the chemistry of its various products—it appears a venturesome thing to attempt to determine material. The evidence so far available does not support the inclusion of *C. Tamala* as Australian, but points to the occurrence of the following species of Cinnamoma in and restricted to Australia :—

Australian Cinnamoma—

Penniveined leaves and camphor-yielding leaves and bark.

C. Laubatti, F. v. M., Fragm. v, 165.

C. Oliveri, F. M. Bailey, Bot. Bull., v, 25.

Penniveined leaves and non-camphor-yielding bark and wood.

C. virens, R. T. Baker, Linn. Soc. N.S.W., 1897, p. 275.

Trinerved leaves and non-camphoraceous.

C. propinquum, F. M. Bailey, Q. Flora, Pt. 4, 1308.

C. Laubatii, F. v. M.—Comparing the leaves of this Australian species with the true *C. Tamala* one finds a characteristic venation in each. *C. Tamala* of India is most distinctly trinerved, both on the upper and lower surfaces. The secondary nerves commence at the petiole and run at first alongside the midrib and then at a point opposite to each other and not far above the base, spread into the leaf tissue. The margins of the leaves are also nerve-like, especially the lower half, and there is an absence of secondary veins branching from the midrib. The minor veining is almost transverse, being slightly concave towards the petiole.

Now in this reputed Australian representative of *C. Tamala* there is not such a marked regularity of veining.

Comparing the material from Rockingham Bay kindly lent me by Professor Ewart with that of the true *C. Tamala* received from India, one is immediately struck with the different facies of the two, and would hardly place them in the same class of trinerved Cinnamoma; for in the Rockingham Bay and Endeavour River Cinnamoma the two lateral nerves are not nearly so well defined as in the Indian tree, and in some leaves only just traceable on the under surface, neither are the margins of the leaves nerve like, whilst the secondary veining certainly approaches more nearly that of *C. Oliveri* than *C. Tamala*. The leaves also are of different texture (if one may use this word in this connection) and have a pale undersurface.

Through the kindness of Mr. F. M. Bailey I have been able to examine specimens (leaves and flowers only) from the Endeavour River collected by W. E. Armit. This has much broader leaves than the above, yet identical with it in venation, and it is almost without doubt that species.

The indications here are all in favour of distinct chemical differences from *C. Tamala* as given for that species in the Semi-Annual Report of Schimmel and Co., April, 1910, p. 122, which contains particulars of three new essential oils.

"The first of these is obtained from the leaves of *Cinnamomum Tamala*, which is a tree of medium size common in southern Asia ; it yields Mutterzimt, Cassia Lignea or wood cassia. In former years the leaves were met with in commerce as Folia Malabathri, but this is no longer the case, though they are still used medicinally in the East Indies. The essential oil obtained from them is lemon-yellow in colour, and possesses a clove-like slightly peppery odour. The sp. gr. at 15 C. is 1.0257. The oil possesses a high eugenol content, and is thus allied closely to the ordinary oil from Ceylon cinnamon leaves."

The evidence from trees examined is therefore, that *C. Tamala* is not a camphor yielding species.

The barks certainly are quite distinct, for this species has a strong aromatic camphor yielding bark, whilst camphor is not found in *C. Tamala*. Surely this is a specific difference.

C. Oliveri, Bail.—If ever there was a distinct species this is one, and it is difficult to understand why Ewart should even suggest that it should be included under *C. Tamala* in view of the marked specific characters it possesses. In comparing—

(1) The leaves. *C. Tamala* has a coriaceous brownish leaf and is most pronouncedly trinerved with transverse secondary veins; in fact, I doubt if it was not this particular venation that led to the application of the name to fossil leaves.

C. Oliveri has a leaf with an entirely different venation, and is certainly not trinerved, faintly penninerved more correctly expresses this leaf feature; in fact, no two leaves could be more unlike in this character, neither are the leaves always opposite, whilst the edges are free from nerves.

(2) Bark (general, *vide* also *infra*). Here we have two diametrically opposite barks in structure and essential oil. *C. Tamala* has a thin, rather unpleasant, faintly odorous bark. *C. Oliveri* has a thick, strongly aromatic bark yielding an oil quite distinct from any other Cinnamomum yet examined, and Mr. Smith's chemical results are given in the paper on the Cinnamomums of N S.W. (*loc. cit.*), and naturally the two differ microscopically.

Again, that *C. Oliveri* is not *C. Tamala* is further demonstrated by differences in the chemical constituents of the leaf oils, for, as previously stated, Schimmel & Co. *loc. cit.* show *C. Tamala* to consist of 78 per cent. of Eugenol and to contain the terpene phellandrene, but no mention of the presence of ordinary camphor is made. Mr. Henry G. Smith of this Museum states :—

"The leaf oil of *Cinnamomum Oliveri* has less than half of one per cent. of Eugenol ; contains much camphor which is identical with the camphor of commerce, together with cineol and pinene. The terpene phellandrene does not occur. The presence of camphor in quantity in the leaf oil shows *C. Oliveri* to be more closely related chemically to *C. officinalis* than to *C. Tamala*, a species with which its affinities are not at all close chemically."

C. virens, R.T.B.—The specific characters of this species, such as leaf venation, enlarged calyx, bark and timber, place it beyond confounding with *C. Tamala* or any other described species; all these features are given in the *loc. cit.* together with a figure.

C. propinquum, Bail.—Speaking from leaf and flowering material only, this tree belongs to an entirely different class to *C. Laubatii*, *C. Oliveri*, and *C. virens*, and more nearly approaches the class in which *C. Tamala* is found, and I am quite prepared to believe that the leaf oil does not contain camphor any more than does that of *C. Tamala* according to Schimmel, *loc. cit.*

Of all the Australian trees this approaches more nearly *C. Tamala* on a venation classification, but because I say this I do not wish it to be inferred that I think it is a variety of it; far from it, or the same species for the matter of that.

It differs from *C. Tamala* in that the leaves are decussate, closely packed, shiny, and glaucous underneath, ovate, acuminate, rounded at the base, coriaceous, and under three inches long with a thick flattened petiole. The panicles are smaller, whilst the individual flowers are much larger.

> The remarks on this species are founded upon material supplied by the late Baron von Mueller from Melbourne Herbarium to F. M. Bailey, Colonial Botanist, Brisbane. I certainly think the species a good one.

Barks of the Species.

Anatomy.—Barks procurable for this investigation were *C. Tamala*, from India; *C. Laubatti*, from Queensland; *C. Oliveri*, Queensland and N.S.W., and *C. virens*.

C. Tamala is a much more irregularly constructed bark than *C. Laubatii* or *Oliveri*; the bast fibres are not at all numerous, nor are they uniformly arranged in concentric circles, but occur without any order. The medullary rays are numerous about three cells wide, and do not show a tendency to spread outwards, and parenchyma, bast and sieve tubes are well represented, especially on the outer cortex, where masses of stone cells are frequent. This was a difficult bark to cut and mount, owing to the presence of a large amount of gummy substance.

C. Laubatii.—This bark in microscopical transverse and longitudinal sections shows a structure distinct from *C. Tamala*. It has a regularity of arrangement of the various elements that go to make up bark structure. Bast cells are prominent and numerous and regularly arranged in concentric rings, mostly one or two deep, separated by sieve tubes and bast parenchyma, coloured dark brown, probably owing to the presence of a manganese compound. There is quite an absence of the empty perenchymatous cells found to figure so largely in *C. Tamala*, and also the gummy substance there mentioned. Stone cells are present, but only to a limited extent. The medullary rays, starting at the cambium a single cell wide, gradually open out to six or more cells in the outer cortex.

C. Oliveri.—This bark is more closely allied to *C. Laubatii* than *C. Tamala*. The bast fibres are, however, more numerous than any species examined, generally running in concentric rings of threes, separated by sieve tubes, and the walls of compressed parenchymatous cells, dark coloured, *vide* remarks under *C. Laubatii*. Masses of stone cells occur frequently in the outer bark, where only a few bands of periderm were seen on the outer cortex.

C. virens.—This was found to be the most compact bark of the four ; the bast fibres, whilst present, are not the most conspicuous object in a cross section, but the walls of the parenchymatous cells bounding the sieve tubes are evidently due to a larger percentage of the manganese compound in the walls. The medullary rays much sooner increase in cell width than in the other species.

CONCLUSIONS.

From the above additional botanical data, and by introducing the cognate science of chemistry, it would appear now that the validity of the Australian species is established, and they are distinct from the Indian trees. Also that the theory set up by myself and colleague in a research on the Eucalypts, that as in the case of those trees the leaf venation indicates the chemical constituents of the leaf, so it is found now to hold good for Cinnamomums in the species examined. And if chemical investigations of the leaf, bark and timber products could be carried out in the respective countries in which the species occur and the results tabulated, much assistance would be given to clear up the doubts at present surrounding their specific rank, and such data would no doubt have considerably assisted Hooker when working on herbarium material only, for he wrote in his "Flora of India," vol. v., under *C. zeylanicum* :—

C. zeylanicum, Breyn in Ephem. Nat. Cur. dec. i. ann. 4, 139.
Syn. :—*C. aromaticum*, Grah. Cat. Bomb. Pl. 173 ; ?*C. iners*, Wight Ic. t. 122 bis. ; *Laurus cinnamomum*, Roxb. Fl. Ind. ii. 295 ; *L. nitida*, Wall. Cat. 2582 ?B. ; *L. cassia*, Burm. Fl. Ind, 91.

Hab. :—Tenasserim, Burma and the Malay Peninsula ; Deccan Peninsula and Ceylon, indigenous or cultivated.

Distrib. :—Cultivated in the Malay Islands and elsewhere in the tropics.

"I am unable to unravel the synonymy of the varieties attributed to this species by Nees and others. Thwaites suspects that it passes into *C. nitidum* and *iners*. This is possible if the fruiting calyces prove the same, though not into *C. obtusifolium*, which, besides its characters of leaf and panicle, appears to have a different range. I have also kept *C. multiflorum* and *ovalifolium* (which Thwaites unites with *zeylanicum*) as distinct, though with hesitation. Kurz (For. Fl.) describes the fruiting perianth of *zeylanicum* as truncately 5-cleft, but I find the lobes in fruit all perfect and rounded in what I take to be typical specimens. Meissner's var. *fœniculaceum* (Ceylon, Thwaites 2284) seems to have no recognisable character, and Thwaites does not distinguish it. Vars. *inodorum* and *Cassia* of Nees I suppose to be the same thing, and are the faintly aromatic wild forms, passing probably into *nitidum*, the fruiting perianth of which is unknown. Beddome's figure of *zeylanicum* is of a very coarse-leaved var. from the Nilghiris, which he calls var. *Wightii* ; his fig. 11 on the same plate representing what he supposes to be fruit of *iners* is perhaps referable to *C. macrocarpum*."

If, therefore, the aid of cognate sciences, such as chemistry, physics, etc., had been employed by Bentham, Hooker and Ewart, systematic dilemmas such as those given above could hardly have occurred; certainly more satisfactory results would have been obtained than by relying on morphology alone.

In fact, from what has already been done, even with a limited number of species, by such a combination, sufficient data have been produced to demonstrate that much of, if not all, the uncertainty surrounding the classification of such valuable trees as the Cinnamomums would be removed.

A research, therefore, on these lines on the whole genus is now a desideratum, not only from a botanical standpoint, but also for a full knowledge of the commercial possibilities of these trees. Anyway, in the Cinnamomums now recorded in this paper Australia could, by a system of cultivation supply her own markets with that useful commodity, camphor—from her own indigenous trees.

5.—NOTES ON THE TASMANIAN FLORA.

By L. RODWAY, Government Botanist of Tasmania.

The Tasmanian flora is essentially Australian. It would be remarkable were it otherwise. The close proximity to the continent and the certain recent continuity could not have other effect but an extension of the plant life. Yet there are many features to render it most interesting to students of migration, and not the least of these are the presence of vestiges of apparently antarctic, and what may prove to be eastern temperate floras.

The extreme complexity of distribution must not be overlooked; we can imagine some of the more recent changes, but beyond that all is dark. We can conjure up a recent land continuity and lines of bird migration transporting seeds, but beyond the data have to be procured from what at present seems a closed book. If we take what is generally admitted to be the last word in flower evolution, the Compositæ, we have vestiges of antarctic conditions in *Abrotanella* and *Pterygopappus* and eastern temperate types in *Sencio primulæfolius* and *S. papillosus*. If we take a slightly earlier type the Rubiaceæ, we have amongst Coprosmas what appear undoubtedly eastern species, and the coastal *Nertera depressa* is common to Tasmania and the western shore of South America. If the distribution of recent forms as in these two families bears witness of complex migration, how can we hope to trace more than the last stage in the movements of such ancient types as the Proteaceæ, Cupuliferæ and Coniferæ?

Another feature in the Tasmanian flora is the large proportion of endemics. Nearly a sixth of the flowering plants are endemic. Considering Tasmania is not isolated, but is little more than an extension of south-eastern Australia, this becomes of interest. Certainly many of these are local productions of actively evolving genera of Composites, Myrtles and Epacrids, but on the other hand, there are many that can only be looked upon as vestiges of a passing state.

Take the family Proteaceæ, a group so typical of Australia. It is represented by twelve genera containing twenty-four species of which no less than twelve are endemic. Of these are the single Telopea and both the Lomatias, which belong to the tribe Embotrieæ, a tribe which is common to eastern Australia and western South America. The genus *Orites*, a purely east Australian group, contains but six species, four of which, all endemic, are found in Tasmania. The genera *Bellendena*, *Agastachys* and *Cenarrhenes* are vestiges not found on the mainland, and it is not possible to trace whence they came. Their presence on the mountains of Tasmania is probably a record that some at least of these highlands have not been submerged during an enormous period of geologic time. The presence in the western half of Tasmania of such fresh water crustaceans as *Anaspides*, *Paranaspides*, *Niphargus* and *Phreatoicus* points in the same direction. The enormous Australian genus *Grevillea* contains nearly two hundred species, yet though it is widely dispersed on the mainland, only one poor little mountain form of *G. australis* is native of the Island. What are the factors restraining its migration ? The closely allied Hakea has not been so prevented.

The Saxifrageæ are represented by few plants all of fixed types. There are five genera, each possessing but a single species, and four out of these few species are endemic, *Bauera rubioides* being the only one common to Tasmania and the mainland. *Anodopetalum* and the peculiarly isolated genus *Tetracarpæa* have not hitherto been found beyond the region of the island. With a family of such wide distribution as this, it is unsafe to theorise whence it came to the Australian region ; yet it is interesting to note it is almost entirely confined to the eastern part, only three species, namely, an *Aphanopetalum*, a *Cephalotus*, and an *Eremosyne*, being found in the west, and of these the last two are monotypic, and confined to Western Australia. The family as found in Australia is peculiar for the number of genera containing but one or few species, and all are of a fixed type, not a single species appears to be actively varying.

The family Cupuliferæ is without doubt of ancient type, and we can hope for no record of its probable multifarious migrations on the face of the globe. The very untrustworthy record founded upon leaf impressions has credited us with a marvellous flora of this family in Tertiary and Post Tertiary ages. The impressions assigned to oaks and beeches and possibly willows are at least tolerably convincing. Is the presence of our native beeches to be migration in common with those of New Zealand and Fuegia from an obliterated Antarctica ? Whether we take the view that the Fagi of Australia, New Zealand and Fuegia are remnants left of a cupuliferous flora that once clothed countries of low latitude to be obliterated, except in the southernmost posts of migration owing to the advance of torrid conditions, or, on the other hand, believe that these are all that are left of a polar flora, there is no gainsaying the fact of the peculiarly close relationship of the deciduous Beeches of Tasmania and South America.

The genus *Fagus* consists of two or three deciduous trees of northern temperate regions and about seventeen species, mostly evergreen, found in Australia, Tasmania, New Zealand, and Fuegia. The southern species have smaller flowers and very narrow medullary rays, otherwise there is little to warrant their being considered generically distinct; but, however that may be, we cannot do otherwise than accept their close relationship, which means, that the groups were once continuous across the equator. There is one point in favour of a polar migration, and that is the deciduous habit of one Tasmanian and three Fuegian species. The shedding of the entire foliage at a stated period of the year is generally ascribed to be an adaption to xerophytic conditions. We know this to be the case in countries with a periodic dry season, and have generally concluded the physiologically dry condition of frozen ground in high latitudes to be sufficient reason for the evolution of a deciduous habit in circumpolar regions. But here probably another factor has had influence, namely, the absence of light for some months at a time. The retention of foliage by a tree condemned to periods of half-yearly starvation is a distinct disadvantage. There is nothing in the climate of Tasmania and Fuegia to render the deciduous habit a benefit, wherefor these trees may with some probability be assumed to have acquired the habit while living on land much nearer the pole. The Tasmanian deciduous Beech appears to be senile. It develops reproductive organs with fair profusion, also quantities of barren nuts, seldom good ones. A further link of attachment of the Tasmanian and Fuegian Fagi to the exclusion of those of New Zealand may be found in the presence of almost identical parasitic *Cyttarias* in both places. Seeds do not float for a great length of time, and do not maintain their germinative capacity after a short submergence in sea water, also the topography of the southern portion of the globe would require the profoundest modification to produce a sufficiently rapid current between Tasmania and Fuegia. It is inconceivable that these Fagi can have been transported by oceanic currents, and quite impossible that the parasitic *Cyttaria* can have been carried in conjunction unless it can be proved that it perennates in the ovule. The life history of this fungus has not been worked out, but what we know of it points to a localised infection and habitation. It appears on the axis where it fruits year after year on the same spot, the vegetating growth inducing hypertrophied knobs often attaining a large size. If its apparent habit is the real one indicating it a wound parasitic, then it can only have migrated with its host along a continuity of land. Whether this continuity was from a cooler equatorial condition till the ultimate habitats of Fuegia and Tasmania were reached, or whether the last phases of habitation are vestiges of a polar continent, appears the question to be decided. The fixed deciduous habit of some species appear to favour the latter conclusion. The presence in Tasmania of a *Drimys*, an *Ourisia*, *Prionotes*, *Nertera*, *Oxalis magellanica*, *Acæna*, *Donatia*, *Azorella*, *Perenettya*, *Lomatia*, *Drapetes*, *Dacrydium*, *Fitzroya*, *Gaimardia*, *Astelia*, *Oreobolus* and *Uncinia*, all characteristic of South America flora, appears suggestive of a closer affinity than the present wide separation should warrant.

The *Erica* family is represented by one *Pernettya* and three *Gaultherias*, and may be considered a remnant of a large group that has been replaced by the more recent Epacrids. Or the existing members may be looked upon as a small group that migrated westward from South America or intervening land. *Pernettya tasmanica* is endemic, and there is one endemic species in New Zealand, otherwise the genus is entirely American. *Gaultheria* has a wider distribution, but is largely American. Of the three Tasmanian forms *G. hispida*, which extends from mountain tops to sea level, is also found in Australia, but only at a high elevation. *G. lanceolata* is only a local variety of this, while *G. antipoda* is common to Tasmania and New Zealand. In Tasmania it is a rare mountain trailing shrub, but it is far more common and variable in New Zealand, where there are also four more of the genus all endemic.

Tasmania is very rich in Epacrids, possessing sixty-one species belonging to sixteen genera. Thirty-four of these species are endemic. *Prionotes* is singular in habit, trailing amongst undergrowth it will, if it meets with a suitable Eucalypt, grow up the stem in the fibrous bark for a height of even a hundred feet, hanging out short branches bearing bright crimson flowers as it travels. There is a doubtful species of *Prionotes* in South America, otherwise the genus is confined to Tasmania.

The genus *Richea* contains eight species, seven of which are endemic in Tasmania, the other one also appearing in the Australian Alps. It is an offshoot of *Dracophyllum*, and may be looked upon as a local development. *R. Milligani*, which does not throw off its corolla but splits it irregularly, is almost an intermediate form between the genera. *Richea pandanifolia* and *Dracophyllum milligani* are of identical habit and almost indistinguishable when the flowers are absent. They have a singular habit, erect, unbranched, with a head of long swordlike leaves more like a *Cordyline* than a Heath. *Dracophyllum minimum* is a dwarf, forming dense cushions in mountain plateaux. It is interesting that this Epacrid, *Abrotanella forsterioides*, a composite, and *Donatia novæ-zelandiæ*, a member of the Stylideæ, are so alike in habit and foliage that they appear identical until found in flower. It is an interesting similar adaptation in three distinct lines.

The endemic *Coprosma Moorei* is one of the few members of the genus that bears a blue fruit. It departs from the generic type by the flowers being bisexual. But for its well developed calyx, it might be placed in Nertera.

Hewardia tasmanica is generally included in the lilies, but it has all the characters of habit and flower structure with the typical three extrorse anthers of the Iris family, except in the one feature, that the ovary is superior or nearly so. It does not appear to be a true link between the families, a vestige of the line of descent, but rather an Iris in which the primordia of the floral leaves have failed to continue their coalescence with the ovarian wall.

A truly remarkable piece of distribution is the presence in southern Tasmania of a *Thismia*. It is strange that a member of an otherwise tropical genus should be found here at all, and that it should be so well adapted that it has been gathered at an elevation exceeding two thousand feet; it is still more remarkable that it has not been found in Australia. This is possibly an oversight, but if at all common on the mainland it should certainly have been gathered before this.

The Coniferæ are made up mainly of ancient remnants, most of which are endemic. *Dacrydium Franklinii* has relatives in New Zealand and South America, and the monotypic *Pherosphæra* is sufficiently close to this genus that it may well be considered a local off-shoot. *Phyllocladus* and *Podocarpus* have a somewhat similar distribution, and it is possibly reasonable to expect they had a similar line of migration, but *Microcachrys* is alone. Though like these others it is a Taxad, it appears to have no relative to suggest whence it came. It is placed nearest *Saxegothæa* of South America, but the affinity is distant.

Fitzroya has but two species, one in Tasmania, the other in South America.

The genus *Arthrotaxis* is confined to Tasmania and is a remnant of the Taxodineæ that possibly had an equatorial distribution. It probably owes its survival to some of the western mountains of Tasmania, having escaped submersion. Tasmania is but a small island, and it would be difficult to account otherwise for so many remnants being confined to its western half when other localities appear to afford climatic conditions equally favourable to their existence.

6.—AUSTRALIAN AND SOUTH SEA ISLAND STICTACEÆ.

By EDWIN CHEEL, Botanical Assistant, National Herbarium, Sydney.

PART I.

Introduction.

The family of plants known as Stictaceæ comprise some of the largest and most beautiful of the foliaceous species of the Lichen Flora, and according to the most modern system of classification are divided into two well-marked genera, namely, *Lobaria* and *Sticta*.

Of these two genera there are recorded in the now overwhelming and ever-increasing mass of lichenological literature the names of upwards of 400 species or sub-species and varieties. Of this number there are already recorded as having been found in Australia, New Zealand and the South Sea Islands the names of about 175 species.

Nearly all the earlier collections of Lichens collected in these provinces have been deposited in the Herbaria of the Royal Gardens at Kew and in the British Museum in London, as well as in the museums of Paris, Berlin and Vienna, so that the study of this group of plants has to a very large extent been restricted to British and Continental Lichenologists, and as many of these eminent scientists, like their Australasian co-w rkers, are so overworked, it has been possible to secure but very little assistance.

It is well recognised that the value of any work dealing with plants depends on the facilities afforded for a critical examination of the types or authentic specimens ; and as so very few of the original specimens are available to Australasian students, it can be well understood that very few of our botanists have cared to undertake the responsibility of naming these lowly plants.

In my searches for specimens of the Phanerogameæ, or higher plant-life, I have also made a considerable collection of Cryptogams, including a fairly extensive collection of Lichens.

To determine the systematic position of these plants, I found it necessary to consult the available literature as well as herbaria containing specimens. My first collection was determined by Mr. F. M. Bailey, Colonial Botanist, of Queensland, and soon afterwards I received some assistance from the authorities at the Royal Herbarium of Kew (England), who forwarded my second collection of these plants to Mr. O. V. Darbishire, of Owens College, Manchester, for determination. About this time Mr. Maiden, the Government Botanist of New South Wales, acquired for the Government of his State the very extensive and valuable collection of Australasian Lichens brought together by the late Rev. F. R. M. Wilson, and as no one was working at these plants Mr. Maiden very kindly gave me free access to this collection.

In the Rev. Mr. Wilson's collection there is a preponderance of crustaceous forms, a large number of which have been determined by European specialists. The foliaceous and fruticolous forms, however, although well represented in the collection, had not, except in very few instances, been determined by European specialists, and as a consequence, through not having access to the original types of the earlier collections of the forms, the determinations of Mr. Wilson were in several instances unreliable.

As a large number of foliaceous forms were constantly being forwarded to the National Herbarium for determination I found it necessary to consult the earlier named collections of these plants, and being on a visit to England in 1905 I enjoyed the privilege of examining a large number of specimens made in Australia and the South Sea Islands in the early days, which are deposited in the collections of the Natural History Branch of the British Museum and at the Royal Herbarium of Kew, in England.

As a result of such examination I have found it necessary to make several changes in the names of a large number of our foliaceous forms or species of Lichens, and accordingly have ventured to do so in the following pages, giving the species and name of collector of the actual specimens examined.

List of Collectors and where their Collections are Deposited:

ARCHER, W. H.—National Herbarium, Sydney.
ANDERSON, W.—Royal Herbarium, Kew.
BAILEY, F. M.—National Herbarium, Melbourne and Brisbane.
BASTOW, R. A.—National Herbarium, Sydney.
BIDWILL, J. T.—Royal Herbarium, Kew.
BOORMAN, J. L.—National Herbarium, Sydney.
BROWN, R.—British Museum and Royal Herbarium, Kew.
CAMPBELL, Miss F. M.—National Herbarium, Melbourne.
COLENSO, W.—Royal Herbarium, Kew.
CLAY, J. W.—National Herbarium, Sydney.
CLELAND, J. BURTON—National Herbarium, Sydney.
CUNNINGHAM, ALLAN—Royal Herbarium, Kew.
DALLACHY—National Herbarium, Melbourne.
DIEFFENBACH, ERNST—Royal Herbarium, Kew.
FILHOL—Royal Herbarium, Kew.
FLOCKTON, MISS M.—Private and National Herbarium, Sydney.
FORSTER, GEORGE—Royal Herbarium, Kew.
FORSYTH, W.—National Herbarium, Sydney.
GARDNER, W.—National Herbarium, Sydney.
GREEN, A.—National Herbarium, Sydney.
GREGSON, J.—National Herbarium, Sydney.
GUNN, R. C.—National Herbarium, Sydney.
HAMILTON, A. G.—National Herbarium, Sydney.
HAMILTON, A. A.—National Herbarium, Sydney.
HARTMANN—National Herbarium, Melbourne.
HECTOR, DR.—Royal Herbarium, Kew.
HODGKINSON, MISS—National Herbarium, Melbourne.
HOOKER, SIR J. D.—Royal Herbarium, Kew.
HORNE, J.—Royal Herbarium, Kew.
JOLLIFE—Royal Herbarium, Kew.
KARSTEN—National Herbarium, Melbourne.
JOHNSTONE, T. H.—National Herbarium, Sydney.
KING, E.—National Herbarium, Sydney.
KNIGHT, C.—Royal Herbarium, Kew; British Museum; Linn. Soc., N.S.W.
LAU, H.—Royal Herbarium, Kew.
LOGAN—Royal Herbarium, Kew.
LYALL, DR.—Royal Herbarium, Kew.
MAIDEN, J. H.—National Herbarium, Sydney.
METCALF—National Herbarium, Sydney.
MOORE, C.—Royal Herbarium, Kew, and National Herbarium, Syd.
MUELLER, BARON VON F.—National Herbarium, Melbourne.
OLDFIELD—National Herbarium, Sydney.
READER, F.—National Herbarium, Sydney and Melbourne.
SAYER—National Herbarium, Melbourne.
SINCLAIR, DR. A.—Royal Herbarium, Kew.
STEPHENSON, W.—Royal Herbarium, Kew.
SULLIVAN, DR.—National Herbarium, Melbourne.

THOZET, MRS.—National Herbarium, Melbourne.
WEYMOUTH, W. A.—National Herbarium, Sydney.
WILCOX—National Herbarium, Melbourne.
WILSON, REV. F. R. M., National Herbarium, Sydney.

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HISTORY OF AUSTRALASIAN LICHENOLOGY.

The earliest record that we have of the Lichen Flora of Australasia or Polynesia, is that by George Forster (7), who in 1786 recorded five Lichens from Polynesia.

John Reinhhold Forster and his son, George Forster, accompanied Captain Furneaux of the "Adventure," which left England in 1772, on Captain Cook's second voyage.

In those days very little was known of Lichens as representing separate genera, except the divisions created by Dillenius in his "Historia Muscorum," so that it is not surprising to find that Forster did not attempt to classify his small collection of Lichens into genera, nor did he attempt to name them specifically, but records them as Lichens under Nos. 584-588.

From an examination of the specimens and MSS. of the Forsters, it has been found that New Zealand was visited, and we have a definite record of one species of Lichen collected by Forster given by Georg Francisc. Hoffmann, who gives a description and excellent drawing of one Lichen under No. 584 in Forster's Herbarium, under the name of *Platisma filix*.

In Hoffmann's work the genera and species are divided chiefly by the structure of their thallus, very little attention being given to the apothecias or receptacles of the spores, which are in our time considered to be the most important structures of these plants. Under these circumstances it is only natural to find that modern Lichenologists have revised the Lichens published by Hoffmann, and, as a consequence of such revision, it has been found necessary to re-habilitate Hoffmann's *Platisma filix* under the name *Sticta filix*, because of the distinct fruits, and the cyphellæ on the under-surface of the thallus, the latter being one of the chief characteristics of the genus *Sticta*.

GENERAL CHARACTERS OF AUSTRALIAN LICHENS.

The numerous species of *Stictacea* found in Australia and the neighbouring Islands differ in some respects from that of any other part of the world. In some species there is a general superficial resemblance to those found in the southern parts of America, and the affinities of certain species are also very closely allied, and in a few cases the species are identical with several found in Madagascar, but, generally speaking, it can safely be said that the lichenose vegetation is just as peculiar to Australia as has been found in the higher class of vegetation.

The individual specimens of Stictaceæ are in some places so very numerous that the trees in the forests have a very peculiar appearance, especially in the forests at Ohakune, New Zealand, and in some parts of Tasmania, where I found the branches and trunks of the trees thickly clothed with these large foliaceous species, varying from about an inch high in some of the smaller species to upwards of 18 inches across in others, so that we can quite understand why Drs. Hooker and Taylor (25) termed them "the Patricians of Lichens," and can also agree with Dr. Nylander in that the "highest point in the classification of Lichens has been reached" in this group or family of plants.

The Structure of Stictaceæ.

The study of this family is very difficult, owing to the immense variation in the lobation of the thallus. It is in general a flattened leaf-like expansion, whose texture or consistence according to its thickness and the arrangement of its cellular tissue is membranaceous, coriaceous, or cartilagineous. The margins of the thallus are variously divided into segments, which, according to their size, are termed lobes or laciniæ, the former being typically broadish and rounded, the latter narrow and usually linear. The upper surface of the thallus of several species may be perfectly smooth, while in others it is roughened with granular soredia or isidia. Occasionally we also find that the margins of the thallus are thickly covered with very minute squamules, which give them a very peculiar appearance, especially when these squamules are bursting with their yellowish, whitish, or leaden-coloured granular contents.

In several species, such as *Lobaria pulmonaria*, *Sticta foveolata*, and *S. cellulifera*, the upper surface is deeply indented and then have a peculiar reticulate or lacunose-appearance. On the upper surface we also find more or less blackish or brownish-coloured little pimples, these are termed the spermagonia, and are variously scattered on the margins of the foveolæ or irregularly over the thallus, and in some species are chiefly confined to the marginal-lobes.

The Apothecia, in which the asci or bags are contained, are usually filled with eight colourless or brownish-coloured one-or-more-septate spores. These are likewise irregularly scattered over the surface of the thalline margins of some species, while in others they are strictly confined to the margins of the lobes, and are usually of a chocolate-brown or sometimes nearly blackish colour.

The under-surface of the thallus is covered more or less with a spongy mass of whitish or brownish coloured fibrils known as rhizineæ, which act as rootlets in holding the plants to the decorticated bark of trees or mossy rocks or earth upon which they are found, but they differ from rootlets in that they do not take upon themselves the functions of rootlets as in the higher classes of plants.

Intermingled with the rhizineæ, and either thickly or thinly scattered on the under-surface of the thallus, are minute whitish, yellowish, or leaden-coloured spots, or in the case of the genus *Lobaria* the under surface may be nearly smooth or more or less covered with bulges or naked gibbi.

These peculiar gibbi or spots enable us to readily distinguish the Stictaceæ from any other foliaceous-lichens and form the superficial characteristics of the family, and are easily seen with the naked eye or by an ordinary pocket lens.

These peculiar structural characters found on the under-surface of the thallus are known as cyphellæ, pseudo-cyphellæ and gibbi, according to their structure, and afford an excellent basis for a natural system of classification of the numerous species of the two genera, into groups or sub-groups, according to the form they take.

For example, if we examine those species with true Cyphellæ, it will be found that they are distinctly urceolate and appear to be minute excavations in the substance of the thallus ; these are usually quite free from soredia or powdery substance.

The Pseudo-cyphellæ, instead of being urceolate or hollow excavations, are minute protrusions filled with minute whitish, golden-yellow, or yellowish-green soredia.

In connection with these structures there seems to be a difference of opinion as to whether they are constant characters in any given species, as will be observed by the following remarks by Dr. Lauder Lindsay (33.420) :—" I am not satisfied that there is any essential distinction (anatomical, morphological, or functional) between Cyphellæ and Pseudo-cyphellæ. Though the former are typically urceolate and smooth, they become pulverulent and shallow; and pass thus, by imperceptible gradations, into the latter."

Having examined a very large series of specimens both in the field under natural conditions in Australia, New Zealand, and Tasmania, as well as numerous collections in herbaria, I have experienced no difficulty in separating the species into their respective sections or groups by this character alone.

Occasionally in very old specimens the soredia will be found to have disappeared from a number of pseudo-cyphellæ, but even in these there is a distinct difference in the structures, and that soredia will be found in the partially developed pseudo-cyphellæ.

In the pseudo-cyphellæ group it will be found that in several species the upper-surface of the thallus is also spotted with erumpent soredia in a similar manner as the under-surface. This peculiar characteristic also affords a basis for a sub-group, which includes *S. argyracea* and the allied species.

If we tear or cut across the thallus of one of these plants it will be found that there is a difference in the colour of the tissues of the thallus, as well as a decided difference in the structure. The upper or cortical layer is composed of spherical or irregularly shaped cells, then there is a bright green, bluish-green or yellowish-green layer known as the gonidial-layer, and then a whitish or creamy-white cottony layer, known as the medullary layer.

The stratum of blue-green or bright chlorophyll-green granules are generally termed the gonidial-layer or algal-constituents of the thallus, and are very similar in general outline to several well-known races of *Algæ*.

In a number of species it will be found that the gonidial-layer of the thallus consists of blue-green granular gonima, very similar in general outline to the *Nostocaceæ* group of *Algæ*. Through the discovery of these distinct organisms, Dr. Nylander was prompted to establish the genus *Stictina* based solely on these distinctive characters.

It has been found by Knight (10), who has examined several Lichens determined by Nylander in the Kew collection, that Nylander has not in every case arranged the species in accordance with his own scheme of classification.

By far the greatest number of Stictaceæ have the gonidial layer made up with chlorophyll-green coloured gonidia, which resemble the Palmellaceæ group of Algæ ; but occasionally we find that the thallus of some species is peculiar in including a second algal constituent in addition to the species which is its principal and constant constituent. For example, the chief algæ in *Lobaria laciniata* resembles those of the Palmellaceæ group, but in addition to these we very often find some *Nostoc*-like gonidia in the peculiar shaped outgrowths from the thallus, which have received the name of Cephalodia.

Occasionally we also find a combination of two distinct Lichens, as in the case of *Dendriscocaulon filicinellum*, which is distinctly blended or fused in a graft-like fashion with *Sticta stipitata*, and which led the late Rev. F. R. M. Wilson to believe that the former was the juvenile state of the latter species (30).

Systematic Arrangement of the Species.

(A) Genus : *Lobaria* (Scrheb.), Hue.

Section I.—Knightiella (Müll-Arg.), A. Zahlb.

Gonidial-layer of the thallus consisting of bright-green Cystococcus-gonidia.

L. leucocarpa, A. Zahlb. (32, p. 188),; *Parmelia splachnirima*, Hook. f. and Tayl. (25, p. 645) ; *Bæomyces squamarioides*, Nyl. (17, p. 184), Wils. (29, p. 146), (28, p. 175) ; *B. splachnirimus*, Bab. & Mitten (3, p. 351, tab. cxcix) ; *Knightiella leucocarpa*, Müll-Arg. (13, No. 1009 *et* 1010) ; *K. squamarioides*, Müll-Arg. (13, No. 1357).

Tasmania : Mount Wellington (Archer), Huon Road (Bastow, No. 816).

Victoria : Mount William, alt. 5000ft. (Sullivan, No. 85).

Section II.—Ricasolia (D. Notes), Hue.

Gonidial-layer of the thallus, with bright green globular or sphæroid Protococcoiden-gonidia.

L. plurimseptata, Kn. M.S., Shirley (21, p. 66), (22, p. 133) ; Cheel (5, p. 689).

New South Wales : Big scrub, Richmond River (Wilson, No. 1221) ; (Watts, Nos. 70, 72, 76, 83) ; Ballina (Watts, No. 89, pr. p.) ; Coff's Harbour (Flockton) ; Stanwell Park (Cheel) ; Macleay River (Boorman).

Queensland : Tambourine Mountain, Woolston, Southport, Emu Vale, Killarney, Upper Coomera, Mount Mistake, Warwick, and Rosewood (Shirley & Wilson).

L. Hartmanni (Müll-Arg) ; *Ricasolia Hartmanni*, Müll-Arg. (13, No. 568) ; Shirley (21, p. 65), (22, p. 133 ; F. v. M. (12, p. 90) ; Stzbgr. (19, p. 112).

Queensland : Toowoomba (Hartmann), Mount Mistake (Shirley), Darling Downs (Lau), Warwick (Gwyther), Coomera (Wilson, No. 1224).

L. discolor, Hue (9, p. 23), Rechinger (18, p. 268) ; *Sticta discolor*, Del. (6, p. 136, tab. xvi, f. 59) ; Müll-Arg. (16, p. 295) ; *Ricasolia discolor*, Nyl. (17, p. 367), Krplhbr. (11, p. 100), Stzbgr. (19, p. 109) ; *Sticta* (*S. Ricasolia*) *discolor*, A. Zahlbr. (31, p. 193).

New South Wales : New England (Moore), Dorrigo (Boorman)

New Caledionia : (Hue).

Samoa : (Reinecke).

This species is also found in Madagascar and Bourbon.

L. pulmonaria, Hoffm.
Forma *papillaris*, Hue.

N.S.W. : Richmond River (Camara), Clarence River (Wilcox), East Maitland (Thompson), Bellinger River, Ellenboro Falls, Manning River and Brushy Mountain (Maiden), Kiama (Forsyth), Mount Wilson (Gregson), Dalmorton (Boorman).

Queensland : Toowoomba (Hartmann), Darling Downs (Lau), Bellenden-Ker (Karsten), Mount Mistake (Bailey).

Forma *hypomela* (Del.).

N.S.W. : Tia Falls (Cheel), Dalmorton and Dorrigo (Boorman), Cambewarra (Forsyth).

Queensland : Brisbane (Bailey, No. 36 in Leighton's Herb. at Kew).

Some of the Dalmorton specimens appear to be hardly distinct from *f. papillaris*. The two forms pass into each other.

Section III.—(*Lobarina*)—Hue.

Gonidial-layer of thallus, consisting of blue-green Nostoc-like gonidia.

L. scrobiculata, D.C. Figured in Dill. Hist. Musc., tab. xxix, f. 114.

N.S. Wales : Mount Wilson (Gregson).
Victoria : Warburton (Wilson).
Tasmania : Risdon Cove (Brown, 541).

L. retigera (Bory), Hue.
N.S. Wales : Crawford River, Bullahdelah (Cheel).
Forma *isidiosa*, Hue.
N.S. Wales : Big scrub, Richmond River (Wilson, No. 1125), Bullahdelah (Cheel).
Queensland : Killarney and Southport (Wilson).

The Australian specimens seem to be identical with those in Kew Herbarium from Umgoe Mountains in Natal, collected by Mr. Plant, as well as several Asiatic specimens.

(B) Genus—*Sticta* (Schreb), Hue.

Section I.—Eu-cyphellatæ.

Under surface of thallus pitted with numerous urceolate-cyphellæ.

Subsection 1.—Eustica.

Gonidial layer of the thallus consisting of bright green or yellowish-green Palmellaceæ gonidia.

S. filix (Hoffm.), Nyl.
N.S. Wales : Guntawang (A. G. Hamilton, No. 126) ; Cambewarra (Forsyth) ; Belmore Falls (Cheel, Clay and Green).
New Zealand :—Forster, Menzies, Hooker, Lyall, Filhol, Stanger, Knight, Nelson, Hochstetter ; Napier and Mount Kaweka, near Hawke's Bay (Colenso) ; Invercargill (Foveaux) ; Dusky Bay (Anderson) ; Dunedin (Lindsay) ; Ohakune (Cheel).

This is a very common species in New Zealand, and is represented in nearly every collection of Lichens. In the forests at Ohakune the trunks and branches of living trees as well as moss-covered decaying logs are often thickly covered with this plant. It is of a vivid-green colour in a fresh-state, and dries a greyish or stone colour in the herbarium. All the specimens in the Kew Herbarium have already been recorded by numerous authors.

S. filix var. *myrioloba*, Müll-Arg.
N.S. Wales : Richmond River (Camara, No. 50), Macleay River (Rudder).
Queensland :—Toowoomba (Hartmann).
This plant is labelled *S. filix* in National Herbarium, Melbourne. Brisbane (Bailey), Toowoomba (J. Staer).

This variety very closely resembles *S. Dufourii* Del. syn. *S. elegans* Leight, found at Rock Walk, Ilsham, near Torquay, England.

In addition to the above we have two other rather marked forms from Allumbah, Queensland, collected by Mr. B. Waller. One has the minute lobules of the var. myrioloba, but is more costate at the base, and approaches in this respect the type from New Zealand. The other form is less costate at the back of the thallus, but is densely clothed with branched rhizinæ.

S. lacera, Müll-Arg.

New Zealand :—There are several collections of this species in the Kew collection, collected by Colenso, Logan, Sinclair, and Knight. It is a very small species, and was considered by Dr. Nylander as a variety of *S. filix*.

S. Sayeri, Müll-Arg.

Queensland : Bellenden-Ker (Sayer, No. 584) ; Allumbah (Waller).

Seems to me very close, if not identical, with the next species.

S. pedunculata, Krplhbr, in Journ. Museum. Godeffroy, Bd. 1, Heft 4 (1874), p. 97, Taf. XIV., fig. 2-4 and 8, and in Rechinger's " Botanische und Zoologische Ergebnisse einer Wissenschaftlichen Forschungreise nach den Samoa-Inseln, dem Neuguinea-Archipel und den Salomonsinseln," p. 69 (265), Taf. ii, fig 3 (1907).

Specimens of this are in Herb. Kew from Fiji, collected by J. Horne in 1877-78.

Rechinger l.c. cites *S. Shirleyana*, Müll-Arg., as a synonym. For further remarks on this see *S. stipitata*.

S. latifrons, A. Rich.

New Zealand : Several specimens of this are in Herb. Kew, collected by Lyall, Hooker, Stephenson and Knight.

In addition to the above, we have in the Wilson collection a small scrap collected by Mrs. Martin, and a fine specimen in the collection of the Linnean Society of N.S. Wales. In the National Herbarium of New South Wales there are some fine specimens from Back River, Tasmania, collected by Gunn and Oldfield.

S. latifrons var. *Menziesii*, Bab.

New Zealand : Dusky Bay (Menzies), Middle and Southern Island (Bidwill), (Lyall) ; Auckland (Drury), Otago (Hector), Napier (Colenso), Dunedin (Lindsay), Greymouth (Helms), Ohakune (Cheel), Waiwera and Pokeno (Flockton).

Both the species and variety are very variable in structure, lobation and colour. In some intermediate forms it is difficult to distinguish the species from the variety, although the extreme forms look very different.

S. latifrons var. *dissecta*, Müll-Arg.

New Zealand: Auckland (Flockton).

S. subcaperata, Nyl.

Tasmania: (Gunn), Mount Wellington, and Mount Arthur (Wilson, No. 1203), East Mount Field (Maiden), Russell Falls (Mrs. Townshend in Flockton Collection).

This is *Lichen filix* of R. Brown, No. 555, collected by him on Table Mountain (Tasmania). Babington, in a note with Brown's specimens, now in Kew Herb., says: "It may perhaps belong to *S. filicina* or a form of *S. latifrons*, A. Rich." There are also specimens in Kew and in National Herbarium, Sydney, collected by Hooker and Oldfield on Mount Wellington and Back River, as already recorded in the Flora of Tasmania ii.

New Zealand: (Knight), Okahune (Cheel).

Knight's specimens in Kew and in the Linnean Society of New South Wales are labelled *S. sinuosa*, but they appear to me to belong to this species.

Victoria: Buffalo Mountains (Mrs. Goodyear, in Flockton collection).

S. sinuosa var. *macrophylla*, Müll-Arg.

Lord Howe Island: (Moore, King, Johnstone.)

The specimens collected by Moore have already been recorded by Zahlbruckner (31.193), but the specimens, however, in the National Herbarium, Sydney, are labelled *S. latifrons*. There is evidently some mistake, as the true *latifrons* is a very different plant. Zahlbruckner l.c. also includes as a synonym of this species *S. subcaperata* of Nylander. I have carefully examined a large series of specimens and have no difficulty whatever of separating the plants from Tasmania and New Zealand, which I take to be the true *S. subcaperata* from those collected in Lord Howe Island.

S. sinuosa var. *caperata*, Hue.

Tasmania: (Gunn). Only a small specimen was found associated with *S. latifrons*, but is very different from that plant, and may be referred to this variety.

S. stipitata, Knight—Proc. Roy. Soc., Queensl., vii., 8 (1889).

Victoria: Mount Macedon (Wilson, No. 239).

When collecting the specimens of this species it appears that Wilson also found some specimens of another lichen, which he described as "a remarkable plant, somewhat like a minute lead-coloured ostrich feather (30, p. 8). (Proc. Roy. Soc., Queensl., vii., 8 (1889). He further states that among the specimens were found one or two which were tipped by a minute broad green frond, having in its under surface white urceolate cyphellæ and containing true yellowish-green gonidia.

In consequence of this discovery, Wilson concluded that these lead-coloured plumules were the juvenile form of *S. stipitata*.

It was apparently not known to Wilson that these lead-coloured little plants were already described under the name of *Dendriscocaulon filicinellum*, and belong to an entirely different species of the Collemaceæ group of lichens. I have recently discovered this species in three different localities, and have recorded some particulars concerning them in the Proc. Linn. Soc., N.S.W., xxxiv., 711 (1909).

Some of the juvenile plants of S. *stipitata* were afterwards forwarded by Wilson to J. Shirley, of Queensland, who communicated them to Dr. Jean Müller, of Geneva. It appears that no indication of where they had been collected was given by Shirley, and as a consequence Dr. Müller naturally concluded they were collected by J. Shirley in Queensland, and determined them as a new species under the name of *S. Shirleyana* in " Hedwigia " (1893), p. 122.

The juvenile state of *S. stipitata* has some resemblance to *S. pedunculata*, Krplhbr., as has subsequently been observed by Müller (Engler's " Jahrbucher," xxiii., 294 (1897), where he gives the remarks, which may be translated as follows :—" The numerous stages of development and branching, and the variation of forms, make it clear that *S. Shirleyana*, which was in 1893 still imperfectly described from sterile specimens, belongs also to *S. penduncnlata*."

In the Wilson collection of lichens now deposited in the National Herbarium of Sydney there is a very fine series of specimens of *S. stipitata* in all stages of growth, and having seen specimens of *S. pedunculata* from Fiji Islands, collected by J. Horne in 1877-78, now in the Kew Herbarium, I can see no resemblance in the adult plants.

The adult plants of *S. stipitata* are freely sprinkled with apothecia, which are scattered all over the upper surface of the thallus, and not marginal as is the case with *S. pedunculata*. The spores of the latter species are described as being 1— septate, 39-44 × 6-8 p, and are very different from those of *S. stipitata*, which are 5 septate, 035 × 007 m.m.

There is some resemblance between *S. stipitata* and *S. subcaperata*, and specimens of this latter species from Tasmania are included by Wilson with his *S. stipitata*.

S. Samoana, Müll.-Arg. in. |Rechinger, in " Bot. und Zool. Samoainseln, dem Neuguinea-Archipel. und den Salomonsinseln " (1907), p. 263 (67 repr.), Taf. II., fig. 4, somewhat resembles *S. stipitata*, and may not be specifically distinct. I have not seen any specimens of this latter species.

S. variabilis, Ach.

New Zealand : Ohakune (Cheel).

N.S Wales : Richmond River (Wilson, Nos 1855 and 1856), Watts, No 11), East Ballina (Watts, No. 87), Byron Bay and Mount Warning (Forsyth), Bullahdelah (Cheel), Tumbulgum (Technological Museum, Sydney, No. 1916).

This species has also been recorded from Queensland, New Zealand, Stewart Island, Fiji, and Kaiser Wilhelmsland

The Rev Mr Watts' specimen, No 11, is labelled and recorded in the Proc. Linn. Soc. N.S.W. (1903), 497, under the name of *Ricasolia coriacea.* This is clearly an error, as there is no resemblance between the species, and, besides, *Sticta coriacea* (*Ricasolia coriacea*) appears to be confined to New Zealand.

S. *cinereo-glanca*, Tayl.

New Zealand : Waiwera, Auckland (Flockton).

S. *dichotomoides*, Nyl.

N.S. Wales : Richmond River (Camara), Kingwell, near Wyong (Watts in Flockton coll.), Ourimbah (Miss Booth in Flockton collection), Byron Bay (Lovegrove). Pearce's Creek, Richmond River (Watts), Dorrigo (Boorman).

S. *hypopsiloides*, Nyl.

New Caledonia : (Roberts in Herbarium, Melbourne.)

Subsection ii.—Stictina.

Gonidial-layer of thallus, consisting of blue-green Nostocoid gonidia.

S. *brevipes*, A. Zahlbr.

Queensland : Bellenden-Ker (Bailey)

New Hebrides : Undine Bay, Efate (Morrison).

S. *cyphellulata* (Müll-Arg.).

N.S. Wales : Richmond River (Wilson), Waterfall (Wilson and Cheel), Stanwell Park, Otford, Bulli and Belmore Falls (Cheel), Helensburgh and Leura Falls, Katoomba (Hamilton), Cambewarra (Forsyth), Mount Wilson (Gregson).

Queensland : Pechey's Scrub, Brisbane, Lowood. Blackwood, Sankey's Scrub and Tambourine Mountain (Wilson, No. 84), Bellenden-Ker Ranges (Bailey), Allumbah (Waller), Toowoomba (Hartmann).

Victoria : Cunningham, Bloomfield, and Warburton (Wilson, No. 1191).

Papua : (King, in Flockton collection).

The Waterfall specimens were recorded by Wilson in Proc. Roy. Soc. Queensl., vi, pp. 87 and 90 (1889), under the name *S. filicina var. marginifera*, and afterwards renamed by Wilson as *S. quercizans f. cervicornis.* Following Wilson, I also recorded it under the latter name in Proc. Linn. Soc. N.S.W. (1903), p. 689.

S. Weigelii, Wain.

N.S. Wales : Big Scrub, Richmond River (Wilson), Ballina (Watts), Bullahdelah (Cheel), Waterfall (Wilson and Cheel).

Queensland : Russell River (Sayer, Herbarium, Melbourne), Sankey Scrub, Lowood, Blackall Ranges, Woolston, Emu Vale, Three Mile Scrub (Wilson, No. 1191).

New Zealand : Auckland (Cheel).

Specimens in Wilson's Herbarium No. 1191 are labelled *S. quercizans*, and have no doubt been recorded previously by him under that name.

S. Weigelli, var. *Beauvosii*, Stzbgr.

N.S. Wales : Illawarra (Kirton).

S. Weigelii, var. *microphylla*, Stzbgr.

N.S. Wales : Richmond River (Hodgkinson, in Herbarium, Melb.), Belmore Falls (Cheel), Leura (Hamilton).

Queensland : Rockhampton (Thozet), Rockingham Bay (Herbarium, Melbourne ; labelled *S. cinereo-glauca*).

The Rockhampton specimens are recorded by Krplhbr. in Verhandl. Zoolog. Bot. Gesselsch., Wien (1880), xxx, p. 335, under the name *Sticta quercizans*, var. *microphylla*. See also Müll-Arg., Revisio Krplhbr. in Flora, p. 114.

S. Weigelii f. *appendiculata*, Stzbgr.

Norfolk Island : (Metcalf, in Flockton collection).

In the Wilson Herbarium there is a specimen labelled *S. damaecornis*, from Mount Hotham, Victoria. It is quite distinct from *S. damaecornis*, and appears to be a form of *S. Weigelii*.

S. fuliginosa, S. Gray. Figured in Dillenius' Hist. Musc., xxvi, 100.

N.S. Wales : Jenolan Caves (Wilson), Mount Wilson (Gregson), Belmore Falls (Cheel), Cambewarra (Boorman).

Victoria : Warragul, Bloomfield, Lake Wat Wat, Tandarook, Cobden and Warburton (Wilson).

Tasmania : (Archer), Newtown Falls (Bastow).

New Zealand : Tarndale and Nelson (Sinclair, in Herbarium, Kew), Mount Ngongotaha, near Rotorua (Cheel), N.Z. (Knight, in Herbarium Linn. Soc. N.S.W.), Napier (Colenso, *vide* Müll-Arg., Lich. Colensoi, p. 201.

S. sylvatica : An allied species has been recorded by Wilson in Proc. Roy. Soc. Tasm. (1892), p. 164, as occurring in Tasmania. I have seen no specimen as yet of this species.

S. limbata, Ach. Figured in Dill. Hist. Musc., xxvi, 100 A.C., and in Eng. Bot., t. 1104.

Victoria: Tandarook, Lake Wat Wat, and Mount Macedon (Wilson, No. 232).

New Zealand: Mount Ngongotaha, near Rotorua (Cheel), Waiwera, near Auckland (Flockton). This species is also recorded from Queensland by Shirley.

S. macrophylla (Bory), Del. Syn. *Stictina suborbicularis* (Müll-Arg.). *S. subtomentella* (Kn.). *S. filicina* (Wilson; not of Ach.), *S. latifrons* (Watts; not of A. Rich.).

New South Wales: Richmond River (Moore), (Watts), Mount Warning (Forsyth), Mount Wilson and Mount Irvine, (A. G. Hamilton) (Gregson), Waterfall (Wilson) (Cheel), Guy Fawkes (Staer).

Queensland: Brisbane and Mount Mistake (Bailey), Darling Downs (Lau).

THE FLORA OF THE BASALTIC TABLELANDS OF SOUTH-EAST QUEENSLAND.

By JOHN SHIRLEY, B.Sc., Senior Inspector of Schools, Queensland.

(Illustrated by 24 lantern slides.)

1. Geography.—In the East Moreton district of Queensland are three mountain tablelands, forming part of the coast range, the watershed between the upper waters of the Bremer and the small rivers flowing into Moreton Bay at its southern end. These tablelands are Tambourine Mountain to the N., Beech Mountain in the centre, and Springbrook, the southern one, which backs up to the Macpherson Range. Tambourine Mountain is separated from Beech Mountain by the valley of the Coomera River, and the valley of Nerang Creek separates Beech Mountain from Springbrook. Both these streams flow into Moreton Bay.

The three mountains have their long axes in a N. and S. direction, and the waters of Moreton Bay and the sands of Stradbroke Island may be seen from their summits. In height they range from 1800-2000 feet, and their tops are remarkably level.

2. Geology.—The base of each mountain is usually of sandstone or conglomerate of Trias-Jura age, and the summit of basalt. The junction of these two formations—the sedimentary and volcanic—varies in height very much. At the northern end of Tambourine it is nearly at the base of the mountain, but alters constantly, and in places reaches 1000 feet above sea level. In the central portion of Tambourine, on the eastern side, the basalt rests on schist of Carboniferous (?) age.

Mr. Marks, B.A., in his report on "The Coal Measures of South-east Moreton," p. 51, says, "The basalt—or rather andesite—seems to be the result of at least two flows, the later of which has developed in many places a well marked columnar structure. The earlier flow, as seen in the head of Sandy Creek, has more of a laminar structure, and is more readily decomposed." These two basalts overlap on the eastern side of each mountain, but towards the west, especially on Tambourine, the older basalt projects from under the recent flow, and forms the so-called "Cedar Shelf," which on the N. mountain is 5-6 miles long, and supplied to the saw-miller an immense quantity of cedar (Cedrela toona *Roxb.*), timber now mainly exhausted.

3. Favourable Conditions.—The decomposition of the basalt produces a very rich soil, in most places of a considerable depth, the distance from the sea is usually less than 30 miles, and the prevailing winds are from the S.E. for the greater portion of the year. This combination of rich soil and a plentiful rainfall produces a most prolific vegetation. As the basalt cap protects the sedimentary or metamorphic rocks below from the disintegration of their upper surface, the drainage channels are sharply but not deeply cut in the volcanic rock. Below the basalt the sandstones and conglomerates are weathered into inaccessible precipices, and over them the small streams from the tablelands fall in beautiful cataracts. Near these the basalt is sometimes cut back by water action sufficiently deeply to show the upper layers of the Trias-Jura rocks, here much altered by the action of heat.

4. Peculiarities of Mountain Floras.—The flora of each of these tablelands has its peculiarities. On Springbrook *Rubus Moorei* F. v. M. is plentiful, and reminds one in its wait-a-bit nature of *Rubus australis*, the bush lawyer of New Zealand. This rosaceous plant is not found on Beech or Tambourine mountains. Again, on Springbrook the commonest fern in the vine scrubs is *Gleichenia flagellaris*, Spreng., which is very rarely seen on the other tablelands. Beech Mountain has generally a growth of *Goodia lotifolia*, Salis., at the junction of scrub and forest, and the vine scrubs abound with species of *Solanum*, of which *S. sporadotrichum*, F.v.M., *S. aviculare*, Forst., *S. simile*, F. v.M., are among the most common. Tambourine Mountain has usually a fringe of the mountain bracken surrounding its scrubs, and marking the junction of scrub and forest. This is the fern *Davallia dubia*, R. Br., which so closely, in outward appearance, resembles *Hypolepis tenuifolia*, Bernh. On this mountain, too, the open forest is marked by thickets of *Indigofera australis*, Willd, v. *minor*, one of the most shrubby of the numerous varieties of this variable leguminous plant.

5. Plant Formations.—The plant associations on these mountains are four in number :—

1. The plants of the jungles, known locally as vine scrubs.
2. The plants of the open forest country.

3. The plants of the creek sides in the lower parts of the tableland.
4. The plants of the precipices.

These associations, or formations as they are called, differ most radically in the plants that compose them, and will be treated in order, and in detail.

6. The Vine Scrubs.—These are best studied from the tracks, of which each mountain has one chief track, following mainly its N. and S. axis, and kept clear for riding or driving; and many timber tracks, more or less overgrown. The sides of the tracks are usually lined with a dense growth of *Pollia macrophylla*, Benth., a tall plant of the order Commelinaceæ, with dense panicles of white flowers and oval berries; behind this fringe is a taller growth of a plant with somewhat similar aspect—*Alpinia cærulea*, Benth.—one of the Scitamineæ, whose flowers, from their colour and labellum, might make one think they belonged to the orchid family. Among these grows a beautiful lily with white or flesh-pink flowers, *Kreysigia multiflora*, Reich., the specific name is usually a misnomer on these basaltic areas, as the flowers are often solitary, rarely possessing three or four blooms in the same inflorescence.

The tree trunks are drawn up tall and straight by the struggle to reach the light; between them are numerous shrubs, and binding the trees together are still more numerous creeping stems, locally known as "vines." These belong mainly to five orders, Leguminosæ, Ampelideæ, Cucurbitaceæ, Menispermaceæ, and Liliaceæ. The leguminous plants show nothing that can compete in size of pod with the match-box bean of N. Queensland, but many are interesting on account of their flowers, as *Milletia megasperma*, F. v. M., a near relation of the Chinese Wistaria; *Kennedya rubicunda*, Vent., with dark red flowers, 1½ to 2 inches long; *Mucuna gigantea*, D.C., whose pods are covered with hairs that are pungent and irritating; *Canavalia obtusifolia*, D.C., whose leaves, like the last mentioned, are trifoliate, but with white or pink flowers instead of the greenish yellow of *Mucuna*; *Derris scandens*, whose pods are one or several seeded, thin, and acute at both ends; and finally the Blood Vine, as it is known locally, distinguished by its dark purple flowers and blood-red sap—*Lonchocarpus Blackii*, Benth.

The vine family, Ampelideæ is very fully represented. The most common species is *Vitis antarctica*, Benth., with simple leaves, whose stems form great cables drooping in curves from the tallest trees. Trifoliate leaved vines are represented by *Vitis nitens*, F. v. M., and *V. acris*, F. v. M. Vines whose leaves are divided into five leaflets are *V. clematidea*, F. v. M., with a pedate arrangement of leaflets; *V. hypoglauca*, F. v. M., whose leaflets are digitate and large, while the leaves of *V. opaca*, F. v. M., are digitate and small. These are all known to bushmen as water-vines, but the name is specially applicable to *Vitis antarctica*, Benth., because where water is scarce a section of the vine as thick as a man's wrist, and some two feet long, is cut and upended in a pannikin, when half that vessel is filled with a clear, tasteless sap, that can be drunk, and will quench thirst like water. The fruits of several species are fairly large and juicy, but when swallowed they affect the throat and palate like a strong astringent .

The most rampant climbers of the order Cucurbitaceæ are *Alsomitra suberosa*, Bail., whose stems are furnished with corky flanges, hence the specific name, and *Trichosanthes subvelutina*, F.v.M., with enormous melon-like fruits, 6 or 7 inches long, and 3 or 4 inches wide, which ripen about the middle of summer They are oval in shape, and have yellow splashes on a dark green ground. The roots of this species are furnished with large underground tubers.

The most common climber of the order Menispermaceæ is *Stephania hernandiæfolia*, Walp., which is usually found on the edges of the scrub, and sometimes in the open forest country. As described in a former paper,[1] it is locally known as the "tape vine," and was called by the aborigines Nyannum. It was beaten out by them with their tomahawks, until it formed flat fibrous "tapes," and was then thrown into water-holes, stupefying the fish, and causing them to float to the surface on their backs, when they were secured and eaten. An ally with prickly stems, named on that account, *S. aculeata*, Bail., is sparingly found on the edges of scrubs. Another plant of this order with active poisonous effects is *Sarcopetalum Harveyanum*, F. v. M., easily distinguished from the two last, which have more or less peltate leaves, and a solitary carpel, by its cordate leaves, and 3 to 6 carpels. Another vine of these southern scrubs is *Legnephora Moorei*, Miers, better known as *Cocculus Moorei*, F. v. M.; it has leaves 6 inches long and nearly as broad, varying from ovate to acutely pointed, with a flattened base.

Liliaceous climbers belong mainly to the genera *Smilax* and *Rhipogonum*: they are known to country people as "supplejacks." Two species of *Smilax* inhabit these scrubs—*S. australis* R.Br., with prickly stems, and leaves usually five-nerved, and *S. glycyphylla* Sm. with unarmed stems, and leaves usually three-nerved. As a Brazilian species supplies most of the sarsaparilla of the pharmacist, while a North American species provides the bowls of the well-known "briar-root" pipes, it seems a pity that no experiments so far have been made with our native species. Four species of *Rhipogonum* may be found on these mountains, of which one—*R. Fawcettianum*, F. v. M., has unarmed stems and ovate-cordate leaves: the others have prickly stems and usually oblong leaves.

Two plants belonging to the order Apocynaceæ are also commonly found as lianas in these scrubs. One *Lyonsia largiflorens*, F. v. M., is fairly common. It may be distinguished by its large cordate opposite leaves, often six inches long, and its axillary cymes. The young shoots and flower clusters are covered with a minute pubescence. The other is rare in the vine scrubs, but

[1] "A Fish Poison of the Aborigines," *Proc. Roy. Soc.*, Vol. XI., pp. 88-90.

common in the creek and basal brushes. It is *Melodinus acutiflorus*, F. v. M., also with opposite leaves, but these are ovate or lanceolate. The fruit is the size and shape of a small apple, and is pulpy within.

But the plant that offers the greatest opposition to the progress of the naturalist is a climbing palm, known as the "Lawyer Cane."[1] Its nodes give off fine sprays, one to two feet long, armed with numerous hooks; these sprays are tough and flexible and twine themselves into the clothing of the visitor, impeding his progress. When young, each cane has a prickly outer coat. The fruit dangles from the vine on long, tough supports, armed with a number of prickles resembling fishhooks.

It is a surprise to the botanist to find the principal tree in the scrub is the Queensland Flooded Gum, *Eucalyptus botryoides*, Sm., with which he is so familiar in the low-lying scrubs along the North Coast railway line, and that it flourishes equally well at heights of 2,000 feet above the sea. This tree, with its French-grey shafts, 6-8 feet in diameter, and rising to a height of 200 feet, is a vision of beauty to the botanist. Although it is usually stated that the butt is covered with rough bark to a considerable height, this is not true in these mountain scrubs, as the trunk is usually smooth from base to summit. The presence of these eucalypts is a hindrance to the settler; when he has felled and burnt the scrub, the roots of the common scrub trees rot out in a few years, but this is not the case with *E. botryoides*, whose roots have to be grubbed out with considerable trouble and labour.

A curious feature of many scrub trees is the growth from the lower parts of the trunk of enormous flanges. These are at times 12 to 15 feet long. The angle between two neighbouring flanges is a favourite hiding place for the smaller marsupials. At times these angles hold water, and the discovery is always welcome to the sportsman or naturalist. The trees that most constantly form buttresses are *Weinmannia lachnocarpa*, F. v. M.; *W. Benthami*, F. v. M. (both known as Marara); *Tarrietia argyrodendron*, Benth., and its variety *trifoliata*, F. v. M., called by the settlers Booyong.

At times trees that are supposed to be peculiar to Northern Queensland are found, under favourable conditions of soil and climate, to range much further south, and to appear in unexpected localities. The discovery of *Endiandra insignis*, Bail., as one of the commonest trees on Tambourine Mountain is a case in point. Its very characteristic fruit, two to three inches long, and changing from pink to dull red when ripening, should have revealed its southern habitat. Known heretofore form the Cairns district only, it was found, as stated, by Drs. Domin and Danes and the writer in March, 1909.

The orders most fully represented are the Pittosporeæ, of which the commonest are *P. undulatum*, Vent., and *P. revolutum*, Ait.; Tiliaceæ, best exemplified by *Sloanea australis*, Benth., and

1. Calamus Muelleri, *W. & D.*

S. Woollsii, F. v. M. ; Rutaceæ of many species, belonging mainly to the genera *Acronychia*, *Melicope* and *Evodia*. *Acronychia lævis*, Forst., *A. Baueri*, Schott., and *A. Scortechinii*, Bail., are the most common of the simple-leaved species, and of the trifoliate forms *Melicope neurococca*, Benth., *M. erythrococca*, Benth., *M. pubescens*, Bail., *Evodia micrococca*, F. v. M. and *E. accedens*, Blume. Several of these are common also in the creek scrubs at the foot of the mountains. The Meliaceæ are in strong force, including several species of *Dysoxylon*, especially *D. Muelleri*, F. v. M., locally known as Kedgy-kedgy, *Synoum glandulosum*, A. Juss., which forms dense thickets in scrub land that has been cleared and abandoned, *Owenia venosa*, F. v. M., and *O. cepiodora*, F. v. M., the latter well known to bushmen from its onion-like scent. *Melia composita*, the white cedar, *Cedrela Toona*, Roxb., the red cedar, *Flindersia australis*, R. Br., *F. Oxleyana*, F. v. M., *F. Bennettiana*, Benth., and other species of crows-ash. Plants of the order Sapindaceæ abound in every part of the vine scrub. The most common are *Cupania serrata*, F. v. M., *C. pseudorhus*, A. Rich., which, when growing on the edge of the jungle, forms a shady rounded head, presenting panicles of pink or reddish flowers, later on to be succeeded by bunches of golden yellow, velvety capsules ; *Ratonia anodonta*, Benth., and *R. tenax*, Benth., are fairly common, the latter often flowering as a shrub of 5-10 feet. The best represented genus of this family is without doubt *Nephelium* : of this section seven or eight species may be gathered. The most easily found are *N. semiglaucum*, F. v. M., with steely blue undersides to the leaves, and *N. connatum*, F. v. M., with its fruit of two or three carpels connected like vegetable Siamese twins or triplets. Also belonging to this order are tulipwoods (*Harpullia*), turnipwoods (*Akania*) and hopbushes (*Dodonæa*). The myrtle family also occupies a dominant place in this plant formation. Its commonest species are the white myrtle, *Myrtus acmenioides*, F. v. M., *M. Hillii*, the scrub ironwood, whose smooth polished trunk reminds one of the guava, *Rhodamnia trinervia*, Benth., and *R. argentea*, Benth., each with triple-nerved leaves, the latter silvery underneath. *Eugenia Hodgkinsoniæ*, F. v. M., *E. paniculata*, Banks *et* Sol., *E. punctulata*, Bail., and *E. corynantha*, F. v. M., all locally known as scrub cherries. The Monimiaceæ have for their most common representatives *Mollinedia Huegeliana*, Tul., *Kibara macrophylla*, Benth., and *Hedycarya angustifolia*, A. Cunn. The first named is called by the mountain settlers pigeon-berry, a name elsewhere given to species of *Acronychia*. This mountain pigeon-berry has for its fruit a reddish or yellowish disc, on which are fixed five or six oval drupes, each half an inch long. Lastly, there are numerous species of Laurineæ, including the native Sycamore, *Cryptocarya obovata*, R. Br., and its allies, *C. australis*, Benth., *C. glaucescens*, R. Br., and *C. triplinervis*, R. Br., species of *Endiandra*, as *E. virens*, F. v. M., and *E. insignis*, Bail., ; the Sassafras, *Cinnamomum oliveri*, Bail. ; the Bally-gum, *Litsea reticulata*, B. & H., and two others of the genus, *L. dealbata*, Nees, and *L. zeylanica*, Nees.

The trunks of trees are clothed with mosses and lichens, with festoons of the climbing ferns *Polypodium scandens*, Forst., and *Aspidium ramosum*, Beau, the fronds of the former showing the greatest diversity of shape and margin, or with the climbing aroid *Pothos Loureiri*, Hook. & Arn. The last named has red or orange coloured fruits, three-quarters of an inch long, and, at this stage especially, is one of the beauties of the vegetable world. Other climbing ferns are *Polypodium serpens*, Forst., and *P. confluens*, R. Br., each with small, simple fronds. The large trunks of scrub trees are at times covered with heavy masses of the yellow bloom of *Dendrobium speciosum*, Sm., or of its white variety *Hillii*, F. v. M. Other common epiphytical orchids are *D. tetragonum*, A. Cunn.; *D. æmulum*, R. Br.; *D. gracilicaule*, F. v. M.; *D. monophyllum*, F. v. M.; *D. linguiforme*, Swartz; the tongue orchid, *D. teretifolium*, R. Br.; the pencil orchid[1] and its allies, *D. Beckleri*, F. v. M., and *D. Mortii*, F. v. M. Of the genus *Bulbophyllum* the most common are *B. aurantiacum*, F. v. M. with orange-coloured flowers and small ovoid pseudobulbs; *B. exiguum*, F. v. M, climbing for long distances on small trees, usually in the more open parts of the scrub, its small pseudobulbs joined by slender threads; and *B. Elisæ*, with its white, pink, or purple flowers turned to one side of the stem. The genus *Sarchochilus* is fairly exemplified by numerous specimens of *S. divitiflorus*, F. Muell.; *S. falcatus*, R. Br.; *S. olivaceus*, Linde; and *S. Ceciliæ*, the racemes of the last species showing lovely sprays of pink bells.

Underfoot, the cunjevoi, *Alocasia macrorrhiza*, Schott, is everywhere, the earth near the rootstock almost always showing freshly dug holes, where the scrub turkey, *Tallegallus Lathami*, Gray, has been feeding. One treads upon low bushes of three species of Rubiaceae, *Psychotria daphnoides*, A. Cunn., *P. loniceroides*, Sieb., the former with glabrous leaves, the latter with hairy ones, and a species with glaucous green leaves, about one inch long, with a procumbent habit, probably *P. simmondsiana v. exigua*? which may prove a new species. The common terrestrial ferns are *Polypodium aspidioides*, Bail, *Aspidium aristatum*, Swartz, *A. decompositum*, Spreng, and *A aculeatum*.

7. THE OPEN FOREST.—In this association most of the plants of Indo-Malayan affinities are conspicuous by their absence, myrtaceous and leguminous plants are the dominant feature. Besides the well-known Queensland blue gum, *Eucalyptus tereticornis*, Sm., there are present the grey gum, *E. saligna*, Sm., the bloodwood, *E. corymbosa*, Sm., the Brisbane box, *Tristania conferta*, R. Br., the yellow-flowered box, also known as a water gum, *Tristania laurina*, R. Br., and the tallow-wood, or turpentine, *Eucalyptus microcorys*, F.v.M. This last has a far healthier appearance than on the coast plains; its bark is of a clear cinnamon brown, and next to *Eucalyptus botryoides*, Sm., it is the largest plant of the myrtle family on these tablelands. Although less in height, it exceeds the water gum in girth; one specimen was 26 feet in girth at a height of 6 feet from the ground.

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1. Dendrobium teretifolium, *R. Br.*

Of the many legume-bearers in the forest country, the most interesting is *Daviesia arborea*, W. Hill, the only arborescent Queensland species in a genus usually represented by undershrubs. This plant, when not in flower, has the aspect of a wattle, resembling the acacias in bark aspect, and simulating phyllodes in its leaves. The leaves are, however, lighter and more polished on the upper side than is usual in wattles. Its papilionaceous blossoms are crowded along the stems, and are golden yellow at first, becoming reddish when fading. It forms dense thickets on the eastern side of Tambourine Mountain, and is quite a feature of that side of the northern tableland. The common wattles on the summits are *Acacia decurrens*, Willd., and *A. implexa*. Benth, with twisted pods; at lower levels these are replaced by *A. Cunninghamii*, Hook., *A. aulacocarpa*, A. Cunn., *A. falcata*. Willd., and *A. longifolia*, Willd. In broken gullies, just before the streams reach the coast plain, small clumps of *A. amœna*, Wendl., are common.

8. THE CREEK SIDES.—In this formation we have a mixture of scrub and forest trees, but still it has many features of its own. There are masses of the East Indian *Cæsalpinia sepiaria*, Roxb., now thoroughly acclimatised, and forming prickly, impenetrable thickets along the sides of the narrow creek scrubs. With these, but more commonly in broken ground where the creek leaves the lowest spurs, are two allied native species *Mezoneurum brachycarpum*, Benth., whose stems are winged with corky flanges, and *M. scortechinii*, F.v.M., with cylindrical stems. Many scrub trees found on the summits descend to the coast plain on the eastern sides of the tablelands, especially the Rutaceæ and Myrtaceæ. Here they have a totally different aspect, being less lofty, more symmetrically branched, and having well-shaped rounded heads. Several plants of the order *Anonaceæ* find a home in these stream-fringing scrubs, as *Ancana stenopetala*, F.v.M., with yellowish flowers one inch long, and having a vinous odour; the native custard-apple, *Eupomatia Bennettii*, F. v. M., with edible fruits, and *Eupomatia laurina*, R. Br., with fruits like those of a eucalypt in outward appearance. A plant worthy of cultivation is *Hedraianthera porphyropetala*, F. v. M., a shrub with glabrous leaves, corymbs of purple flowers, and capsules which, when they dehisce, straighten out the valves into one plane, so as to form five-pointed stars. Another plant worthy of a place in our public gardens is *Hymenosporum flavum*, F. v. M., which reaches a height of 15-20 feet, and, when covered with its wealth of yellow, scented blossoms, with a background of dark scrub foliage, and a running stream in front, is a picture well worth seeing. Here, too, one can see thickets of the finger lime, *Citrus australasica*, F. v. M., with scattered shrubs of its variety *sanguinea*, Bail., the blood lime. Introduced American pests are prominent, especially *Lantana camara*, L., with its umbels of pink, white and yellow flowers.

9. THE ROCK FLORA.—This includes plants which are able to bear great extremes of heat and cold, flourishing equally well under the winter frosts or when the rocks are heated by the summer sun.

These are mainly *Piperaceæ*, as *Peperomia leptostachya*, Hook, et. Arn., *P. reflexa*, A. Dietr., and the newly-discovered *P. affinis*, Domin ; *Crassulaceæ* as *Tillia ver icillaris*, D.C., *T. recurva*. Hook., and in places the naturalised African plant *Bryophyllum calycinum*, Salisb. Rarely the shrubby umbellifer, *Siebera linearifolia*, Benth., is found on the edges of precipitous cliff, as are also *Dendrobium kingianum*, Bidw., and the ferns *Polypodium rigidulum*, Sw., and *Notholæna distans*, R. Br.

10. Conclusion.—These tablelands, together with the Lamington Plateau at the head of the Logan River, should have been kept as beauty spots and health resorts for all future generations. To Tambourine, Beech and Springbrook Mountains, roads have been constructed, with some very stiff gradients, but still available for wheel traffic. Unfortunately, much of the land on these tablelands is alienated. The State has not done for them what New South Wales has done for the Blue Mountains, and visitors have to depend on boarding-houses and farmhouses for accommodation, and on their own bushmanship for guidance. The Lamington Plateau is still unalienated, and it is to be hoped that this natural botanic garden, the home of a true beech, *Fagus Moorei*, F. v. M., and many other rare plant forms, may be reserved as a National Park for all future generations of tourists and naturalists.

8.—GROWTH, DEVELOPMENT AND LIFE-HISTORY IN THE *DESMIDIACEÆ*.

By G. I. PLAYFAIR.

Degeneration in type, the great law of Desmid life.—Among the Desmids there is not to be found that steady upward growth to sexual maturity and onwards to perfection of form which is characteristic of the higher orders of plants. Their life-history discloses a perpetual struggle between the forces that make for the multiplication of cells as against those that tend towards the perfection of the individual, and in this struggle the former are generally triumphant. Degeneration of type, that is to say, holds sway over their life rather than development. Beginning life perfect by development of the zygospore, multitudes of individuals are produced by a rapid process of quickly-repeated cell-division at the expense, as regards size, form and ornamentation of the original and more or less of every succeeding type. A species, therefore, might be described as the sum total of all the forms resulting from any given zygospore by a conflicting process of degeneration[1] and development, were it at all certain that only one zygospore is concerned. (See under *Zygospore.*)

1 Degeneration here and throughout this paper is not used in any specialised sense, but as the most convenient word to express the degradation of type (as regards size, shape, and ornamentation) in cells produced by quickly repeated cell-division.

General degeneration of type, then, resulting from rapid and exhausting, because oftentimes almost continuous, division is the great law of Desmid life, and it may naturally be asked—To what extent does this hold good, how far can it affect the size, form and ornamentation of the cell? It has been far too much taken for granted that it did so only to a slight extent. Each characteristic and well-known form is itself so variable within certain narrow limits that it has come to be understood, entirely erroneously, however, that these minute variations, with a zygospore to match, constituted the sum of its life history, outside of which it did not move. The discovery, too, that many Desmids have a major and minor form (sometimes also a *forma maxima* and *forma minima*) of exactly the same shape, has perhaps strengthened the idea that identity in outline is the sign of identity in species, the minor form being supposed to pass into the major by a process, not of development through varying types, but by one of *pure growth* equally in all directions—a thing that can hardly be said to have any place at all in Desmid life.

In other words, we have considered the Desmids in some ways too much in the light of the growth of the higher orders of plants, in which the production of seed is the end and aim of existence and their life history a continuous *upward growth* to a sexual maturity; whereas among the Desmidiaceæ the succession of polymorphic forms, which constitutes the life history of any species, exhibits in the characteristics of the several forms a gradual *degeneration* from a perfect sporangial type, and the objective of desmid life is not the production of zygospores but the multiplication of cells. Everything is arranged to give way to this, just as everything gives way to the production of seed in the flowering plant The fact does not seem to have received sufficient recognition that among the microscopic forms of life, both animal and vegetable, with which the waters teem, polymorphism of the most extensive kind plays a leading part. In no family, however, does it more completely dominate the whole life history than among the Desmids. A true Desmid species consists of an immense number of distinct polymorphic forms, which are partly successive modifications of the sporangial type under stress of repeated cell-division, partly abnormal (but in no sense monstrous) forms brought about by unusual combinations of circumstances, and partly types arising from all these as the result of their struggle to develop upwards towards the perfect exemplar of the species.

SIZE.—The question, then, as to how far degeneration affects the size, form and ornamentation of the Desmids may be answered in one word, viz., that under conditions favourable to its operations it never ceases to affect them till it has reduced all three to the simplest possible. It would be interesting to know just how far down the cells of a species could go without being entirely deleted. There seems to be some natural limit, as the smallest forms that I know of are all just about the same dimensions. They are *Cylindrocystis* (so-called) *minutissima*, Turn., 9 x 7μ, the smallest variation of *Pen. Mooreanum*, Arch., and also of *Pen. polymorphum*, Perty; *Cos. minimum* var. *subrotundatum*, W. & G. S. West, 7 x 6u, the lowest form of *Cos. ellipsoideum*, Eltv. (and of others); and *Cos. concinnum* v. *pygmæum* (Hantzsch), Rein., 8 x 8u, a minute polymorphic form of *Cos. anisochondrum*, Nord. Very minute forms of *Cyclotella Meneghiniana* (greatest observed diameter 32u) are found in the plankton of the Sydney Water Supply, measuring only 4u across. It is evident, of course, that Desmids, on account of their bilateral symmetry, cannot be expected to descend to as small a size as others of the lower algæ. Most of my recent observations have been upon forms of *Cosmarium*, but in one species of *Closterium*, viz., *C. decorum*, Bréb, whose variations are common here, I have been able to note the strength of this degenerating influence. In this genus and others, where the length of the cell is the prominent feature, it might be supposed that the length would suffer rather than the breadth, but this is not the case when all the variations have been passed in review. The length of this species falls from 756u to 198u, and the breadth from 48u to 13u—one-quarter of the maximum in each case. These figures also give a very inadequate idea of the immense difference *in appearance*—the optical area being reduced to the sixteenth part. *C. gracile* also, whose greatest length is about 450u, I have found as low down as 56u.

Form.—Quickly repeated division of the cell always tends to reduce the outline eventually to the very simplest shape—circle, oblong, ellipse—and this is true even of the very long cells of *Docidium* and *Closterium*. Even the most salient angle gets rounded off. Compare Delponte, *Desm. subalp.*, T. xviii, f. 46, where a number of degraded cells of *Doc. trabecula* are shown involved in mucus, which has been thrown out to protect them in time of drought. Under favourable conditions these forms will develope into perfect specimens of the type.

Ornament.—With regard to ornamentation, those adornments which are most prominent are generally the first to go, as they are the last to come. *Arthrodesmus* and *Xanthidium* lose their spines at once and become to all appearance forms of *Cosmarium*, with the result that at present there are several young forms connected with these genera masquerading as *Cosmaria*. Indeed, there are very good reasons for believing that the lower forms of all species of *Xanthidium* and *Arthrodesmus* are well known "species" of *Cosmarium*, just as the genus *Arthrodesmus* itself is merely a collection of certain lower forms of *Xanthidium*.

Striæ, puncta, scrobiculæ, crenations, granules, verrucæ, all gradually disappear in degenerate forms, generally also in the reverse order to that in which they make their appearance. Neither outline, size nor markings are, *per se*, indications of specific identity or even of generic rank. Cf. *Ar. glaucescens*, Wittr., Om Gotland's Sötv. Alg., T. iv, f. 11, which, however much it may look like an *Arthrodesmus*, has been shown to be a *Theapedia*. Of course to say that these ornaments are *lost* is merely a *facon de parler*, as a matter of fact they never grow. Cell-division becomes so continuous that there is not time for them to form on the young semicells.

Influence of Local Conditions.—In the determination of the life-histories a great deal has been expected from the cultivation of Desmids and Diatoms under artificial conditions in a laboratory or aquarium. This does not appear to have answered even with the Diatoms, which do not seem to be so acutely affected by their surroundings, provided there is abundance of silica in the water they inhabit. The Desmidiaceæ, on the other hand, are extremely sensitive to very slight changes of temperature, wind, currents, sunlight, the chemical condition of the water, the liability of their habitat to dry up, and whether this takes place regularly at a certain period of the year, or irregularly, according to the rainfall. it is this sensitiveness and responsiveness to external stimuli which are the cause of the immense number and variety of the forms included within any species. There is good reason to doubt whether under the equable conditions of an aquarium the polymorphic forms would be reproduced. Each distinct form is the product of particular conditions, the tendency being to perpetually reproduce that same form while the same conditions continue. As confirmatory of this, it is interesting to note the experience of G. S. West, mentioned in "British Freshwater Algæ," on the occurrence of certain polymorphic forms of *Eremosphæra viridis*, reported by Chodat. "Specimens kept under cultivation for two years," he says, "developed no forms other than globular daughter cells." On the other hand I have observed here several distinct forms of *Eremosphæra viridis* when growing under natural conditions, and traced a connection with a good many more."

Pause or Hesitation Points.—At any rate it is certain that in different localities the same species may be regularly met with, here under this form and there under that. All the forms are capable of going forward to perfection, and under other circumstances do so; yet here and there they never seem to get beyond a certain stage. All these polymorphic forms are transitory, mere stages of growth, however diverse in outline and markings they may be, yet there is a stability about certain variations which gets them the credit of being fully developed. This is due to a disinclination on the part of the cell to go forward. For fresh development it needs, as do all plants, an external stimulus from Nature, and this is not always forthcoming, perhaps only rarely, except at certain seasons of the year. The degenerate cell, therefore, simply goes on reduplicating its own and still more degenerate forms over a considerable period of the year. This disinclination to develop, shown by the Desmid at any stage of its existence, has been taken to be *an inability to proceed further*, and what is merely a temporary pause in their life-history has been elevated into the rule of Desmid life. It is well known that the higher plants come to a standstill in dry weather, but who has not observed the instant growth they make under the stimulus of good rain. Aquatic life also has its appropriate stimuli, and until these are supplied the Desmid will simply remain in much the same condition, though slight changes still go on. Each characteristic form, therefore, marks the place for a pause in the development of the species, and in each locality there is a tendency for this pause to remain constant at some particular variation.

I lately transported, from a small piece of sphagnum bog at Coogee, a medley of Desmids and sowed them on a small isolated piece of natural swampy ground at Auburn. Among them was *Eu. dideltoides*, not found at Auburn. At Coogee, where there is a generous current of cool water, this plant maintains itself full grown, though I have once caught it young in a state like *Eu. ansatum*, Ralfs, but in its new habitat, where water only lies after rain for a few weeks at a time, it took on a new shape, the kink in the side being accentuated to produce a figure like a form of *Eu. sinuosum.* Again at Collector, 250 miles up country from Sydney, its prevailing young form was that described and figured as *E. triangulum*, Playf. (*Jour. Linn. Soc., N.S.W.*, 1907, p. 171, Pl. iii, f. 7), which should stand in future as *Eu. dideltoides* var. *triangulum.* The same Desmid, therefore, in different localities may have alternative life-histories, or at any rate different young forms become prominent.

Influence of Heat.—Rise in temperature is the principal cause of cell-division. This will be at once noted in gatherings taken on a hot day from shallow water ; these are sure to contain cells in all stages of division, and even the most mature of them more or less degenerate. The same thing may be observed in gatherings kept alive in glass jars during hot weather ; division proceeds so rapidly and continuously that the characteristic size, form and markings of the cells are entirely obliterated in the cells produced. A gathering of Desmids was lately obtained in which, among others, *Micr. truncata* v. *decemdentata* was abundant. A part of this gathering was placed in a small glass jar near a window, where it caught the sun daily for a few hours. Examined after some days, the original var. *decemdentata* could hardly be found except in mixed forms, but quite a number of degenerate types had come into existence, showing great debasement of form consequent upon quickly repeated division. Not a trace of any of these forms was originally present.[1]

The Desmids frequent shallow waters, and these in tropical and sub-tropical countries easily become quite hot. Moreover they abound in the tufty heads of water weeds, by which they are generally elevated into the upper, and therefore warmer, strata of their habitat. All this tends to promote multiplication of degenerate forms and to reduce all the species to their smallest and most compact proportions. It is interesting to note that this very fact

[1] *Jour. Linn. Soc., N.S.W.*, 1910, Pl. xiv.

proves their salvation in drought. The drying up of the water, by the consequent gradual rise in temperature, automatically brings them into the best condition for resisting desiccation. If the heat of the water had tended to promote development to their highest proportions the drought would find them at their largest, with the maximum surface to be attacked by the heat and with the broadest possible pores to be protected from evaporation.

It seems to be still considered doubtful whether the Desmids can survive the desiccation of their habitat. From considerable experience of swampy patches of ground which dry up periodically I can state unreservedly that despite their delicate appearance *there is no class of organism better qualified to withstand drought* under natural conditions. I have on many occasions taken fine gatherings of Desmids from ground which had only a few days before been revivified by rain, having previously been dry for months under the fierce heat of an Australian sun. The mucus with which the cells surround themselves is quite able to keep the drought at bay for a considerable period. Besides, to organisms of their microscopic proportions the solid ground is like perforated zinc, and although apparently quite dry, yet within the interstices into which they can descend there is still sufficient moisture in many cases to keep minute plants alive.

Occasional Variations.—Besides the line of variations which constitutes the normal life-history of any species, each of its component types is the centre of a cluster of forms which are not in the direct line of development, but are the product of special conditions. These may be called "occasional" variations. They have no place in the normal life history, but they are not for that reason to be considered as developmental *culs-de-sac.* They grow out of one form and into another and develop onwards towards the final form, producing a secondary life-history more or less irregular. These occasional variations are, of course, merely temporary ; but still having occurred once there is always the likelihood of their occurring again. It is unfortunate when, as sometimes happens, one becomes the type of a species as the form first found. This class of variation is useful from the way in which the cells sometimes combine the shape of one form with the markings of another, thus establishing their connection with the same species.

Senile Forms.—Akin to these occasional variations are what Turner, in *Alg. of E. India*, has termed senile forms, a very suitable name, which may well be perpetuated. If a cell gets into a backwater of life, into circumstances, that is, which are inimical to robust growth, a feeble life often continues to go on in the cell, but the only outcome of it is to cause incrassation and yellowing of the membrane generally, the puncta or scrobiculæ being thus brought greatly into prominence. The rounded outline of the semicell at the same time becomes angular, and even the spines, if present, become incrassate. Such are *Pen. cucurbitinum* var. *pachydermum* (Playf.), *Jour. Linn. Soc. N.S.W.*, 1907, Pl. ii, f. 6 ; *Ar. gibberulus*

Josh. (l.c., Pl. iv, f. 5); *Doc. trabecula* var. *Delpontei*, f. *mediolævis*, (*Pl. mediolæve*), l.c., Pl. ii, f. 10, which are senile forms of *Pen. cucurbitinum* β *subpolymorphum*, Nord., *Ar. gibberulus* var. *ellipticus* (Playf.), l.c., Pl. iv, f. 4; and *Doc. trabecula* var. *Delpontei mihi* respectively. The same condition may come about naturally in course of time if the cell survive long enough without division. That this is caused by a feeble life I had demonstrated to me lately. Obtaining a gathering of *Doc. trabecula* var. *crenulatum*, I put it up in phials, part with preservative and part in plain water. Examining these samples some months afterwards I found that the majority of the specimens in water had become incrassate, while those in preservative showed the original condition.

An *appearance* of incrassation is occasionally noticeable, generally in front, but sometimes in side view. This is an optical illusion caused by close plication in the membrane, which produces an appearance of extra solidity through refraction. The same appearance may be observed when the grooves in the bottom of cut-glass dish, or tumbler, are viewed from within. A similar refraction in front view is produced by vertical plicæ in *Cos. rectangulare* var. *sulcatum*, by papillæ in *Cos. Bœckii* var. *trifoliatum* (Playf.), by the inflations of many species of *Euastrum* when the cells are put a little out of focus, and by the prominent tumour of *St. assurgens*.

Mixed Forms.—The bulk of the evidence regarding the identity of various "species" and the connection existing between the variations must necessarily be derived from those cells, only too sparingly found, unfortunately, in which the semi-cells belong to different types. And the fact of these occurring at all is a proof (1) that one form *can* develop into another, and (2) of the powerful effect exercised on development by a sudden change of conditions. These mixed forms must be produced at division, and the rule among Desmids is that the young semi-cell develops immediately into the facsimile of the other, however degenerate the latter may be. But in a mixed form, in the midst of this process some change of environment has been experienced, making either for a stronger or weaker growth, and the young semi-cell attains to a higher or more probably falls to a lower form than that of its mate.

In such mixed forms, while division is proceeding, each semi-cell retains its own shape, for it is a law, or rather a necessity, of the case that development of the semi-cell cannot proceed while cell-division is going on. A mixed form, A+B, therefore, at its next division produces two cells, A+A and B+B, and in this way all sorts of variations are created and multiplied. It should be noted, as some explanation of the spread of variations, that a mixed form develops *in equal proportions* into the type and the variant. Such a variation B+B has a well-defined shape, but it is not on that account permanent. Let circumstances come in favourable to cell-development, and not to division, and B+B will immediately develop back again into A+A or into some still higher form.

The rule of growth seems to be the establishment and maintenance of an *equilibrium of life* between the semi-cells of every Desmid. If external circumstances upset this equilibrium (as in division) the whole energy of the cell is put forth to restore it again by the development of the new semi-cell *to an equality* with the other, *but no more*. However immature the original semi-cell may be, it is impossible for the nascent semi-cell to surpass it, because there is not sufficient force left in the cell after the equilibrium has been established. Further development can take place, but it must be of both semi-cells *pari passu*. Under ordinary conditions there seems to be a very slow but continuous development of this kind always going on between the periods of cell-division, but for any sudden and considerable growth to take place in the cell as a whole an external stimulus from nature is required.

TRANSITION FORMS.—In successive gatherings taken from the same spot at various times careful comparison will often reveal the existence of a series of variations acting as transition forms between several "species." Each form has its own characteristics and size, but the sizes form an ascending series, and there is a general agreement in shape between the variations. *Doc. trabecula* affords a striking illustration of this. A well-grown form, var. *crenulatum* (Roy and Bisset) is the most common Desmid of this country, and in the same locality, and even in the same gathering sometimes, an ascending series of stages may easily be traced through var. *Ehrenbergii*, which is its invariable companion. For instance *Doc. trabecula*, var. *baculoides* (R. & B.), lat. bas., 12-16μ; var. *Ehrenbergii* f. *minor*, lat. bas. 16-20μ, type, 20-25μ, f. *elongata*, 25-28μ; var. *Delpontei mihi*, lat. bas., 30-39μ; var. *crenulatum* (R. & B.), lat. bas., 35-54μ.

All these sizes I have actually observed and measured. With the exception of var. *baculoides* all the forms are common. *Docidium* may be taken as a representative of the long Desmids, in which it is particularly differences of length and breadth, specially the latter, which mark off the stages of a species one from another. Under such circumstances, of course, transition forms are such as are found to bridge the gaps between those of one diameter and those of another. In *Cosmarium* and other closely related genera where outline and ornament are the distinguishing feature transition forms may also be found connecting one *form* with another and one *class of ornamentation* with another, showing that these cells, though possessing such characteristic shapes and embellishments as to have been generally considered distinct species, are really growing forms of one species—one shape gradually dissolving into another and one style of ornament into another. (See notes under *Cos. rectangulare* in *Jour. Linn. Soc., N.S.W.*, 1910, p. 475.)

ZYGOSPORES.—In the elucidation of species and their life histories a great deal of help has been expected from the zygospores, but I do not think that much has yet been obtained. It seems to have been largely taken for granted that every variety of Desmid forms a zygospore, and a zygospore, too, of distinct characteristics and fixed size. This is the necessary corollary of the idea that a distinct outline infers a distinct species. As a matter of fact, however, every species includes among its multitudinous growing forms quite a number of entirely distinct shapes—its type-forms or sub-species.

The question as to the formation of zygospores immediately comes up for solution. We seem to have two possibilities to choose between as a working hypothesis :—1. That every sub-species has a distinct zygospore, the zygospore answering to the outline. This is simply the old idea, but now with an added difficulty, viz., that as the species includes a number of sub-species, so it would also include a number of different zygospores. There is also an original difficulty about this idea, viz., the impossibility of conceiving several thousand distinct zygospores, to which may be added the fact that only a few distinct types appear to be found in nature. 2. The second possibility is *one zygospore for each species*, distinct in appearance when mature, but varying in size according to the dimensions of the variation by which it is formed. The first of these two will not, I think, commend itself to anyone, but the second I desire to put forward as the true law of zygospores. It means that Desmids forming the same kind of zygospore appertain to the same species, *however different in size and shape the cells may be.* In connection with the variation of the zygospore in size, the case of *Doc. trabecula*, cited above, may be mentioned. Both *Ehrenbergii* and *trabecula* have smooth ellipsoid zygospores, *vide* Ralp., T. xxvi, f. 4, for *Ehrenbergii*, and Wittrock, *Om Gotl.*, p. 62, where he gives the diameter as 125μ for *Doc. trabecula.* I have seen a specimen of the former ; it was broadly oval and measured 66 x 48. Ralp. gives 90μ.

Having lately had the opportunity of perusing W. & G. S. West's *Monograph of the British Desmidiaceæ*, I was specially interested to note the support afforded to this rule by the figures of zygospores. In Vol. I, Pl. i, figs. 6, 7, 14, those of *Gon. monotænium*, *Gon. Brebissonii*, and *Gon. Breb.* var. *læve*, are all exactly alike, but differ in size. These three Desmids are certainly forms of one species. They are all quite common round Sydney. The subcapitate head of *Gon. Brebissonii* unrolls as the cell swells upwards from the middle—as in *Docidium.* (The same subcapitate end I have observed lately in a young form of a species of *Spirotænia* ; its object appears to be to ensure a truncate apex.) Compare also Pl. vi, *Pen. cylindrus* and *Pen. cuticulare.* Still more noticeable are the zygospores of *Eu. oblongum*, *Eu. didelta*, and *Eu. ampullaceum* in Vol. ii, Pl. xxxv, figs. 2, 7, 10. I have no knowledge, unfortunately, of these three *Eustra.* none of which occur here as far as I know, but there is nothing whatever to prevent them all being forms of a single species, however they may differ in outline. Nor is there any *fundamental* difference in their outlines. Compare the shape of the polar lobe in *ampullaceum*, *affine*, *crassum*, *oblongum* ; these and many others have all practically the same sideline from base to apex, a three-lobed one; their dimensions are the same, too. Once frankly recognise that they may be growing forms and the fundamental likeness appears at once. Note also Monog., Vol. III, *Cos. ornatum*, Pl. 78, f. 1-10; *Cos. commissurale*, f. 11-14; and *Cos. corbula*, Pl. 82, f. 9-11. These are forms of one species; the zygospores are identical. Compare the remarks by J. A. Cushman.[1]

Zygospores are rare in this country, and I would like to broach three ideas which may be proved or disproved by more fortunately situated observers :—

1. That the large strong-growing Desmids do not produce zygospores, conjugation being the outcome not of strength but of weakness.

2. That the fully-developed cells of any species do not form zygospores, and that cells found in conjugation are by that very fact shown to be more or less degenerate. The zygospore I consider to be an arrangement for keeping up the size of the species, like the auxospore of the diatoms—a confession of weakness. For fully-developed cells to unite for this purpose could only tend to increase the size. I have not seen many examples of cells in conjugation, but in every case where I *have* seen them the cells were certainly degenerate. Compare W. & G. S. West, "*New Brit. Frw. Algæ*,"[2] where an interesting array of zygospores is figured. The authors themselves refer to the fact that in several cases the zygospores had been formed by cells newly divided and not yet fully formed, *vide* Pl. iii, f. 29, Pl. iv, f. 43, and the note on *Cl. Ehrenbergii*, p. 151. In three other cases than those cited, to my certain knowledge, the cells are degenerate forms, viz., *Cos. pseudoprotuberans*, Pl. iv, f. 34, *St. margaritaceum*, Pl. iv, f. 36, and *St. orbiculare*, Pl. iii, f. 28. None of these desmids are mature forms of the species they represent.

3. That every variation of a Desmid can form a zygospore, even those which are exceedingly degenerate in size: cf. *Cos. tinctum*, Ralp.[3]

Again the zygospores themselves go through a course of development. All are quite smooth at first, next papillæ may form which develope a spine at the apex, or simple spines may develope directly from the body. All these spines are simple to start with, but most become at least bifid with growth, and some even twice or thrice dichotomus, with elegantly curled tips. Compare *Cos. orthopunctulatum*, Schm. Zygo (l.c., 1907, Pl. v, fig. 28), where *a* is the immature and *b* the more mature form; also Ralfs, T. vii, where spines may be seen in all stages on the same zygospore. There are two different ways, however, in which this fission comes about. In some zygospores (*Cos. subspeciosum* β *validius*, Nord., for instance) the spines are first subulate but

1 *Bull. Torrey Bot. Club*, Vol. 32, No. 4, 1905, p. 223.
2 *Journ. Roy. Micros. Soc.*, 1896, part. 2.
3 *Brit. Desm.*, Pl. 32, f. 7.

curved to one side, the tips bend at right angles, and the other branch grows out from the angle. In others (*e.g.*, *Cos. subcrenatum*, Hantzsch, Rein.) the spines are straight and rod-like with blunt ends ; the ends divide evenly into two branches. It may, I think, also be taken as a general rule that mature zygospores are spherical, those which are elliptic, subglobose, or quadrate (with a fair number of exceptions), being not yet perfectly formed. In cases where the cells fuse together the zygospores are often more or less cruciform at first ; nevertheless, they soon become subquadrate, then subglobose, and finally spherical. On this point compare Ralfs, T. xxv, fig. 6, where he gives a complete series illustrating the formation of the zygospore of *Cylindrocystis* (*Penium*) *Brébissonii* Cf. also De Bary, Conjugatæ, T. v, figs. 26-27.

Pyrenoids.—In the genus *Cosmarium*, forms of which have specially engaged my attention lately, it used I believe to be considered that cells with double pyrenoids were specifically distinct from those with single ones. (See Delponte, *Desm.*, *subalp.*, p. 275, where the species are classified thus.) How far this is accepted to-day I have no means of knowing. In a recent gathering, however, I came across a cell of *Cos. subspeciosum β validius*, Nord., *forma*, in which just above the isthmus was a single pyrenoid, giving by its appearance every indication of age, while above were two others, apparently much fresher and younger. The impression could not be avoided that the single pyrenoid was a legacy from the younger stages—the cell was even then not nearly mature. A strong suspicion has formed in my mind therefore that probably in this genus only the variations with binate pyrenoids are approximately fully developed, *that the perfect form of the species of Cosmarium always bears geminate pyrenoids*, and that variations with only one to the semi-cell are more degenerate forms. If this is true, two things result—first it does away with all minute and small species (in the true sense), as these small forms almost always have but single pyrenoids, and secondly it provides a *terminus ad quem* towards which one may look in working out a life-history, since we cannot have arrived at or near the end till we have traced a connection with such a form. Under any circumstances I see very good reasons for believing that almost all the smaller kinds of Desmids are merely degenerate forms of larger ones, and not distinct species at all. As I remarked at the outset, in Desmid life degeneration and multiplication triumph, as a rule, at the expense of individual perfection. We must not be surprised under such circumstances to find in nature a multiplicity of immature forms and relatively few distinct species.

In the case of *Cos. subspeciosum forma* cited above, the old pyrenoid had occupied no doubt the normal place for a single amylaceous nucleus, viz., the centre of the semi-cell, from which it had dropped to a position a little above the isthmus, and the two new ones were in the usual position for double pyrenoids, viz., a little to right and left of the centre. These latter did not look as if they had been formed from the old nucleus by division, but as if they were of separate growth. I see no reason why secondary pyrenoids should not form *de novo* as well as the original ones.

In the long Closteria we may often see one series of very distinct pyrenoids which alternate with fainter or smaller ones in a second series. Sometimes the pyrenoids are so close together as to be almost touching. The second series, I have noticed, is usually on a slightly different plane in the cell to the other, and it may well be therefore that Kleb's figure of *Cl. lunula β coloratum*, T. i, f. ib, is *Cl. lanceolatum forma* with two central rows of pyrenoids. Such I have considered it in "Some Sydney Desmids." As the curved *Closteria* grow in length an extra pyrenoid, or more than one, often forms towards the tip of the semi-cell.

Since writing the above a fine gathering has been obtained from a small pool at Canley Vale (110 N.H.S.)[1] in which *Cos. pseudoprotuberans* was in profusion. The endochrome was in excellent state for observation and presented a variety of conditions. Some cells had the chloroplasts plainly divided vertically, but the pyrenoid was single and central. In others again the pyrenoid, while single, was evidently dividing vertically, the centre from top to bottom being much more faint than the sides, and the shape somewhat produced laterally. Other cells of this variety had indifferently one or two pyrenoids to the semi-cell, the number of cells with each being about equal. Here and there also one might be seen with a single pyrenoid in one semi-cell and two in the other. It seems certain, then, that my suspicion was well founded, for I am *certain* that *Cos. pseudoprotuberans*, Kirchn., is the penultimate subspecies (or variation) of *Cos. rectangulare*, Grun., which always has binate pyrenoids. It is evident also that the number of pyrenoids has no value at all as an indication of specific identity or for purposes of classification. The pyrenoids double in every species at latest in the penultimate form, and *no Cosmarium can therefore be called mature which has not geminate pyrenoids to the semi-cell.*

ENDOCHROME.—As the cell develops, so do the chloroplasts. The single flat axillary chloroplast found in *Gonatozygon* and certain *Closteria* does not always remain flat. A longitudinal ruck forms down the centre on each side and it becomes an axillary four-rayed chloroplast. I have observed this arrangement in *Gon. monotænium* var. Brébissonii, rolling the cell over several times to make sure. Much the same development is found in *Cl. Leibleinii*. In the same gathering I have noted specimens with a simple axile lamina, also with four and with six longitudinal plications. The third and fourth are formed as longitudinal plications down the centre of the original lamina, and later they seem to give rise to the next pair. As the cell develops the number of ridges increases. The same is true of the parietal chloroplasts of *Docidium* (including *Pleurotænium*). In the smaller forms of *Doc. trabecula*, for example, such as var. *Ehrenbergii*, there are only four chloroplasts;

1 Samples deposited in the National Herbarium, Sydney.

in var. *Delpontei* (the stouter *Ehrenbergii*) there are six; and in forms of *trabecula* itself eight or ten. In *Cl. rostratum* also, and its var. *Kutzingii*, the chloroplast is generally simple, or at any rate the ridges are not very marked. I have observed, however, a mixed form of these two, showing plainly six well-defined ridges. In *Cosmarium* the chloroplasts divide vertically, prior to the division of the pyrenoid into two.

MEMBRANE.—Too much weight must not be placed upon the character of the membrane as an indication of specific distinctness or specific identity. All the cell-membranes are smooth and colourless to start with. *Cl. decorum* var. *Delpontei*, for example, is strongly rufescent and decidedly striate, but I have observed well-grown forms almost colourless but still striate, and young forms rufescent, but without striæ. In gathering 53 N.H.S. also I noted a fine specimen of this species 516μ long, perfectly colourless except towards the tips, which were slightly yellow, nor could a trace of striæ be detected upon the membrane. In slide 10 N.H.S. there may be seen specimens of *Cl. turgidum* also, quite colourless and with striæ hardly visible, accompanied by its var. *Pritchardianum* in the same condition and much resembling *Cl. acerosum*.

Again, the fineness or coarseness of the striolation is no criterion. Some species do indeed show finer striæ than others as a regular thing, but it does not follow that a form with costæ is therefore no connection. I have observed *Cl. turgidum* with one semi-cell costate, the other normal; also its var. *Pritchardianum* with a costate portion at each end, the central growth being striolate. The costæ of such cells is hardly an irregularity, it is a definite alternative method of growth; the normal striolation forms later, as I have myself noted, by one or more striæ developing *between the costæ*, the general striolation becoming regular.

Further, the punctulation or scrobiculation of the membrane proves nothing. *Doc. trabecula*, for instance, has been found with a faintly-scrobiculate, puncta-scrobiculate, strongly-scrobiculate, granulate, and even incrassate-reticulate membrane (*Jour. Linn. Soc. N.S.W.*, 1910, Pl. ii, f. 21). I have observed also a cell with a strongly-scrobiculate patch on one side, the remainder being only faintly-scrobiculate. *Truncatum* and *Ehrenbergii* may be found with all these different membranes (cf. Pl. i, f. 3), the latter even spinous with incrassation (*Pl. Hutchinsonii* (Turn.), W. & G. S. West, *Monog*. Pl. 31, f. 7). Almost all *Cosmaria* are at least punctate when closely examined, and the punctulation or scrobiculation generally becomes more obvious in their more fully-developed forms or older condition. This accentuation is merely the result of incrassation. In very degenerate forms again puncta spots or scrobiculæ often take the place of the puncta-granules that afterwards appear. Lately I noticed a cell of *Cos. biretum* perfectly smooth outwardly (slide 3b also), the granules being replaced by scrobiculations within. Also an unequal cell of *Cos. magnificum* was observed, one semi-cell normal, but in the other and growing semi-cell the granules were represented by distinct scrobiculæ (apparently lacunæ). It is evident, therefore, that scrobiculæ are interchangeable even with the larger granules.

Not only so, but a form which has a perfectly smooth membrane may develope into one with rows of puncta-granules. Such is *St. retusum*, Turn., which develops into *St. retusum* var. *punctulatum*, Eich. and Gutw. (var. *granulatum*, Borge). Doubt has been expressed with regard to this, but as I observed the two forms together many years ago at Collector, and have lately obtained them again from Fairfield, and carefully examined *St. retusum*, I am in a position to confirm Turner's observation.

I desire to make it quite plain that there is no stagnation of life in the Desmidiaceæ; everything develops—the cell, the chloroplasts, the membrane.

PLANKTON FORMS.—Whilst stagnant water and increased temperature promote cell-division, cooler conditions, rain, or a gentle current of water encourage the development of the cell itself. The truth of the latter statement becomes quite clear with the observation of forms which have fallen under plankton conditions. Such soon discover latent powers of expansion and ability to proceed to further developments. I do not remember ever to have found *St. orbiculare* var. *germinosum* (a plankton form from the Sydney Water Supply) except under these conditions. As for a free-swimming life, its tendency is to cause great exaggeration of any characteristic feature of outline. Slender forms such as *Cl. gracile* and *Cl. acutum*, as also *Synedra acus* among the Diatomaceæ, are drawn out to an immense length, and that, too, without corresponding increase in breadth; the rays of *Staurastrum* are more produced and often more divergent in front view, denticulations, spines, verrucæ are accentuated, and in the simpler forms spines and processes are often developed, especially at the angles. *Micr. Thomasiana* var. *pulcherrima*, G. S. West, *Algæ Yan Yean*, Pl. 4, f. 1, and *Eu. quadratum* var. *perornatum*, Playf., *ante* 1908, Pl. xii, f. 1, serve to show how plankton conditions tend to bring out every spine and process and verruca of which a cell is capable and to produce them to an unusual length.[1] In speaking of tqese variations as plankton forms, I do not mean that they are separate permanent varieties evolved in the course of ages through remote ancestors having adopted a free-swimming existence, and which are now proper to the plankton. They are simply growth variations produced in ordinary forms by being washed down into a stream or lake and forced to develope under plankton conditions. There is no such thing as a plankton *species* of Desmid.

I have consistently used in this paper the word development rather than growth, because the latter might be taken to mean (1) increase in size *only*, whereas among the Desmids increase in size always means transition into a new shape *as well*; or (2)

1 Cf. W. & G. S. West in *Trans. Roy. Soc. Edin.*, Vol. XLI., part iii, 1905, Pl. VI., figs. 1, 2, 21 and Pl. VII., figs. 8. 9, 13, 14, 22, for excellent illustrations of this.

increase in size *in all directions at once*, a thing that only takes place in the early stages of cell-division. Desmids *do* grow, and in growing they develope from one form to another; it is entirely erroneous to regard each form as fully developed and unchangeable. But increase in size takes place according to certain definite rules; every species indeed has peculiarities of its own, but the general rule applicable to all is that increase in size takes place alternately in length and breadth.

GRANULES, ETC.—Granules, verrucæ, teeth, spines and processes are simply rucks in the cell membrane produced by obscure forces proceeding from the cytioplasm.. Their growth would appear to be always connected with the chloroplasts, and sometimes with an angle or ridge in the chloroplast. In *Docidium*, where the chloroplasts are bent suddenly round at the apex, rugæ, teeth or even elaborate tubercles make their appearance exactly opposite these angles; and very probably the variation in the number of tubercles in the forms of *Doc. coronulatum* is due to some difference in the size or shape of the chloroplasts at this point. A most striking case is *Cos. magnificum*. This Desmid is covered with abruptly truncate verrucæ, which viewed from above are seen to be circular, with three granules in a triangle on each. Moreover, occasionally these verrucæ grow out into decided teeth (? *Cos. denticulatum*, Borge). It is not surprising therefore to find when the cytioplasm has been shrunk with preservative that a separate filament projects into each verruca. *Cos. Askenasyi*, Schm., has its endochrome even more cut up into fibrils on the outer side, and though it seems to have been originally smooth, yet it is obvious that verrucæ are making their appearance.

Again, in those *Staurastra* which have a circle of processes at the apex, these processes are always arranged above the six radiating plates of the chloroplast and correspond in number to them; and if there are processes down the angles they are almost always in pairs over the two chloroplasts. In *Xan. bifurcatum*, Borge, and *Xan. gloriosum*, G. S. West (*X. pulcherrimum*, Playf.) there are six ridges in the chloroplast which correspond to the six apical processes, and the lateral processes are also on the lines of these ridges. Somewhat the same state of things is to be found in *Euastrum* in *Eu. dideltoides*, Rac., at any rate the chloroplast exhibits six longitudinal plications, connected, one with each side of the semi-cell and the other four with the lateral pairs of inflations. The lateral basal inflations, which are the most pronounced in this species, lie directly over the sudden bend in these last, where they twist round towards the centre of the isthmus. The rule seems to be that inflations, processes, spines, teeth, granules, etc., follow the ridges of the chloroplasts and have some direct connection with them. It seems probable that even the puncta-granules may be the outcome of some invisible differentiation on the surface of the chloroplast.

The growth of spines on the zygospore has already been noticed; they grow in the same manner on the cell. Spines, processes, etc., often originate as puncta-spots in the membrane, cf. Ralfs., xxi, f. 5i, where at the tip of the angles a faint spot is delineated, an indication of the process afterwards found in *St. orbiculare* var. *germinosum*, and of the tooth in var. *denticulatum*, Nord. (the senile form of *orbiculare*, cf. Nord. Cent. Braz., T. iv, f. 42). The puncta-spots develop into puncta-granules, or denticulations form, which grow out generally into a thin spicule, often becoming bifid before expanding into a simple smooth bifid process. This spinous growth occurs in *Xan. hastiferum*, Turn., in the four apical spines most markedly. Entirely wanting in *β inevolutum*, Nord., Frw. Alg. N.Z., Pl. iv, f. 24, they have grown into minute spicules in forma *typica* (Turner, *Alg. E. Ind.*, t. xii, f. 25) and are seen full grown in var. *javanicum* (Nord.). Turn., l.c., T. xii, f. 23. I have found all these forms associated together in this country.

Much the same process takes place in *St. patens*, Turn., in the growth of the apical processes. First, a faint pustule or granule (l.c., 1907, Pl. v, f. 9), then a triangular tooth (var. *planctonicum*, G. S. West, *Alg. Yan Yean*, Pl. 6, f. 14), next the tooth grows into a stout spine (author's MS. figure) and the spine becomes a smooth bifid process (l.c. 1908, Pl. xiii, p. 11-12). The outer two of the four processes in fig. 11 can be *seen* to be developing out of a spine—the original point of the spine being bent outwards as the other angle of the process forms.

Similar development is found in *St. sexangulare*, Bulnh. The young forms have only *one* set of rays to the semi-cell, the rays moreover to start with being almost smooth (var. *stellinum*, Turn., l.c., 1907, Pl. v, f. 11). The denticulations on the rays form first, the rays getting stouter and shorter, var. *platycerum*, Josh., l.c., 1910, Pl. ii, f. 9. At the base of each ray a broad triangular tooth then forms and grows first into a stout spine (var. *dentatum*, l.c., Pl. ii, f. 10) and then into a smooth bifid process (var. *gemmescens*, l.c., Pl. ii, f. 11). The latter lengthens, and denticulations gradually form (var. *subglabrum*, W. & G. S. West, l.c., Pl. ii, f. 12), the ends of the processes becoming 3 or 4-fid by growth of one or two extra spines (cf. var. *asperum*, l.c., Pl. ii, p. 13). Pl. ii, f. 10a shows an alternative mode of changing from spine to bifid process. A denticulation forms on each side of the spine; these grow outwards into aculei, the original point falls in and is drawn out flat.

Attention has already been directed to the growth of processes in *St. orbiculare* f. *major*; its var. *muticum* f. *minor* is also the basis of a series of forms caused by the gradual development of similar processes. This series includes all those forms hitherto grouped under *St. monticulosum*, Bréb.; *St. submonticulosum*, Roy and Bisset; *St. forficulatum*, Lund.; and *St. aggeratum*, Playf. The cell is first quite smooth, then faint denticulations form (var. *granulosum*, l.c., 1910, Pl. ii, f. 16), showing in vertical view as faint granules. These develope into small triangular teeth in var. *aggeratum*, Playf. (l.c., 1907, Pl. iv, f. 21), and next into spines (var.

aculeatum, l.c., 1910, Pl. ii, f. 17), and then by degrees into smooth bifid processes (var. *bifarium*, Pl. ii, f. 18), which grow out to a definite length, var. *Tohopekaligense* (Wolle) *mihi* (cf. W. & G. S. West, Frw. Alg. Ceylon, Pl. 21, f. 27). In all the specimens I have seen, and these forms are fairly general round Sydney, the lateral processes grow out one corner at a time (the general rule indeed with all processes). First a delicate spine shows alone, then a denticulation forms a little above and pushes out, carrying the intervening membrane with it, thus forming a bifid process. Later on a couple more spines often grow out from the angle between the first two ; this is quite the general thing in *Staurastrum*.

I cannot see why there should be any difficulty in accepting the growth of spines on the cell, seeing that it is well understood that much more elaborate ones develop by a regular process on the zygospore.

Absorption.—Not only do granules and spines develop, but they are occasionally absorbed again. A good example of this is *Xan. simplicius*, Nord. In var. *botanicum*, Playf. (l.c., 1908, Pl. xi, f. 10, p. 620), which is a young form, there is a long spine at each angle. As the cell matures, however, the body of the semi-cell grows outwards, absorbing part of the spines, and a second spine forms, first at the upper and later also at the lower angles. In the young form the spines are about 9μ long, in the type only half that length. Again, in *Staurastrum* the granulation in young forms is very often coarser (the granules larger, fewer and more distinct) than in the more fully developed state. This occurs in *St. punctulatum* and *St. hexacerum* sometimes ; the granules are probably partly absorbed and fresh intermediate ones formed. The same process has already been mentioned with regard to the striolation of *Closterium*, partial absorption of costæ taking place, with simultaneous formation of intermediate striæ. It should be remembered that spines and processes are hollow, even those most delicate spicules that sometimes adorn the apex of the verrucæ in *St. assurgens* and *Cos. subspeciosum*, and that they are in vital connection with the contents of the cell, even up to the very tip, by means of a minute thread of homogeneous protoplasm. The same is true of the setaceous rostra of certain *Closteria*. W. & G. S. West have indeed described the processes of *St. Freemanii* (*Frw. Alg. Ceylon*, p. 177) as being solid, but this apparent solidity I have reason to believe to be an optical illusion. It is another instance of the *appearance* of incrassation already remarked on. The illusion is caused by the hollow process being filled with homogeneous protoplasm of a highly refractive nature Every granule, tooth, spine, and process, however small or however elaborate, is a hollow prolongation of the cell-wall.

American workers in this field have the opportunity of a very interesting investigation into the polymorphism of a species and the growth of spines and development of the cell in the life-history of *Xan. tetracentrotum*, Wolle. Compare Cushman, *Rhodora*, Vol. 7, No. 84, 1905. On Pl. 64, figs. 8, 9, 10 show plainly the development of *Xan. tetracentrotum* (fig. 8) into fig. 9, and thence into *Xan. Bengalicum*, Turn., f. 10. With these figures cf. Lagerheim, "Amer. Desm.," figs. 18, 19, 20, 24, which all belong to the same species. Fig. 18, *Ar. incrassatus*, Lag., is *Xan. tetracentrotum*, Wolle, and fig. 24 is the same with two other pairs of spines developing. When this form is grown, what difference will there be between it and *Xan. hastiferum* var. *Javanicum* (Nord.), Turn.? Note also W. & G. S. West, *North Amer. Desm.*, Pl. 15, f. 24.

LIFE-HISTORIES.—The investigation of the life-histories of the Desmidiaceæ is urgently needed. Turner as long ago as 1885 in "Some New and Rare Desmids," observed that "the life-histories of all but a very small number are yet unknown, the latter remark applying to very common forms." This is well within the mark even to-day; it would be interesting to know the names of "the very small number." As a matter of fact not a single life-history has yet been elucidated. It will not be supposed, of course, that the life-history of a Desmid species is of precisely similar nature to that, say, of one of the higher cryptogamic species. In its progress to maturity every specimen of the latter passes through the same well-defined series of stages. But the Desmid is the sport of the conflicting forces of cell-division and cell-development, and its life-history is the outcome of the resultant of these forces in any particular locality. In other habitats the balance of these forces is different; the life-history, therefore, varies, and other forms of the species result. The life-history of a Desmid species, then, is the history of the degeneration and development of an *ideal* cell which is supposed to pass through all the stages (polymorphic forms) which are comprised within the species, arranged in proper biological sequence as far as it can be ascertained. The cell must be an ideal one, as owing to the peculiarities of Desmid life and the exigences of microscopical examination it is impossible to trace the process in any single individual. The biological sequence, however, is correct, and the life-history (or histories, for there are generally many alternative lines) a real one, although compounded from many individuals.

It is hardly necessary to make any remarks about the maturity or immaturity of specimens. As soon as it is recognised that fully 90 per cent. of the forms one meets with either in nature or in print are growth forms of the other ten, it must be abundantly evident that, though a semi-cell may be termed mature when it resembles its mate, the Desmid-cell itself is not entitled to be called so until it has acquired its fully-developed form.

BIOLOGICAL OR SCIAGRAPHICAL.—In the preceding paragraphs I have in most cases used the word "sub-species" in the sense in which I suppose it is generally used. Under a system of classification by outline the only meaning it can properly have is, it seems to me, "a distinctly new shape manifesting itself among the forms comprising a species, which it is convenient to use as a *sub-heading* because of the number of variations directly connected with it. Having lately found it necessary, in order to name two simple forms of *Doc. coronulatum*, Grun., to make out a complete sciagraphical synopsis of all its variations, I append the result. It will serve to show the lengths to which a true Desmid species runs, to indicate my conception of a sub-species when classification goes by outline, and to point the urgent need that exists for critical revision. The simple fact of all these forms having the same ring of tubercles at the apex is of itself amply sufficient to warrant their inclusion in one species. In this genus the species are broadly defined, the characteristics of each are simple and evident, while the variations are multifarious, run the whole gamut of certain approprate shapes, and admit even *the suppression of one or more of the typical elements*. In *Doc. coronulatum* the tubercles, in *Doc. Ehr.-trab.-coronatum* the apical granules (or rugæ), in *Doc. nodosum* (incl. *D. constrictum*) the verticils of inflations, in *D. verrucosum* the reticulate scrobiculations—*these* are the fundamental points characteristic of the species. The same class of polymorphic forms may be found in every species, viz., inflated, stout, medium, narrow semi-cells and those with undulate sides, and there may be every possible combination of length and breadth within the limits, but none of these indicate any fundamental specific difference. The same is true of *Closterium*.

Every Desmid species holds a certain number of distinct *possibilities* as regards form, length, breadth and ornamentation, and it is the immense number and variety of the combinations that can be made out of these that is the cause of the vast bulk of the species and the intricate character of its life-history—the connection, that is, of its innumerable polymorphic forms.

Sciagraphical synopsis of the species *Doc. coronulatum* (Grun.) Lund. :—

(1). Cells tumid, no basal inflation—

Doc. coronulatum Grun., Insel Banka, 1865, T. II, f. 20.

var. *Willei mihi.*, *Pl. coron.* var. *Caldense* Wille, *Sydam.*, 1884, T. I, f. 43.

var. *ligatum* (W. & G. S. West), *Frw. Alg. Madag.*, 1894, Plate V, f. 42.

var. *regale* (Turn.), *Doc. regale* Turn., l.c. T. III, f. 6.

var. *Bengalense* (Turn.), *D. Bengalense* Turn., l.c. T. III, f. 4.

var. *firmum* (W. & G. S. West), *Frw. Alg. Madag.*, 1894, Pl. V, f. 41.

(2). Sides undulate. Subspecies *alternans*.

var. *alternans* (Nord.), *Desm. Braz.* Cehn. 1869, T. III, f. 36.

var. *Caldense* (Nord.), *Alg. Braz.* 1877, T. II, f. 2.

(Syn. *D. salebrosum* Turn., l.c. 1892, T. II, f. 12)

(Syn. *D. conjunctum* Turn., l.c. T. IV, f. 6)

var. *granulatum* (Borge), *Alg. Regnell.*, 1903, T. II, f. 4.

var. *subalternans* (Borge), Trop. u. subtrop., 1899, T. I, f. 12.

(3). Base inflated, sides straight. Subspecies *maculatum*.

var. *maculatum* (Turn.), l.c. 1892, T. IV, f. 3. Apex inflated.
 (Syn. *D. robustum* Turn., T. II, f. 8)
 (Syn. *D. elatum* Turn., T. II, f. 16)
 (Syn. *D. coron.* Grun., Josh., Burm., 1886, Pl. 25, f.16,17)
var. *Wallichianum* (Turn.), T. III, f. 2. Apex half formed.
var. *cristatum* (Turn.), T. IV, f. 7. More slender, apex square.
 (Syn. *D. orientale* Turn., T. IV, f. 1)
 (Syn. *Pl. moniliferum* W. & G. S. West, *Alg. Mad.*, 1894, Pl. V, f. 32)
 (Syn. *D. sub-coronulatum* Turn., l.c. T. III, f. 1)
 (Syn. *D. cylindricum* Turn., l.c. T. II, f. 11)
var. *detum* (W. & G. S. West), *N. Amer. Desm.*, 1895, Pl. XIII, f. 2, 3.

Subspecies *eugeneum*.

(4). Rugæ only at apex, within the margin, or not yet formed.

var. *eugeneum* (Turn.), l.c. 1892, T. III, f. 3.
var. *gloriosum* (Turn.). l.c. T. III, f. 5.
var. *parallelum* (W. & G. S. West), *Alg. Madag.*, 1894, Pl. V, f. 34.
var. *indicum* Turn. (non Grun.), T. IV, f. 8.

Immediately, however, an attempt is made to work out the life-history of a species it becomes clear that in some genera there are distinct *biological* subspecies entirely at variance with the usual sciagraphical ones, the latter being merely artificial, while the former are natural. *Doc. coronulatum* would have furnished an excellent object lesson in these. Unfortunately, though the species occurs here, it is not common enough for me to have made any observations on its life-history. I will therefore endeavour to show these biological subspecies in the chart of a common and well-known species—*Doc. trabecula*—in which, luckily, they are very plainly shown, and whose various forms I have pretty thoroughly investigated.

Biological chart of the species *Doc. trabecula* :—

Diam. 60-85 u.
v. *truncatum major* =v. *nodulosum*=v. *coronatum*
↑
v. *maximum* (Reinsch)
↑
v. *Archerii* (Delponte)
↑
Diam. 40-60 u.
v. *truncatum minor*=*trabecula*=*trab.* v. *crenulatum* (R. & B.)
↑
v. *Delpontei mihi*
↑
v. *constrictum mihi*
↑
Diam. 10-40 u.
v. *baculum*=v. *baculoides*=v. *Ehrenbergii*=v. *indicum* (Grun.).

The first, fourth and seventh lines show the normal life-history of the *biological* subspecies *coronatum*, *trabecula* and *Ehrenbergii* respectively, the youngest forms on the left. The sign = denotes connection by growth and development, principally in length. The vertical lines show the points at which and the intermediate forms through which ascent takes place from one subspecies to another.

From this chart it will be seen that *truncatum*, *maximum*, *Archerii*, *baculoides* are not species but merely *shapes*, which occur and recur at various stages of the development of one Desmid. At three different points we meet with the same trio of shapes closely connected in life and growth :—1. *Baculum*, a strongly constricted form, drawn in above the constriction and more or less inflated. 2. *Baculoides*, a severely cylindrical form with decided basal inflation. 3. *Ehrenbergii*, a cylindrical form with the secondary basal undulations more in evidence. These three are represented again higher up, by var. *constrictum mihi*, var. *Delpontei mihi*, and var. *Ehrenbergii* f. *elongata*. And again with still larger diameter in var. *phædodermum* Schaar. (or var. *Georgicum* Lagerh.), var. *maximum* Reinsch., and var. *Archerii* Delp.

9.—A CONTRIBUTION TO THE STUDY OF THE PRECIPITINS.

By Dr. H. G. CHAPMAN.

THE application of the precipitin reaction to the elucidation of the blood relationship of the species of the animal kingdom has shown that the test may be used to determine such relationships as are established by morphological study.

The use of the test has now been extended to the vegetable kingdom, and the preliminary investigations recorded in this paper show that the test may be employed in the vegetable kingdom to determine the relationship of plant species. The method should be of value, as it is not easy to determine the degree of relationship of different plants by morphological means.

Experiments on the nature of the reaction are also recorded. The application of the test to the diagnosis of hydatid disease, as carried out by the author in conjunction with Professor Welsh, is also mentioned.

It has been found that a precipitate or deposit is frequently formed when the serum of a person containing a hydatid cyst is mixed with fluid from a hydatid cyst. Whenever such a deposit is produced a cyst is present in the person. No precipitates or deposits are formed when the serum from a healthy person is mixed with hydatid fluid. The test has been found of much value in some cases in which a diagnosis could not be made by other means.

10.—A CASE OF INJURY AND REPAIR IN THE CUTICLE OF A NEMATODE.

By J. BURTON CLELAND, M.D., Ch.M., and T. HARVEY JOHNSTON, M.A., D.Sc.,
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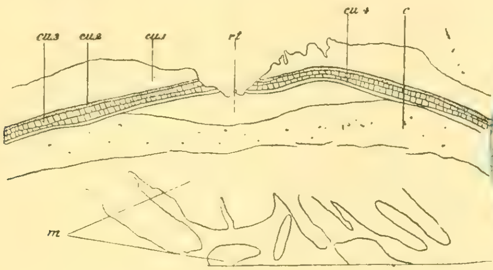
A PATHOLOGICAL process may be defined as the reaction which follows an injury with the object of limiting its extent or of repairing the tissue. Our knowledge of pathological processes is almost entirely confined to vertebrates. An instance of such a process in the nematode worm, *Ascaris suilla*, of the pig, has therefore seemed to us worthy of record. In this case the essential process at work was reparative in the sense of compensation for a breach of the cuticle; in other words, we consider it to be of the same nature as an inflammatory reaction in a vertebrate.



Amongst a number of specimens of *Ascaris suilla* obtained from pigs in the Sydney district in whose intestines *Gigantorhynchus gigas* was also present in considerable numbers, were various specimens showing small crateriform projections little bigger than a pin's head, scattered irregularly over the cuticle. The number of these projections would vary on an individual from several to 15 or 20, or even more. Each showed itself as a slightly raised ring with a central depression, the appearance, in fact, suggesting that some parasite might have attached itself at the centre forming the small depression, while the reaction to this irritation produced the slightly raised ring around. It naturally occurred to us that possibly the injuries might have been inflicted by the Echinorhynchs also present in the intestine. Unless the condition was due to microbial agency it seems hard otherwise to account for it.

The microscopical appearances presented are also interesting. In the healthy part of the cuticle away from the lesion the following layers may be noticed in a cross section of the worm in passing from without, inwards :—

1. *Cuticle and Epidermis.*
   - (*a*) A thick outermost layer of the cuticle showing no structural details and forming a projecting layer externally, slightly raised into ridges.
   - (*b*) A narrow layer rather more deeply stained than (*a*).

(*c*) Another layer much broader than (*b*) showing a recticulate or areolar appearance.

(*d*) A sharply contoured narrow band resembling a basement membrane.

2. *Cutis.* Showing an undifferentiated mass of protoplasm of considerable thickness, with scattered nuclei.

3. *Muscular layer.* More or less differentiated.

At the injured spot we found that the following alterations have taken place in the cuticle and in the cutis. In the centre of the ulcer all the layers which we have mentioned as belonging to the cuticle and epidermis are deficient. Passing towards the edge, the basement membrane-like layer is first met with, and then the other layers in regular order, all presenting a more or less irregular jagged appearance. There is no evidence of repair on the part of any of these layers. From the cutis, however, a very decided reaction has taken place, consisting in the separation of a definite part of the cutis which is shut off from the rest of the cutis by a well-defined line, although structurally it does not differ in appearance from the cutis proper, excepting that nuclei were not detected in it. This area in the centre of the ulcer forms a deep layer which extends laterally on each side, thinning out rapidly from within outwards so that it forms a kind of lens-shaped area occupying in the depths of the tissue an area about equal in extent to the size of the ulcer on the surface. Our interpretation of these appearances is as follows :—

At the site of the ulcer an injury had been inflicted upon the worm, and had extended down as far as the cutis. The loss of tissue affected chiefly the cuticle in the form of a crateriform depression. There has been no reaction on the part of the cuticle to repair the damage thus done. As regards the outer layers of the cuticle this is what might have been expected, as living cells could not be expected to be present in them to repair the damage. In the deepest layers of the epidermis, however, where living cells would be present at least in young individuals, some repair might have been expected. In the outermost layers of the cutis, however, there has been a very definite multiplication of the tissue, due presumably to the activity of the cells scattered throughout it. This activity has resulted in the production of a button-like area which has been separated off from the rest of the cutis, and tends as it were to plug the defect in the cuticle above and thus compensate for the weakening in the wall of the worm.

TEXT FIGURE I.

Section through an "ulcer."

c., Cutis with scattered nuclei ; cu. 1, cu. 2, cu. 3, cu. 4, various layers of the cuticle ; *m.*, musculature of the body wall ; *r.t.*, "repair tissue" below the point of injury.

11.—THE HELMINTH PARASITES OF MAN IN AUSTRALIA.

By T. HARVEY JOHNSTON, M.A., D.Sc., *and* J. BURTON CLELAND, M.D., Ch.M.
(From the Government Bureau of Microbiology, Sydney, New South Wales.)

In this note we endeavour to bring together the various references to the occurrence of the different helminths recorded from human beings in Australia. Though a goodly number have been identified, yet most of them are rare, while only a few are common. The main exceptions are the hydatid (the larval form of *Tænia echinococcus* v. Sieb. or, more correctly, *Echinococcus granulosus* Gmel.), *Oxyuris*, *Ankylostoma*, and *Filaria bancrofti*.

Hydatids are very frequently met with in man in every part of the Commonwealth. They are of such economic importance that we are reserving until a later date a survey of the literature referring to them. *Ankylostoma duodenale* Dubini, (—according to strict zoological nomenclature, perhaps more correctly known as *Agchylostoma duodenale*), the "hookworm," is restricted to the coastal districts of Queensland, where it is not uncommon. *Filaria bancrofti*, Cobbold, more usually known under the name of its larva, *Filaria* (*Microfilaria*) *nocturna* or *F. sanguinis hominis*, is now quite common in Queensland, and is also found, though much less frequently, in some of the other Australian States. *Oxyuris vermicularis* is here, as elsewhere, quite a common parasite of children. There have appeared recently some papers in which the majority of the references quoted below have been collected. The first was published by Dr. G. Sweet[1], followed very closely by another from one of us[2]. In addition to these two articles, more or less complete lists of our known endoparasites of man have also appeared[3], but these do not contain any references to literature, though a number of new records are established in them. However, all the abovementioned papers refer to the zoological side of the matter.

The helminth parasites of man, as far as Australia is concerned, belong exclusively to the Trematoda, Cestoda and Nematoda.

Trematoda.—We may safely say that trematodes are practically absent in Australians. Three parasites belonging to this class have been recorded :—

1. FASCIOLA *hepatica*, Abildg, the common "liver fluke," found in sheep and cattle, has been found in man by Allen (Trans. Intercol. Med. Congr. Austr. II. 1899, p. 1004) on three occasions in five years in the Melbourne Hospital, seven worms being obtained in one case, and one in each of the others, abscesses being present in the liver of each patient. In addition to this reference there is another in the Austr. Med. Journ., IX., 1864, p. 29, where a letter from a Mr. Crawford of Swan Hill, Victoria, to a newspaper is quoted. In this letter he stated that the blacks of the Lower

(1) Sweet, *Proc. Roy. Soc. Vict.* XXI. (n.s.), 1908 (1909), p. 454 sqq.
(2) Johnston, *Rec. Austr. Museum*, VII., 1909, p. 329 sqq.
(3) Johnston, *Agric. Gaz. N.S. Wales*, XX., 1909, p. 581 sqq.
Austr. Med. Gaz., Sept., 1909, p. 479-481.
Ann. Rep. Bur. Microbiology, N.S. Wales, 1909 (1910), pp. 75-6.

Murray River were being exterminated by the flukeworm and tapeworm of the sheep. In the light of present knowledge of parasitology we think it advisable to disregard this latter reference entirely.

2. *Clonorchis sinensis* Cobbold, more commonly known as *Distomum sinense* or *Opisthorchis sinensis*, the Chinese fluke, has been found in Sydney and in Victoria in Chinamen, no cases being reported from Australians (Austr. Med. Jour., XVIII., 1873, p. 85 (Victoria); Jamieson, A.M.G., XVI., 1897, pp. 71, 147 (Sydney); Corlette, A. Med. Gaz., XVI., 1897, p. 146, 195 (Sydney).

3. *Schistosomum* (*Bilharzia*) *hæmatobium*, Bilharz. Several cases have been found in the Commonwealth, but in every instance the parasites had gained an entrance in South Africa. On the return of our troops from the South African War many were found to have become infected. The helminth appears to be able to live for many years, as we have quite recently found the ova in the urine of men who have been in Australia for a number of years since their stay in South Africa. The earliest record is that by Poulton (Austr. Med. Gaz. 1892, p. 347), the next being that by Seabrooke (A.M.G., 1893, p. 194), both of these being found in Adelaide in individuals who had resided in South Africa. Then follow a number of references mainly as a result of the return of infected soldiers (Hinder, A.M.G., XXIII., 1904, p. 511—Sydney; Stacy, A.M.G., XXV., 1906, pp. 350, 397—Sydney; Johnston, Proc. Linn. Soc., N.S. Wales, XXXIV., 1909, p. 118, and A.M.G., 1909, p. 480—Sydney;—Morton A.M.G., 1909, p. 79—N.S.W.). Newmarch (A.M.G., XXVI., 1907, p. 336; Inter. Med. Jour. Austr., 1907, p. 466), recorded finding one ovum of this blood fluke in Newcastle, N.S. Wales, in the urine of a patient who had not been out of Australia for 23 years. We agree with Nash (A.M.G., XXVI., 1907, p. 419) in regarding the record as invalid, being based on a mistaken identification. Another case is referred to by Dr. Tidswell in the Ann. Rep. Bur. Microbiology, N.S.W., 1909 (1910), p. 90.

Cestoda.—1. As already mentioned, tapeworms are quite rare in human beings in Australia, and as far as we can find out all those which have been acquired locally belong to the species *Tænia saginata* G., also known as *T. mediocanellata*, Kchm., the larva of which is *Cysticercus bovis*, a bladder worm producing measly beef. We do not know of any instances of the larva having been found in Australia, this indicating its extreme rarity, as it would be reported if met with during meat inspection. Of course it is quite possible that the cysticercus occurs in some country localities, more especially dairying districts, by infection from introduced cases in man, and might here be overlooked. It is in these districts where man and the ox are closely associated, whereas in the pastoral districts where cattle are raised for the meat market there is practically no such association. The recorded cases are as follows:—

Johnson, Trans. Inter. Med. Congr. Austr., 1905, p. 380 (Adelaide); Johnston, Proc. Linn. Soc., N.S. Wales, XXXIV., 1909,

p. 118 (Sydney), *ibid*, XXXV., 1910, p. 28 (Queensland). Jour. Proc. Roy. Soc. N.S. Wales, 1909, p. XX. (West Austr.), A.M.G., 1909, p. 480 (N.S.W.). In addition to these definite records there are a few others where mention is made of tapeworms, some of them of very considerable length, taken from human beings. They no doubt belong to this species (Flynn, A.M.G., 1901, p. 496--Q'land).

2. *Tænia solium* Linn., the armed cestode, is practically unknown, the only definite record being that by Johnston (Proc. Linn. Soc. N.S. Wales, xxiv, 1909, p. 118, N.S.W.), but as no history could be obtained it is not improbable that the patient had become infested elsewhere. This suggestion is supported by the fact that the larval or cystic stage, *Cysticercus cellulosæ*, which lives in the pig, has only once been reported from the Commonwealth (Johnston, Proc. Linn. Soc. N.S. Wales, 1909, p. 118), and moreover there is doubt as to the correct locality of the specimen. There are two other references to this parasite in man (Iffla, A.M.G., Melbourne, 1869—Victoria, and Anonymous, N.S. Wales, Med. Gaz. V. 1874-5, p. 57—N.S.W.), but both of these are more likely to refer to *T. saginata*.

3. *Dibothriocephalus latus* L. has once been reported, but very little is known of the history of the case, which was without doubt an imported one (Johnston, Proc. Linn. Soc. N.S. Wales, xxxiv, 1909, p. 118—Sydney). The larva of this parasite is known to infest various European fish

4. *Dibothriocephalus parvus* Stephens. This form was obtained by Dr. Elkington from a Syrian in Launceston, Tasmania, and like the last mentioned *Bothriocephalid* is also an importation from elsewhere. This parasite was considered as a new species by Stephens (Ann. Trop. Med. Parasitol., Feb., 1908).

5. In addition to the four above mentioned adult species, two larval forms have been recorded, one of them, the hydatid (*Echinococcus veterinorum* Rud., *E. hominis*, Rud., *E. polymorphus* Dies, etc.), being already briefly referred to. As stated previously, its importance medically is sufficient justification for it to be considered separately in a future communication.

6. The other is a larval Bothriocephalid, regarded as being identical with that described by Cobbold and Leuckart, and known variously as *Sparganum* (*Bothriocephalus, Ligula*) *Mansoni* Cobbold, and *B. liguloides* Leuckt. We think that the form in question may be similar to the Ligula-like larvæ found locally in lizards, snakes and frogs. It is probable that they are not specifically identical with Cobbold's species, but larval Bothriocephalid worms offer few points of specific value. All of these evidently occur only accidentally as human parasites. The one case was reported from Bathurst district, N.S. Wales, by Spencer (Trans. Inter. Med. Congr. Austr. III, 1892, p. 433), and the other by MacCormick and

Hill (Trans. Inter. Med. Congr. Austr. VII, 1905, pp. 367-8) in a patient from Sydney. In Spencer's case the worms were associated with abdominal tumours. In the latter case the patient had never lived out of Sydney.

7. A reference in A.M.G. 1891, p. 361, to a cystic disease of the liver resembling hydatids reminds one of *Cysticercus tenuicollis*, the "water-ball" found in sheep, cattle, and pigs.

8. Watson (A.M.G. 1906, p. 645) exhibited a large number of larval cestodes to illustrate a paper by him on hydatids, but there is no reason for incorporating them as records for Australia.

Nematoda.—The greater number of helminth parasites of man belong to the Nematodes, or roundworms. There appear to be seven which have established themselves in the Commonwealth, viz., *Ascaris lumbricoides*, L. *Oxyuris vermicularis* L., *Trichocephalus trichiurus* L. (*T. dispar* Rud.), *Filaria bancrofti* Cobbold, *Strongyloides intestinalis* Bavay, *Agchylostoma duodenale* Dub., and *Necator americanus* Stiles. In addition to these, a few others have been met with, but the source of infection has been traced to be beyond Australia. These include *Filaria medinensis*, *F. loa*, and *Trichinella spiralis*. *Filaria demarquayi* has been doubtfully recorded from New Guinea natives.

1. The commonest in Australia is the small threadworm or pinworm, *Oxyuris vermicularis* L., which occurs in all States. As it does not usually cause much trouble its presence has been practically unrecorded. Cobb, in 1890 (Proc. Linn. Soc. N.S.W., V, 1890, p. 168), dealt with its life-history. In 1901 R. H. Russell (Inter. Med. Jour. Austr., VI. 1901, p. 576) referred to a persistent appendicular colic caused by threadworms (Melbourne). Johnston mentioned the presence of this species in the various States (Proc. Linn. Soc. N.S. Wales, XXXIV, 1909, p. 119—N.S. Wales; *ibid.* 1910, p. 28—Queensland-South Australia; Jour. Proc. Roy. Soc., N.S.W., 1909, p. xx—West Australia).

2. *Ascaris lumbricoides*, L.—This intestinal parasite is found occasionally in man throughout Australia, but since it rarely gives rise to pathological conditions references in literature to its presence in Australia are very scanty. Morphologically it closely resembles, if it is not identical with, the roundworm, *Ascaris suilla*, of the pig. It is possible that if these species are identical infections of man may occur not infrequently from the pig, as for instance by means of the ova adhering to a sausage-skin derived from pig, and the ova not being killed by the cooking. Both the parasites have a peculiar sweetish smell, which is very characteristic and enables the species to be identified even in the dark.

The first reference to the presence of this worm in Australia occurs in a work entitled "Two Years in New South Wales"

(2nd edit., I, 1827, p. 172), by Surgeon P. Cunningham. He mentions the presence of "teres" or roundworms in the children in the settlement at Port Jackson. In 1897 Robison (Inter. Med. Jour. Austr., II, 1897, p. 87) reported a case of "Apical Pneumonia and Cerebral Symptoms associated with Worms" in a child of 4 years in Sydney; 29 large roundworms were passed. In 1898 Springthorpe (Austr. Med. Gaz. 1898, p. 214) exhibited in Melbourne four roundworms which were passed dead during a typhoid fever attack, the patient giving a history of having vomited a roundworm 10 years before after a blow in the stomach. It would be interesting to know whether the death of these roundworms was due to the high temperature during the fever, to toxins produced by the typhoid bacilli, or to the altered condition of the intestinal contents. In the same year Lewers (Inter. Med. Jour. Austr., III, 1898, p. 534) reported the case of a Victorian girl of 17 years who had asthmatic-like attacks, and on the fifth night coughed or retched up a roundworm about 9 inches long. After this she felt great relief and had no further trouble. No more worms were passed, though suitable treatment was adopted.

In 1901 Flynn (Austr. Med. Gaz., 1901, p. 496) exhibited a roundworm from a Queensland patient, and in 1906 Ramsay (Austr. Med. Gaz., 1908, p. 468) showed a number vomited by a boy in Perth, West Australia, one being 9 inches long. Sweet (Proc. Roy. Soc. Vict., 1908, p. 515) mentioned its occurrence in Melbourne; while Johnston (l.c. 1909 and 1910) referred to its presence in the various States.

Belonging to the *Trichotrachelidæ* are *Trichinella spiralis* and *Trichocephalus trichiurus*.

3. *Trichinella spiralis* Owen, more commonly known as *Trichina spiralis*, has been found in a few instances, but the disease Trichiniasis may be said not to exist in man or animals at the present time in Australia. We have ourselves examined portions of the muscles of pigs in West Australia, and of the rats *Mus decumanus* and *Mus alexandrinus* in Sydney, and have failed to detect the presence of any of these parasites, though in both sets of animals Sarcosporidia were met with in the muscle fibres. It is true that the number of animals thus examined was small, but did the disease exist it is almost certain that instances of it in human beings would from time to time present themselves clinically. With one exception (in some pigs from Richmond, N.S.W., many years ago) the few cases that have occurred have owed their origin to localities outside Australia. The first Australian instance on record of the disease in man occurred at Hobart in 1870 (Austr. Med. Jour., XV, 1870, p. 318), when the captain, two mates, the cook, and a young lady passenger on a German vessel in that port were infected in consequence of eating ham forming part of the provisions. In 1871 (Austr. Med. Gaz., XVI, 1871, p. 224) it is said that some pigs in Richmond, N.S.W., were found largely

affected with the trichina. In 1898 Dr. Halford (Austr. Med. Gaz., 1898, p. 263) read a note on and exhibited before the Queensland Branch of the British Medical Association specimens of this parasite, distributed throughout the muscular substance of a patient that had been operated on for epithelioma on the floor of the mouth. In 1902 Professor Watson, Dr. Angas Johnson, and Mr. Veterinary-Surgeon Desmond (A.M.G., 1902, pp. 106, 120 and 415, and Trans. Inter. Med. Congr. Austr., 1905, pp. 370, 380, S. Australia) reported a case whose nature was discovered during an operation for malignant growth in the neck. The disease was traced to infected meat received from outside Australia. Braun ("Animal Parasites," Engl., transl. 1906, p. 319) mentions its occurrence in man in Australia.

4. *Trichocephalus trichiurus* L., better known as *T. dispar* Rud., a parasite infesting the human cæcum, has been recorded on a few occasions from Queensland and New South Wales, but not as yet from any of the other States. There is little doubt that it occurs in them also. Hogg (Austr. Med. Gaz., VIII., 1888-9, p. 133) reported it from Queensland at the same time as he made known for the first time the existence of the hookworm in Australia. Bacot (A.M.G., XI., 1892, p. 430) also found both of these worms present at a post-mortem at Cairns, North Queensland. Bancroft in 1893 (A.M.G., 1893, p. 258) mentioned that this helminth was common in Brisbane. Lawes (A.M.G., XIV., 1895, p. 446) found it in company with Ankylostoma in 1895 while performing a post-mortem in Brisbane Hospital on a boy who had come from the Tweed Heads, New South Wales. Other references were made by Mollison in 1898 (Trans. Intercol. Med. Congr., 1898, p. 417, Queensland and N.S. Wales), and by Johnston in 1909 and 1910 (l.c. 1909, 1910, Queensland and N.S. Wales).

5. *Strongyloides intestinalis* Bavay, also known as *Anguillula* or *Rhabdonema stercoralis*, was found in Queensland in 1896 by Ashworth (Austr. Med. Gaz., XV., 1896, p. 483), in company with *Ankylostoma*. He did not identify it definitely, but there is no doubt but that this is the species referred to. Turner (A.M.G., 1896, p. 484) refers to Ashworth's find, and remarked that the worms were neither *Oxyuris* nor *Ankylostoma*.

Belonging to the *Strongylidae* in its wide sense are the two hookworms *Agchylostoma duodenale* and *Necator americanus*, both reported from Queensland. Besides these *Eustrongylus gigas* is said to have been found. The last mentioned was recorded by Allan (A.M.G., XVI., 1897, p. 607) as being passed with the urine by an old man. This is evidently a case of mistaken identity, as a glance at his account will show. It was almost certainly not a worm at all.

6. *Agchylostoma duodenale* Dubini. Undoubtedly the three most important human parasites in Australia are the hydatid, the

filaria *F. bancrofti*, and the hookworm. The latter is more commonly known as *Ankylostoma duodenale*, though it is spelt in more than a dozen different ways, *Agchylostoma* being the first used. Some workers now use the term *Ankylostoma* as a popular name for the parasite, but retain the original spelling when referring to the worm under its scientific name. We all know of its ravages in some parts of the world. It is becoming very widespread along the coastal districts of Queensland, especially in the rural districts, where there is a lack of sanitary conveniences, and where the children, who are the main sufferers, go barefoot. With a single exception all the cases come from the Northern State.

As already mentioned, Hogg was the first to find the hookworm in Australia (A.M.G., VIII., 1888-9, pp. 60, 92, 133, and Brit. Med. Jour., 1889, p. 792), obtaining it at Goonda Lunatic Asylum, Queensland. It is quite possible that the anæmia referred to by Ahearne (A.M.G., 1890, p. 293), as being present in the inhabitants of Townsville, was the result of infection by Ankylostomes, which had not at that time been detected in that part of Queensland.

In 1892 we find that Bacot (A.M.G., 1892, p. 450) and Gibson (*Ibid.* 440) refer to cases, the former finding it in three children from Cairns, the latter detecting it in an adult from Maryborough. There is also a reference by Gibson and Turner to its occurrence in North Queensland in the Trans. Inter. Med. Congr. Austr. 1892, p. 134. In the next year Dr. T. L. Bancroft exhibited specimens (A.M,G. 1893, p. 258) before the Queensland Branch of the British Medical Association. In 1895 several references occur. Turner, Gibson, Love and Ashworth (A.M.G., 1895, p. 456) all refer to it, Turner mentioning its occurrence in children in Brisbane and North Queensland; Gibson referring to his finding it in an adult; Love to its presence in a child of four years of age, from whose fæces Ashworth stated that he had obtained two hundred ankylostomes after Love had employed thymol. In the same year Lawes (A.M.G., 1895, pp. 445-8) published notes on two cases in children, one coming from the Tweed Heads, just within the New South Wales border, the other from Brisbane. Turner refers to it again in the Proc. Roy. Soc. Queensland, XI., 1895, p. 99.

In 1896 this parasite is again dealt with by Ashworth (A.M.G., 1896, pp. 482-4) and Turner (A.M.G., 1896, p. 484; Trans. Inter. Med. Congr. Austr. 1896, p. 101; and Inter. Med. Jour. Austr. I., 1896, p. 65). Ashworth mentions that he treated a child of ten years of age with thymol and picked out 650 hookworms from the first two succeeding stools. In addition to the ankylostomes, the *Rhabdonema* referred to above was also present (p. 483-4). Turner referred to Ashworth's case, making remarks on the *Rhabdonema*.

In 1897 Hardie (A.M.G., 1897, p. 354) found the parasite in an adult in Cairns. In the next year O'Doherty (A.M.G., 1898, p. 47) in a presidential address referred to the hookworm, and some of the earlier records to its presence in Queensland.

In 1902 T. L. Bancroft (A.M.G., 1902, p. 66) called attention to Looss's discovery of infection by Ankylostoma through the skin, and stated that cases which had occurred in two families at Deception Bay could be explained in a similar way, viz., by foot-infection. He referred to the lack of sanitary conveniences and to the want of covering on the feet of the children.

There do not appear to be any further references until 1906, when Hamilton-Kenny (A.M.G., 1906, p. 399) furnished notes on an outbreak in Gympie, where five cases were treated. Conditions similar to those mentioned by Bancroft were found in this locality also.

In 1908 Macdonald (Lancet, 11th Jan., 1908) referred to the prevalence of and effects due to *A. duodenale* in Northern Queensland, while O'Brien (A.M.G., 1908, p. 122) mentioned that it was quite common in Cairns district, remarking at the same time that he believed the hookworm in Australia to be different to the Old World parasite, *A. duodenale*, and the American hookworm *Necator americanus*.

In 1909 a fairly comprehensive paper by Salter appeared in the Aust. Med. Gaz., 1909, p. 352-6, abstracted in Inter. Med. Jour. Austr., 1909, p. 423. In this he gives the number of cases treated in Brisbane Hospital between 1900 and 1909, and mentioned infected localities. He quotes many of the earlier cases and refers to work in Porto Rico and elsewhere, making special reference to Looss's discovery. He emphasises the danger of coming into contact with contaminated surface-soil. In the paper (p. 355) he makes mention of Bancroft's finding of *Necator americanus* in Queensland. In the same year Turner (A.M.G., 1909, p. 351) called attention to the wide distribution of ankylostoma along the Queensland coast as well as the northern rivers of New South Wales. The fact that the infected children are generally barefoot and belong to homes where sanitary conveniences are lacking strongly supports Looss's view of skin-infection. Halford, Gibson, P. Bancroft and Robertson (A.M.G., 1909, p. 391) all briefly refer to the occurrence of this parasite in the northern State. Other references include those of Johnston (*loc. cit.* 1909, 1910). A few records of *A. duodenale* and *Necator americanus* are re-published in Jour. Trop. Med. Hyg. XII., 1909, p. 348.

From a consideration of the above it will be seen that the infected district is very extensive, that the infection is confined mainly to children who live in rural districts, who go barefoot and whose homes do not possess sanitary conveniences. The evidence also still further proves the value of thymol in cases of ankylostomiasis, a fact already well known from the report of the Porto Rico Commission.

7. *Necator Americanus* Stiles. The American hookworm was identified by Sandwith and Leiper in some material sent by Dr. T.

L. Bancroft (Brit. Med. Jour., Oct., 1908, p. 1354) from Queensland, Salter (A.M.G., 1909, p. 355) mentioning the fact in his paper on Ankylostoma (*vide supra*).

Filaria.—Belonging to the Filariidæ are a number of human parasites, one of which *F. bancrofti* Cobbold is frequently met with. Certain others have been reported, but in these cases infection had taken place beyond Australia.

8. *Filaria bancrofti* Cobbold.—This interesting and important helminth is very frequently called *F.* (*Microfilaria*) *nocturna* Manson and *F. sanguinis hominis* Lewis. It has a very wide geographical range, but it is only its Australian distribution which concerns us here. An account of the earlier work and workers may be found in Cobbold's "Parasites, A treatise on the Entozoa of Man and Animals," 1879, p. 186, sqq., and p. 487. The earliest reference to the presence of these microfilariæ in Australia was in Cobbold's papers published in 1876 in the Brit. Med. Jour. of June, and the Veterinarian of July of that year. In these he confirmed Dr. J. Bancroft's finding of the embryos in specimens of blood from a case of chyluria in Queensland, which the latter had forwarded to him. Cobbold then questions Bancroft's discovery of the adult filaria in lymphatic abscesses and in hydroceles in December, 1876, publishing, (p. 186-7), a letter written from Brisbane in April, 1877, by the latter informing Cobbold of his find. In the Lancet (July, 1877, p. 70) the worm was named *F. bancrofti*, and further particulars were given on p. 495. In 1878 Bancroft recorded in the Trans. Pathol. Soc. London, XXIX., p. 407, a number of cases of filariasis. Then followed other papers by Cobbold, Manson and others in the Lancet and Jour. Linn. Soc. Lond., in which references were made to Bancroft's work. Then Cobbold published a letter from Bancroft in the *Lancet* of February, 1879. The latter published further information in the A.M.G., 1882, p. 170, and the A.M. Jour. IV., 1882, p. 361, and the Trans. Intercol. Med. Congr. Austr., 1889, p. 49.

Love (A.M.G., 1889, p. 135) mentioned that he found embryo filariæ in the blood of a girl suffering from chylous urine. In 1890 Turner (A.M.G., 1890, p. 65) dealt with two cases, the subjects being Brisbane boys. In one instance there were well marked lymph swellings in the groin, in the other chyluria was present. In 1892 Hogg (A.M.G., 1892, p. 416) met with a case of elephantiasis of both legs, filariæ being present in the blood.

In the same year, in an article on Leprosy in Queensland, Dr. Joseph Bancroft (A.M.G., 1892, p. 427) made some very interesting remarks on the cases of filariasis that he had encountered. He took charge of the Brisbane Hospital as Resident Surgeon in 1868, and in reviewing the cases of leprosy he had met with during his sojourn in Brisbane since that time he states that his attention was turned from the few cases of leprosy to cases in which large elastic tumours, mostly of the groin, were found, and also cases of chyluria. Filaria were found associated with both of these latter, and he became of opinion that both the leprosy and the filaria were associated diseases brought here by the Chinese, and distributed by mosquitoes. Numerous cases of filarial disease were found in the families of cottagers, who had wells, open water butts, and tanks, and in one instance there were four children suffering from filaria in one family. His researches led him to the more careful exclusion of mosquitoes from water tanks by gauze covers, and the disuse of wells, and he states that happily since the large water-works pipes were distributed so freely few young children were now found with manifestations of filarial diseases. He referred to his original paper published in the Pathological Society's Transac., 1878, vol. 29, p. 407, at which meeting he crossed swords with the President, Sir Erasmus Wilson, who called him to task for affirming that the term " Elephantiasis " should be used for the big leg disease only, and that " Elephantiasis græcorum " as applied to leprosy should be abandoned. On reading over the old case books of the Brisbane Hospital he became convinced that amongst its records there were cases of leprosy and possibly also of filarial diseases.

In a paper written in 1893 (A.M.G., 1893, p. 260) Dr. E. S. Jackson, of the Brisbane Hospital, states that he had seen 40 cases in two years, and had histories of recent experience of nearly 30 cases embracing most of the conditions which observers in other countries had attributed to filaria. The majority of his cases had enjoyed good health, even those who were subject to periodical attacks of the pyrexia which Faro has termed " elephantoid fever." Most of his cases were under 20 years of age, the oldest being 52 years. This latter case was the worst he had seen, for the patient had marked elpehantiasis in his leg and foot, and was subject to much erysipelas. The disease as he had seen it occurred only in the native born population or in people who had come to Queensland at an early age. He believed that the severer forms had not been found amongst aborigines, and surmised from that, that the disease had been introduced into this country from some other place. Most of the cases had come from places within thirty miles of Brisbane, one from New South Wales, and two from European countries. In several instances two or three people in one family were affected, which, he was led to believe, was a common experience. The duration of the disease was from one to twelve years, and he was inclined to think that one of the effects of the parasite was delayed menstruation in girls and the later arrival of puberty in boys.

In the discussion on this paper Dr. Marks referred to two patients suffering from this disease who died very suddenly, in his opinion, from cardiac embolism. Dr. Peter Bancroft was of opinion that, judging from the number of young children he saw whose blood contained filarial embryos, the disease was increasing in Brisbane, and referred to two patients in the Children's Hospital, Brisbane, suffering from popliteal abscesses, which were very common things in children in Brisbane who harbour the parasite. Dr. T. L. Bancroft said he was of opinion that the filariæ were introduced from China and the South Sea Islands, and that the aborigines of Australia originally did not harbour the parasite. He stated that filariasis was endemic all along the coast.

Dr. T. L. Bancroft in 1893 (A.M.G., 1893, p. 258) exhibited specimens of Filariæ in blood and chylous urine, making references to the nocturnal appearance of the embryos.

In 1894 Drs. Peter Bancroft, E. S. Jackson, and T. L. Bancroft (A.M.G., 1894, p. 6) referred to a slight increase of the leucocytes in the blood of infected patients. They give the leucocyte counts of six cases. In three of them there were popliteal abscesses, and the leucocytes varied from 12,000 to 23,750 per c.mm.; in two other cases there were elephantiasis, and the leucocytes varied from 14,500 to 27,300. In the fifth case, about which no details are given, the leucocytes were 5500. No attempt was made to ascertain the type of leucocytes increased, but in such of the cases in which there was a marked increase in their number, either from abscesses or from elephantiasis, it is probable that the increase was chiefly in the polymorphonuclear leucocytes, thus indicating a bacterial invasion of some kind.

In 1898 (A.M.G., 1898, p. 271) appears a letter from T. L. Bancroft, in which he mentions that he has been able to record the metamorphosis of *Filaria sanguinis hominis* in the muscles of the thorax of two species of mosquito, viz., *Culex ciliaris* and *Culex vigilax*. Also that upon the death of the mosquito the young filariæ do not escape from its body into water and therein live a free life, but invariably die, and that those embryo filariæ which are destined to develop leave the stomach of the mosquito at an early date and take up their abode in the muscles of the thorax. He suggests that possibly human infection may result from swallowing mosquitoes which have imbibed filarial blood. Early in 1899 (A.M.G., 1899, p. 120) this author made another communication referring to his experiments on the transmission of filariæ by mosquitoes, in which he stated that he believed water to be the medium into which the embryos escaped after leaving the insect. A very important paper was published later in the same year (Jour. Proc. Roy. Soc. N.S. Wales, XXXIII., 1889, p. 48-62) by him. In it he deals with the metamorphosis of the young form of *F. bancrofti* in the body of *Culex ciliaris* L., the house mosquito of Australia. He induced the mosquitoes which he had bred out from larvæ to bite an infected Queensland girl, and was able to demonstrate the presence of actively moving embryos in the mosquito on the sixteenth or seventeenth day, but not before. If the weather were cold, this stage might be delayed till the twentieth day, or even the thirty-fifth day (p. 62). No further development of the embryo occurred even after a sojourn of sixty days in the body of the mosquito. He found that the young filariæ were usually present in the thorax, and occasionally in the abdomen.

There were usually three or four, but sometimes as many as twenty-five embryos in a filariated mosquito, whereas he did not find any embryos in his "control" insects. Since the larvæ died after three or four hours' immersion in water, he concluded that water could not be the medium by which the filariæ reached man after leaving the mosquito. He suggested that the latter would need to be swallowed (as does happen accidentally sometimes) by man for infection to occur. In an addendum (p. 62) he mentions that he also thinks that young filariæ may gain entrance to human beings when the mosquitoes bearing them are in the act of drawing blood, the warmth of which may stimulate the embryos to pierce the insect's œsophagus and to pass down the proboscis into the human skin. We know now that this latter suggestion regarding direct transmission from the mosquito is the correct one. *Culex notoscriptus* Skuse and *C. annulirostris* Skuse are given as additional hosts (p. 61). He thought it not unreasonable to suppose that since the larvæ were killed by water they would be probably killed by the human digestive juices.

In 1903 Dr. Flynn, of Ipswich, Queensland (A.M.G., 1903, p. 248), stated that he had had about 60 cases in the last five years. He suggested that the disease had been introduced from China or the Pacific Islands, and referred to the various clinical signs which his series of cases exhibited, such as elephantiasis, chyluria, lymphscrotum, chylous hydroceles, orchitis, etc. He referred to the typical pyrexial attacks in the elephantiasis cases. He mentioned the occurrence in chylous cases of rigors heralding the outbreak. In chyloceles he found the embryos present in numbers. He mentioned that an increase occurred in leucocytes in one of his patients at the approach of an attack of pyrexia.

In the same month Dr. T. L. Bancroft (A.M.G., 1903, p. 251) published a paper entitled "Notes on Filaria and Mosquitoes." Cosh and Sawkins (A.M.G., 1903, p. 214) both refer to the disease. Dr. Macdonald (A.M.G., 1905, p. 334) showed illustrations of a case of filarial elephantiasis of the scalp. O'Brien (A.M.G., 1908, p. 123) mentioned that filariasis existed sporadically in Northern Queensland.

In a paper on "The Manifestations of Filariasis as it appears in Queensland," Dr. E. S. Jackson (A.M.G., 1908, p. 344) was of opinion that the complaint was greatly on the increase in Brisbane. He stated that the disease had not been observed yet in the Tweed River district of New South Wales, which forms part of the boundary between Queensland and New South Wales. He had found it more commonly in the male sex and chiefly in the native-born population, or those who had come to Queensland in early childhood. The poorer classes were more subject to it. He also referred to the various lesions produced by the disease. In the discussion (p. 370) on this paper Dr. Maclean referred to the fact that he had examined the blood of all the patients of three wards in the hospital and had found filaria in from 15 to 18 per cent. of them. Dr. Salter reported a case of chyluria which had recovered subsequently to an attack of typhoid fever; and Dr. Dodds mentioned a case in which cerebral symptoms intervened. Dr. Peter Bancroft related a case in which a number of adult worms were found in a tumour removed from the groin, and remarked that the death of a patient suffering from filariasis occurs sometimes immediately after the death of the worms.

In 1909 Maclean (A.M.G., 1909, p. 444) mentioned that out of 600 consecutive admissions to the Brisbane General Hospital 15 per cent. had filariae in the blood. In 1909 17 per cent. out of 200 cases were found to be affected, and a month later there were 16 per cent. In 1910 three articles appeared in the A.M.G. on the subject. Jackson's (A.M.G., 1910, p. 231) communication is mainly historical, and in it he gives a summary of earlier literature referring to the parasite in Queensland. P. Bancroft (p. 233) and Maclean (p. 234) published some notes on the disease. Other references to the occurrence of filariasis in Australia are as follow:—

Colledge, Proc. Roy. Soc. Q'land, XV, 1900, p. 127 (Queensland).

Bancroft, Jour. Trop. Med. Lond., 1899-1900, II, pp. 91, 149; 1901, p. 822 (Queensland).

Manson & Shipley, in Allbutt & Rolleston's Syst. Med., II, part ii, p. 933, 936 (Queensland).

Cleland, Jour. West. Austr. Nat. Hist. Soc., June, 1906 (Queensland—North-West Austr. ?); Jour. Trop. Med. Hyg., 1909, XII, p. 348 (Queensland); Bull. 7-9 Dept. State Med. & Publ. Health, West Austr., 1908, p. 22 (West Austr.).

Fülleborn & Rodenwaldt, "Filarien" in Real. Encyclopadie d. Gesamt Heilk., Aufl. 4, p. 55-64 (Queensland).

Blanchard, Arch d. Parasitol, III, 1900, p. 285 (Queensland).

Johnston, Agric. Gaz. N.S. Wales, XX, 1909, p. 583; Rec. Austr. Mus., VII, 1909, p. 336; A.M.G., 1909, p. 479 (Queensland, N.S.W., S. Australia, W. Australia).

Looss, in Mense's "Handb. d. Tropenkr.," I, 1905, p. 162.

Braun, "Animal Parasites of Man," 1906, pp. 289-291 (Queensland).

9. *Filaria medinensis* Velsch (=*Dracunculus medinensis*). The only instance in which this worm is recorded as having been found in Australia occurred in an officer on board a ship in Hobson's Bay in 1860. The case was reported by MacGillivray (A.M.J., Vol. 5, p. 172).

10. *Filaria loa* Guyot (=*Loa loa*). In 1874 Tassell (A.M.J., Vol. 19, 1874, p. 33) removed from the eye of a middle-aged man a worm about 1½ in. long, which he had seen wriggling over the

anterior surface of the sclerotic, beneath the conjunctiva. The patient could feel the animal moving about.

In 1898 Dr. Cherry (Inter. Med. Jour. Austr., III, 1898, p. 416) exhibited before the Medical Society of Victoria a worm about 2½ in. long, removed by Dr. Harris, of Rutherglen, from the subcutaneous tissues of the eyelid of a man who had been a missionary in tropical Africa. Dr. Barrett said it resembled in general appearance *Filaria oculi humani*, or *F. loa*. These two references are undoubtedly to *Filaria loa*, which is certainly an imported parasite.

11. *Microfilaria demarquayi* Manson ? . Manson ("Tropical Diseases," London, 1898, p. 446) regarded embryonic filariæ found in the blood of New Guinea natives as being probably the same as the above species, which is only found in the West Indies.

Braun ("Animal Parasites," 1906, p. 297) and Looss (Mense's "Handb. d. Tropenkr.," I, 1905, p. 169) mention Manson's reference. Fülleborn and Rodenwaldt ("Filarien" in Real. Encycl. d. Gesamt. Heilkunde Aufl. 4. Berlin, p. 79) regard the identification as doubtful.

Occasionally references occur in the literature to other parasites found in man in Australia. In 1897 Dr. Brummitt, of Adelaide, showed a worm 10 in. in length, very thin, white, and round, passed with the urine by a woman. (A.M.G., 1897, p. 135.) The nature of this organism seems quite uncertain, and it is possible that it may have been an adventitious addition to the urine. In 1902 Dr. Angas Johnson, of Adelaide, described a worm passed in the urine (A.M.G., 1902, p. 924).

12.—THE FIRST INTRODUCTION OF CAMELS INTO SOUTH AUSTRALIA AND THE WEST—DID SURRA OCCUR AMONGST THEM ?

By J. BURTON CLELAND, M.D., Ch.M. (Syd.).

Recently, while reading the Journal of Col. Warburton on his expedition from Central Australia to the De Grey River in 1872 and 1873—the first successful expedition to cross the centre of the continent—I have come across some interesting references to camels, especially in the information in the introduction of the volume—a brief survey of previous explorations in the same direction—by C. H. Eden.

From this introduction it appears that in 1846 a camel accompanied Mr. Horrocks on an expedition in South Australia. A few of these animals accompanied Burke and Wills, and also McKinlay, on their expeditions, but they were not numerous until Sir Thomas Elder (then Mr. Elder) in 1866 despatched a gentleman named Stuckey to India, who shipped 124 camels from Kurrachee, 121 of which were landed in South Australia in excellent condition and very fat. Three died on the voyage, it is said from cold and inflammation of the lungs. Then Mr. Elder goes on to say :—" After landing the camels commenced rapidly to increase, but an epidemic attacked them, a kind of mange, by which disease more than seventy were swept away. The Afghan drivers, some dozen in number, who had accompanied their animals, stated that this complaint was common to the camel in its own country, and that it could be cured by means of oil extracted from certain shrubs. But none of the requisite specific could be found in Australia, and a grave objection to the importation of camels seemed likely to present itself, for the sudden loss of so large a number at one fell sweep was a serious matter. The luxuriant feed seemed to encourage the disease, and a remedy was looked for in vain. At length it was proposed to apply Stockholm tar externally, and to administer the same ingredient mixed up with oil internally; and the experiment was attended with the happiest effects, the Afghans themselves pronouncing it far superior to the native medicines."

About five years after their arrival we find Colonel Warburton starting on his expedition, the first in which camels alone were employed. Had it not been for these animals the undertaking must have ended with disaster. On September 15th, when in Western Australia, Warburton mentions that the master-bull was very ill, as if poisoned, and the young bulls very troublesome in consequence of the lessening of his restraint over them. They tried to doctor him with mustard, but he had to be left behind at the well next day. On the 18th Colonel Warburton says:—"Obliged to abandon two riding-camels at our last camp; they could not stir. We at first thought they were poisoned, but it now appears that they have been struck in the loins by the night wind. My son's riding-camel is also struck; it cannot drag its hind legs after it, so we kill it here for meat instead of leaving it to die." Later, on October 4th, he writes of the loss of another camel:—"The former camels were struck in the loins, just as horses are struck by the land-wind in India, but this one is diseased in the hips, and quite lame."

These records are of very great interest, for we find that, in 1866 or 1867, 121 camels of three types—the fast Mekrana camel, the hill camel of Scinda, and the hairy camel from Candahar, *i.e.*, camels collected from various parts of India, were shipped from Kurrachee, the very place from which the recent Port Hedland camels were shipped. It is highly probable, therefore, that some of these camels may have been suffering from trypanosomiasis (surra). Some time after their arrival we find an epidemic, said to be a kind of mange, attacking them, with the loss of more than 70. The disease yielded to Stockholm tar applied externally and internally. Then we find Colonel Warburton using some of these very camels, and that, towards the end of his journey, when approaching the Oakover River, several of them, almost worn out by hardship, the spiny spinifex grass (*Triodia*), and lack of water, were "struck in the loins" by weakness, as Colonel Warburton significantly adds, "as horses are struck by the land-wind in India," and had to be abandoned.

It seems to me not at all unlikely that some of the 70 camels dying from the epidemic in the first instance may have actually died of surra, and not of mange, or that the mange (in extensive form, and admittedly often *a* fatal complaint in the camel) may have flourished especially on sickly camels, and death have been attributed rather to it than to an unknown disease. Still more suggestive is the description of the illness of Colonel Warburton's camels and his comparison of the disease with one known in horses in India. Supposing these particular animals to have harboured trypanosomes, it is only to be expected that after such hardships surra should have been lighted up again, and the camels have died from it. In regard to the reference to the disease of horses in India, it must be remembered that the mortality among horses in India from surra is high, that at the time when Colonel Warburton wrote the disease was imperfectly known, and its parasite not yet discovered, and that paresis of the hindquarters is not an uncommon occurrence towards the end of the infection.

If my suppositions are correct, it would appear that amongst the first handful of camels that reached West Australia, several died within its borders of surra, and that at a spot not far from where 35 years later the Port Hedland camels were quarantined. Of course there is nothing to suggest that in any of these animals was the disease acquired in Australia—only that the parasites were imported in the camels and manifested their presence later in those animals in which they came. On the other hand, no one can say with certainty that the disease cannot be spread here from affected imported animals, especially when it is remembered that we have biting flies allied to those responsible for such spread elsewhere.

13.—ONCHOCERCA GIBSONI: THE CAUSE OF WORM NODULES IN AUSTRALIAN CATTLE.

By J. A. GILRUTH, D.V.Sc., M.R.C.V.S., F.R.S.E., Professor of Veterinary Pathology, and GEORGINA SWEET, D.Sc., Lecturer in Parasitology, Melbourne University Veterinary Institute.

Introduction.
General.
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Geographical Distribution of the Disease in Australia.
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    Location and Number.
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Introduction.

This paper presents a study of the distribution, the situation, the structure, the pathological effects, and, to some extent, the life-history of the parasite "*Onchocerca gibsoni*, Cleland and Johnston, **1910**," the cause of what are known by such terms as "Worm Nodules," "Worm Nests," "Kernels," etc., within the briskets and thighs of cattle in certain parts of Australia. The importance of the parasite from the human point of view is but incidentally touched upon.

While the presence of the fibrous tumours which surround the parasite undoubtedly renders the portions of meat in which they are situated abnormal in appearance, and, consequently, more or less unsaleable, the parasites are not deleterious to the health of the host, for in the majority of cases a careful search is required to detect their existence, even on post-mortem examination. The parasites cannot reproduce themselves completely within the bovine system, a contention proved by the fact that although each adult female may be said to be continuously liberating numbers of motile larvæ, it is rare to find in any host over fifty matured females. Further, in our experiments, we have repeatedly injected thousands of living eggs and larvæ underneath the skin of cattle, yet post-mortem examination, months afterwards, has failed to show a single fully developed mature worm. Again, we have found that neither the adult parasite nor the immature sexless larvæ are able to retain their vitality under the most favourable conditions for more than two days after the death of the host. It does not, therefore, require even the process of freezing or of cooking to destroy the life of these parasites, but even were they more resistant than they are to ordinary influences, it is certain that these processes would speedily cause their death.

But beyond all this, a study of the life-history of parasites in general, and of those closely allied to this species in particular, enables us to confidently affirm that under no circumstances could they infect the human being, whether introduced along with the food or otherwise. Indeed, it may be further assumed that they are unlikely to be found in the tissues of any other domesticated animal, even in the closely-related buffalo, so specialised are such parasites for individual species of mammals.

Thus, from all points of view, the contention is justified that, so far as the public health of this or any other country is concerned, they are absolutely innocuous.

That from the commercial point of view these parasites are important to a country exporting large quantities of beef for human consumption cannot, however, be gainsaid, and it is to be hoped, therefore, that the further researches being conducted here and elsewhere will demonstrate the intermediate host, and so enable a policy to be outlined which may ultimately exterminate the parasite.

General.

Observations on the general subject of these parasites were commenced by us in 1909, independently of Dr. Cleland and Dr. T. H. Johnston, who have recently (February, 1910) published a preliminary report in the Agricultural Gazette of New South Wales, Volume XXI., 1910, p. 173, and further communications in the Proceedings of the Royal Society of New South Wales, Volume XLIV., 1910, p. 156-189, the substance of which is also contained in the Report of the Bureau of Microbiology, Sydney, 1910.

In Melbourne fresh material is difficult to obtain on account of the rarity with which Victorian cattle are affected, and it is only when Northern New South Wales or Queensland cattle which have been imported as stores, and fattened locally, are slaughtered at the abattoirs that there is any opportunity of securing specimens for examination. However, during the past year, thanks to the courtesy of Mr. John Robertson, Superintendent of the City Abattoir, we have from time to time received material. Further, one of us (J.A.G.) during a visit to Queensland examined a large number of affected cattle, both at slaughtering establishments and on stations under normal conditions. As is to be expected, our observations in many respects confirm those of Cleland and Johnston, although conflicting in regard to certain details.

History of Occurrence in Australia.

This has been fully dealt with by Cleland and Johnston. In addition to their observations it is worthy of record that several individuals in Queensland, who have been connected with cattle and the meat trade all their lives, are emphatic in their statements that they have known these nodules in the briskets of cattle for upwards of forty years.

As will be seen later, there is little doubt that the parasites first appeared in the cattle of the northern districts of Australia, and even now, comparatively speaking, the number of animals affected diminishes the further south one travels. Mr. Holt, G.M.V.C., Superintendent and Veterinary Inspector at the Hobart Municipal Abattoir, assures us that although frequent in animals imported from New South Wales, the nodules have never been found by him in cattle from King Island (Bass Straits), or in cattle bred in Tasmania.

It is certain that had this parasite been common or even rarely present in British and European cattle or their descendants in various other cattle-breeding countries of the world, such as North and South America, South Africa, and New Zealand, their presence would have been the subject of some comment at least, and in the absence of any reference whatever, either in scientific or stock journals, it is perfectly permissible to assume their absence. While it is possible, as indicated by Cleland and Johnston, that the buffalo, which was imported into Australia from Timor eighty-five years ago, is the true originating host, it must not be overlooked that possibly along with the buffalo, or at about the same time, cattle were also imported, for permission was given for such to be done. (Report, Bureau of Microbiology, 1910, p. 99.) This is important, for De Does has observed similar nodules in the pectoral region of cattle born in Java (Railliet and Henry—Comptes Rendus des seances de la Société de Biologie, T. LXVIII., 1910, p. 250). Java, it should be remembered, is connected by a continuous chain of islands with Timor, and consequently it is more than probable the Timor cattle also harbour these parasites. Under these circumstances, therefore, it is probably unnecessary to assume a transference from an original host, *e.g.*, buffalo (*Bos indicus*) (?) to a new species (*Bos taurus*). (*See* Note, p. 342.)

Geographical Distribution of the Disease in Australasia.

In New Zealand these nodules have never been detected. All cattle slaughtered for export, and all cattle slaughtered for sale within towns of over 2,000 inhabitants, being the subject of very careful post-mortem examination in the Dominion by a body of qualified State Inspectors, it may be confidently stated that had such a diseased condition existed it would have been reported long ere this.

In Tasmania the disease has never been observed in locally-bred or in King Island cattle, although frequently detected in New South Wales cattle imported for immediate slaughter.

In Melbourne the nodules are from time to time encountered in cattle slaughtered at the abattoirs. The inspectors almost invariably state, however, that they are solely to be found in "northern" cattle, or cattle which have been imported into Victoria from northern New South Wales and Queensland. We have been assured, however, by one careful inspector that he has observed them occasionally in Victorian-bred cattle. There are records of their occurrence in cattle slaughtered in Adelaide, which is not surprising, seeing many of them are bred in the Northern Territory, and they appear to be well known in West Australia.

In Sydney, as Cleland and Johnston have shown, they are frequently observed in cattle slaughtered at the abattoirs. Stanley (Gibson—Trans. Intercol. Med. Congress, August, 1892, p. 576) in 1892 stated that they might be detected at least in 50 per cent. of the animals slaughtered; but we think, from personal observation, this is extremely doubtful. In cattle from northern New South Wales, the Clarence and Richmond River districts, they appear to be fairly common, the opinion of Sydney inspectors being confirmed by the Brisbane inspectors and works managers.

So far as can be ascertained no cattle station in Queensland is entirely free of the parasite, though, naturally, some are more affected than others. From the experience of one of us (J.A.G.) we estimate that they may be found in at least 20 per cent. of the cattle on what may be termed the "cleanest" stations—possibly 50 per cent. on complete examination would be more approximate. For example, in one lot from a notoriously "clean" station in south-western Queensland, 10 per cent. on very careful examination by manipulation, using incision only when certain or doubtful were found to be affected, but later on when the briskets of a number were partially dissected another 25 per cent. were found to harbour the nodules. Again, in two mobs from stations widely apart in north-western Queensland their presence could be detected in 60 per cent. by observation without any manipulation; more careful examination by dissection showed that every one of these animals contained from one nodule upwards.

All the evidence, therefore, available points strongly to a more general infection of herds the further north the cattle are bred and pastured. No information, however, points in the direction of soil. climate, rainfall or management being contributory to the prevalence. Examination of records at freezing works, which were kindly permitted, entirely negatives any such supposition. Personal examination of cattle from different districts of the rich low-lying well-watered coastal country in the north, with heavy annual rainfall, showed them no more and no less affected than cattle from the dry western downs, and those from the high and cold basalt country. Further, close herding does not seem to have any effect; the proportion affected may be quite as great (often much greater) where the number of cattle per square mile is under a dozen, as where one to every two or three acres is pastured.

Age Incidence.

The nodules may be found in cattle of almost any age. Inspector Miller, of the Bowen Freezing Works, who has made a very complete examination by definite incisions of thousands of carcases, has found as large a percentage of 2 and 3-years old bullocks affected, and practically with as many nodules per individual average as old cows.

The experience of J.A.G. supported this, no appreciable difference being found in the number of nodules present on the average in a hundred old cows from the number present in 3 and 4-years old bullocks, many from the same station as the cows. Further, on different stations he had an opportunity of thoroughly examining both ante and post-mortem animals of various ages, with the following results :—

First Station.—Two Jersey cows, one 3 years old and one 4 years old. Manipulation in subcutaneous tissues behind the point of the shoulder while alive detected nodules on each side of both animals. Two old cows, one 14 years old, the other 17 years old, were slaughtered and examined. The former contained twenty-five and the latter thirty nodules. All these cows were paddocked, that is, pastured in comparatively small areas (say, 50 to 200 acres), and were used for dairy purposes. No doubt, examination post-mortem of the two young cows would have disclosed quite as many nodules in the inter-muscular spaces as were found in the old cows.

Second Station.—(Notorious for prevalence of these nodules.) Yearling heifer examined post-mortem. Twenty nodules in brisket, varying in size from a pea to a large marble.

Another yearling, probably 10 months old, killed and examined, showed twenty-four nodules, a group of five being clustered at one place over the sixth and seventh intercostal spaces. These varied in size from a split pea to a walnut.

Calf, about 3 months old, running with mother, killed and examined; no nodules could be detected anywhere.

Third Station.—In same district as previous stations (recognised as comparatively "clean"). Cow, aged 8-10 years; killed and examined. Only four nodules, each the size of a marble, present.

Calf, 6 to 8 months old, running with mother; killed and examined. Four small nodules present.

Heifer, 18-20 months old; killed and examined. No nodules found after very careful examination.

(It may here be noted that on this station the cattle are dipped in arsenical solution every three to four weeks in order to combat cattle-tick infection, whereas on the other stations dipping is not carried out so frequently or so thoroughly).

It may be observed that the older the animal, generally speaking, the greater the tendency for the parasites to be degenerated. For example, the parasites of all the nodules in the 17-years-old cow, and the majority of those in the 14-years-old cow, were degenerated and calcified; while in the 8-10-years-old cow three of the four nodules contained degenerated worms, one of which was partially calcified, lying free in a muco-purulent fluid. In the younger cattle no degenerated worms were found.

These observations indicate very clearly that the most general period in the life of the host when the filaria enters or at least establishes itself in the system is during youth, probably the first year. They have, therefore, an important bearing on the general life-history, as will be discussed later.

New Growths (Nodules) induced by Parasite.

Location and Number.—In spite of the observations of some to the contrary, the experience of one of us (J.A.G.), gained from the examination of over 700 cattle affected, is that the nodules are invariably confined to two distinct and separate situations.

The commonest situation is the region of the brisket, chiefly the triangular outline formed by the junction of the ribs with the costal cartilages, especially between the fourth and sixth ribs, but often extending backwards to the tenth, and, at times, forward to the second rib. Frequently they are superficial, *i.e.*, in the subcutaneous tissues, but more often they are situated between the posterior portion of the superficial pectoral muscle and the anterior part of the posterior deep pectoral, between the posterior portion of the deep pectoral and the external abdominal oblique, and between the panniculus carnosus and the posterior portion of the external oblique, rarely deeper.

The number of the tumours varies in different animals, irrespective of the age of the animal. There may be only one or two, but there may be fifty in the one animal.

The other situation is the external surface of the hind limb, especially behind the femoro-tibial joint, and the groove leading upwards to the pelvis, anterior to the gluteus maximus, and even near the angle of the haunch. While occasionally superficial and readily detected, they are often under the dense subcutaneous fascia lata, when they are much more liable to be overlooked. Generally single in the hind limb, it is not very unusual to discover a group of four to six. Usually flattened, they present practically the same characters as those found in the fore limb.

It is well to observe that slaughtermen, and even inspectors. state they occasionally find such nodules elsewhere than in the situations mentioned. For example, that they have been detected on the inner surface of the thigh, in the groin, and even throughout the body. Other very careful observers, however, deny this. Certainly J.A.G. saw no indication of their presence elsewhere, even in the most badly affected cases, and we are strongly inclined to the opinion that such conclusions have resulted from small tumours of different origin being mistaken for these nodules.

Macroscopic Appearance.—In the vast majority of cases it is absolutely impossible to detect the presence of nodules during life, and, indeed, it is impossible without definite incision to be certain that none are present even in a dressed carcase. In some instances, however, during life, they may be detected by manipulation, and often by simple observation as definite spherical firm tumours situated almost in a direct line behind the point of the elbow. When present in the subcutaneous tissue they are generally globular and not pedunculated. Occasionally they may be so firmly attached to the dermis that the butcher in flaying the animal divides the nodule. Very rarely are they situated in the intra-muscular connective tissue, even in part. When found in the intermuscular loose connective tissue they are seen as flattened spherical, sometimes ovoid, bodies of very dense consistency, lying amongst a greater or less quantity of looser, flaccid tissue, which permits a considerable amount of free lateral movement, so preventing, no doubt, the bruising that otherwise would naturally tend to occur when the host is in the recumbent position on a hard surface. The nodules themselves are, in our experience, almost invariably difficult to remove from this loose connective tissue, and only rarely have we found them easy to enucleate, as observed by Cleland and Johnston. It is true that occasionally on incising the muscle immediately over a small tumour it may extrude, but this is generally because when the carcase is hung up and "dressed" the pectoral muscles are in a condition of great and unnatural tension, but while the nodule with some of the loose surrounding tissue may be then readily removed, it is not always the case, and in any circumstance cannot be termed "readily enucleated."

Occasionally evidence of recent hæmorrhage in the periphery of the nodule may be detected. Probably this is always the result of the falling of the animal when stunned prior to bleeding, for we have never observed it in tumours from the hind quarters.

The blood vessels supplying the nodule are always very distinct, generally tortuous to an extraordinary degree, no doubt owing to the frequent partial displacement of the nodules. The walls of these vessels, particularly the arteries, are especially thick and the lumina comparatively narrow.

The size of the nodule, as does the space occupied by the parasite within, varies very considerably. Generally speaking, the size of the former is that of a marble, about 2 cm., but it is not uncommon to find it reach that of a walnut, 3.5 cm. Occasionally we have found an individual nodule the size of a mandarine orange, about 5 cm., one of the largest measuring 11 cm. by 8 cm. In our experience, although it is very rare to find a nodule of less size than that of a small marble, they may be found as small as a split pea, 6 mm. in diameter, but then only after careful search through a large number of animals. On section the tumour is seen to be composed of a very dense fibrous wall (*see* figs. 1, 1a, and 2), which varies very much in thickness in different nodules, enclosing a tightly-coiled mass of worm "*xx*" in tunnels, and lying bathed in a small quantity of opalescent fluid (*see also* figs. 30 and 32). This fibrous capsule has no general relation in thickness to the space occupied by the parasite; for example, in one nodule measuring 7 cm. in diameter the worm-area was 15 mm. in diameter, and in another measuring 11 cm. by 8 cm. the worm-area was only 9 mm. (*compare* fig. 2). Notwithstanding this, as Cleland and Johnston stated, the worm-area shows little variation in comparison with the thickness of the capsule. Further, although the worm-area is usually centrally situated, it is not invariably so, especially in the flattened ovoid tumours.

Calcareous degeneration is not uncommon, and occasionally a purulent form of degeneration may be seen in which fragments of the dead parasite lie free. Often these degenerations attack only one portion of the worm-area, the other containing still undegenerated parasite with living larvæ. These degenerations appear solely to affect the parasite and the tissue between the coils. Degenerated nodules may be found in any animal, but the older the host the greater the likelihood of their presence, as already shown.

Movement of Parasite.—Careful examination of the cut surface of a nodule taken from an animal soon after slaughter enables one to detect some movement of the adult female, especially manifested by a tendency for the cut ends to protrude very slightly but definitely from the tunnels. In such very fresh nodules a considerable length of worm may be withdrawn by gentle traction, showing that it lies practically free within the tunnels, and, moreover, possesses some freedom of movement while enclosed within the nodule.

Microscopical Appearance of Nodules. (See figs. 1, 2, 30, 31, 32)—Sections made serially of different sized nodules showed the general structure to be the same in each instance. The capsule is composed of dense fibrous tissue with many nuclei, and processes therefrom pass inwards, branching and anastomosing to form the walls of the spaces or tunnels within which the adult parasite lies, thus forming what we have termed the worm-area. In the very smallest nodules the fibrous capsule is often very thin, while the branches entering the worm area are extremely delicate. A very notable feature of the "capsule," especially in the larger tumours, is the extraordinary thickness of the walls of the arteries compared with the very small size of the lumina. This thickening is due to a peri-arteritis, and is often accompanied by a definite end-arteritis, and not infrequently an obliteration of the lumen. In certain nodules a section of the wall seems to be chiefly composed here and there of arteries with greatly thickened walls, between which there is a comparatively loose new connective tissue with many newly-formed blood vessels.

In the thinner capsules, particularly those of very small infertile worm nodules, the thickening of the arterial walls, unless at the point of entry, is not marked. Further, in those nodules composed of much fibrous tissue numerous larvæ can be seen traversing the tissue and often congregated in the vicinity of the blood vessels, whereas in those with very thin capsules migrating larvæ are seldom if ever seen.

The fibrous bands forming the walls of the tunnel vary very much in thickness and in density ; frequently they are only represented by a few delicate strands ; at other times, especially towards the surface of the worm area, the breadth of these bands exceeds the diameter of the tunnels.

In the deeper portions of the worm-area, especially around the heads of the parasites, the tissue is much looser in character, the nuclei are more numerous, and there is generally greater or less infiltration by leucocytes, and especially eosinophiles, which are often massed at the edge of the tunnel wall. The leucocytes are undergoing degeneration in certain areas, as shown by the nuclear disintegration and indefinite staining reaction.

Structure of the Parasite.

As stated previously, the worm lies closely coiled in a very complicated manner in the interior of the nodule, usually, but not necessarily, situated centrally. At times the matrix immediately surrounding the parasite, especially around the head, is less fibrous than elsewhere, but not invariably so. As in the case of some allied forms it is practically impossible, even with the greatest care and patience, to extract the female worm entire, even after the preliminary use of digestive and other like methods. Fifteen and twenty fragments are good records. The length of the worm, found by adding together the lengths of the various pieces obtained by careful dissection, with the production of as few fragments as possible, was in three typical cases of fresh female worms 52.6 cm., 90 cm., 140.3 cm. (*compare* Cleland and Johnston, 97 cm.)

The size of the whole nodule varied but very little in the three cases, the first and third being almost identical (about 6 mm.), though the second was larger (15 mm.). The male (*see* fig. 9), of which a complete specimen has not previously been recorded, was 3.8 cm. to 5.3 c.m., and in the case of the third nodule above mentioned 4.6 cm. long. The nodules appear to us undoubtedly to contain either most generally one female only or, less often, one female and one male ; even when no male can be found in the nodule the female is usually fertile, but not invariably so, the fertile ones being found in the smallest nodules. Whether the male has been present and fertilised the female and then left the nodule or degenerated, or occasionally the female is fertilised before the formation of the nodule, or possibly, though it seems improbable, the eggs are produced parthenogenetically, are all matters, at present, of conjecture. Most probably copulation takes place occasionally before the dense nodule wall is produced, though one act of fertilisation seems wholly inadequate to account for the enormous numbers of larvæ produced by each worm. This opinion is strengthened by the small number of sterile nodules (we have only found three, out of fully a hundred nodules examined for the purpose, to be sterile), the comparatively rare occurrence of the male in the nodule' and also the apparent absence of any degenerated males in the nodules, while it does not seem possible for a mature worm to make its exit through such a tough, fibrous, wall as that surrounding the nodule. When both worms, male and female, are present their anterior ends have a definite relationship to one another. They lie side by side (see figs. 3, 4, 5, and 37), the female head often slightly in advance of the male, in the same tunnel of the tissue of the nodule, quite on the outermost part of the worm area of the nodule, usually on its flattened surface and more or less towards one side. The two worms (fig.4) then pass straight across the centre of the nodule to the opposite side, the middle of the male generally lying once coiled alongside and around the female. The hinder end of the male may occupy a tunnel by itself. The female then passes to one end of the outer region of the worm area, along that end and back again along the side to which the heads were pointing ; from this side it enters more deeply into the coil formed by the remainder of its body. The female tail, when found, was at about half-way between the centre and the periphery.

General External Characters.

The specimens of this worm which we have examined show great variations in several details, especially in the female, though this does not appear to have been noticed by previous writers. The variations met with in three typical males and six typical females are recorded in the accompanying table. One or two of these may be due to differences in age of the worm, or in the amount of ante and post-mortem contraction ; but it is obvious on consideration that all cannot be the result of such factors.

	A.	B.	C.	Range.
	cm.	cm.	cm.	cm.
Length of male	4.6	3.8	5.3	3.8–5.3
	mm.	mm.	mm.	mm. mm.
Diameter, anterior end, 0.15 mm. ..	.052	.062	.062	.052 –.062
Diameter, middle of length	.151	.144	.141	.141 –.151
Diameter, 0.5 mm. from anterior end	.082	.069	.082	.069 –.082
Diameter, level of male opening ..	.051	.042	.042	.042 –.051
Excretory pore from anterior end ..	.251	..	..	.251
Nerve ring from anterior end ..	.188	?	.172	.172 –.188
Cardia from anterior end	..	..	..	
Cardia—length	..	..	..	
—diameter	..	..	..	
Œsophagus—length	.72	.65	?	.65 –.72
—diameter	.0155	.0155	.0155	.0155
Cloacal opening from tip of tail ..	.048	.052	.062	.048 –.062
Spicules—length .. long	.155	.148	.155	.148 –.155
Spicules—length .. short	.094	.078	.078	.078 –.094
—diameter .. long	.010	.0078	.009	.0078–.010
—diameter .. short	.0078	.0061	.007	.0061–.0078

Part.	A.	B.	C.	D.	E.	F.	Range.
	cm.	cm.	cm.				cm. cm.
Length of female	90	140.3	[52.6]	..	..	..	52.6–140.3
	mm.	mm.	mm.	mm.	mm.	mm.	mm.
Diameter .15 mm. from anterior end	.115	.110	.123	.078	.094	.087	.078– .123
,, middle of length	.42	.40	.45	.38	.39	.37	.37 – .45
,, just in front of vulva ..	.125	.155	.207	.109	.106	.125	.106– .207
,, at vulva	.125	.155	.18	.082	.106	.113	.082– .18
,, level of anus	.207	[?.207]	..	..	..	..	.207
Excretory pore from anterior end	..	..	.358	..	.379	..	.358– .379
Nerve ring from anterior end ..	.188	.188	.175	.142	.172	.167	.142– .188
Cardia from anterior end	.41	.69	.573	not seen	.86	.79	.41 – .86
,, length	.031	.062	.034	..	.031	.031	.031– .062
,, diameter	.031	.040	.034	..	.031	.031	.031– .040
Œsophagus, length	.52	.73	.65	.62	.92	.82	.52 – .92
,, diameter	.02	.02	.0207	.02	.021	.0207	.02 –.021
Vulva from anterior end	.46	.69	1.138	.59	.57	.69	.46 –1.138
Vagina and common uterus length	1.656	3.45	1.794	5.10	4.68	2.001	1.656–5.10
Anus from posterior end	.207	[?.175]	..	..	..	..	.207

Size and Shape.—The male, as would be expected in one of the Filariidæ, is not only much shorter, but also considerably thinner than the female. For example, at 0.15 mm. from the anterior end, the male is 0.052 to 0.062 mm., and the female 0.078 to 0.123 mm., and at a distance of 0.5 mm. the male is 0.069 to 0.082 mm., as against the female 0.106 to 0.207 mm., while the average diameter of the male is less than half that of the female, being 0.141 to 0.151 mm., as against 0.37 to 0.45 mm. in the female.

The peculiar shape found to be normal for the female head is not present in the male, even in specimens killed in 70 per cent. absolute alcohol at 65° C., the male head simply tapering to a blunt point. Cleland and Johnston state : " in the male, however, there was no trace of labial structures." Under high magnification and favourable conditions we have seen the three lips, though less distinct than in the female, and in one three very minute papillæ were visible, corresponding to those of the female head.

The Female.—The anterior extremity, 0.5 mm., of the worm tapers more or less rapidly to a usually blunt tip ; sometimes the head is smaller even though the worm is quite mature as seen in the presence of the embryos in the uterus close to the vulva, and the animal is uncontracted, as seen in the structure of the tip. Moreover, this anterior end is sometimes seen to be bent slightly ventrally so that the most anterior part of the head is the dorsal lip. As stated by Cleland and Johnston, Park's description of " teeth-like projections and briar-like barbs " on the head end is quite incorrect, but there is a feature of the normal well-preserved head end which shows clearly in four of the six typical cases chosen for tabulation as well as in others. This appears to have been undescribed so far, though it is present in the drawing given of the head in Jour. Roy. Soc. N.S.W., XLIV. (1910), Pl. XIV., Fig. 1.

The extreme tip is separated from the rest of the head by a fold and depression of the cuticle and dermis (*see* fig. 5), giving it the appearance of a half moon set in to the wider main part of the head. Cleland and Johnston state in their original description of the new species that " the head is not constricted from the rest of the body." The length of this terminal postion is 0.0132 to 0.0136 m.m., and it is present in specimens A, D, E, F, though not so well defined in the specimen D. In the other two cases the head is lacking in this respect (*compare* fig. 6), the absence of the fold being almost certainly due to some contraction in these cases. At least two of those specimens in which this feature appears were fixed in 70 per cent. alcohol, at 65° C., and were excellently preserved, so that there can be no doubt that this is the normal state of the head end. As stated by Cleland and Johnston, " the mouth is small, rounded, and terminal, and appears to be surrounded, in the female, by three slight projecting lips." The lips, which are very small, can only be seen immediately around the mouth opening, and are sometimes almost indistinguishable, even in the female. Papillæ can be detected only occasionally, and then show under high magnification as three tiny papillæ on the outer side of the head, one corresponding to the centre of each lip (*compare* figs. 6 and 7a).

Cervical Papillæ.—These have not been observed in either male or female.

Excretory Pore.—As a rule no excretory ring and pore has been observable externally, but in two females at 0.358 and 0.379 mm., respectively, from the anterior end is a special development of tissue carrying excretory vessels to the mid-ventral line, though the excretory pore could only doubtfully be detected (*see* figs. 6 and 7). In the male the excretory pore was only doubtfully distinguishable in one case at 0.251 mm. from the anterior end.

Vulva.—This, which often appears as a tri-radiate slit or a circular opening on the mid-ventral surface, varies greatly in position compared with the position of 0.8 mm. from the anterior end given by Cleland and Johnston, namely, from 0.46 mm. in an uncontracted specimen to 1.138 mm. in a specimen probably somewhat contracted, the most frequent position being at 0.57 to 0.69 mm. (*compare* figs. 5, 6, and 7).

Tail.—In the male (*compare* fig. 9) this is very fine, gradually tapering, somewhat bluntly pointed. The last part of the body is coiled spirally once or twice ; the cloacal opening is (figs. 10 and 11) a transverse slit which lies at 0.048 to 0.062 mm. from the tip of the tail, the diameter of the body at this level being 0.042 to 0.051 mm. We do not understand the figures given by the authors of the species in reference to the position of the cloacal opening, namely, "the anus in the male is situated at 0.072 mm. from the posterior extremity," and then later on, "the cloacal opening is situated on a median prominence about 0.65 mm. from the end of the parasite." The latter figure should presumably read 0.065 mm., and is even then slightly in excess of what our specimens show.

The anal papillæ are given by Cleland and Johnston in their second account of the parasite as six pairs, with perhaps the representative of another pair of papillæ. Our specimens show very clearly seven pairs (figs. 10-12B), not, however, always bilaterally symmetrical or exactly comparable in different specimens. The figure represents what appears to be the normal arrangement of these structures, that is to say, there are three pairs ad-anal, one pair pre-anal, and three pairs post-anal papillæ. Of these the pre-anal are usually somewhat large, well separated, and readily seen (figs. 10 and 12A). Sometimes they are so far back as to be more correctly described as an additional ad-anal pair (figs. 11 and 12B, and *cf.* Cleland and Johnston, *loc. cit.*, Fig. 3), at other times these two pre-anal papillæ are very much closer to the median ventral line. On one occasion there was one very clearly marked additional papilla on the left side, some distance in front of the normal pre-anal pair, but none could be detected on the right side (fig. 12B). The three smaller ad-anal papillæ on either side are, rarely, so closely arranged as to appear almost continuous with one another at their bases (fig. 11). The most anterior pair of post-anal papillæ are large and generally well separated, but may be much smaller and almost touching in the middle line. The middle post-anal pair are of fair size, and do not appear to show much variation. The posterior post-anal papillæ are situated almost on the extreme posterior end, and although smaller than the others are generally very clear.

In the female the tail is more bluntly pointed than in the male. The anal opening (fig. 8A) lies at a distance of 0.207 mm., or in a less perfect specimen apparently 0.175 mm. from the extremity of the tail; the usual thickness of the body at this level being also 0.207 mm.

Cuticle.—As already described, the cuticle is raised up into one or sometimes two series of spiral ridges, each more or less irregular. Even in extreme cases these ridges only extend as far forward in the female as 0.34 mm. from the anterior end, while behind the anus there is practically no such ornamentation. No transverse striations of the cuticle have been seen, nor any longitudinal striations other than those due to the longitudinal arrangement of the muscles. In the male the spiral ornamentation is naturally much finer and less marked in character.

Internal Structure.

Owing, perhaps, to the conditions of pressure, etc., under which the worm lives, many details of its structure are extremely difficult to decipher, more especially as will be seen in connection with the nervous and excretory systems, which show an asymmetry and irregularity which is quite evidently a characteristic of the worm, independent of methods of fixation, preparation, etc.

Digestive System.—In the male the œsophagus is straight, and is 0.65 to 0.72 mm. long and 0.0155 mm. wide, that is, somewhat narrower than the female. Sometimes slight swellings are present on the œsophagus, just before it enters the intestine, but no definite "cardia," like that of the female, could be found in any instance. The long, straight, intestine passes back to the cloacal opening, and, though much reduced, is similar to that of the female. The spicules will be described in connection with the reproductive system. In the female the long narrow œsophagus, sometimes straight, sometimes twisted (figs. 5, 6, and 7, and 35), varies from 0.52 to 0.92 mm. in length, and is 0.02 mm. in diameter. Just before it enters the intestine the globular "cardia," already described by Cleland and Johnston, is always found, though not always clearly distinguishable. The position of this cardia, measured from the anterior tip of the head, is seen to be at 0.57 to 0.86 mm., and has no invariable relationship to the position of the vulva, as affirmed by Cleland and Johnston. The extreme length and diameter of this cardia is usually 0.031 mm., though in specimen B, in which it was distended by a number of refractive granules, it was 0.069 mm. long by 0.04 mm. wide. The apparent condition of the junction of œsophagus and intestine varies naturally with the more or less sinuous condition of the œsophagus at the time of fixing ; sometimes, as seen in fig. 5, the œsophagus is practically straight till it reaches the cardia at 0.41 mm. from the anterior tip, while in the specimen in which the extreme position of 0.86 mm. from the anterior end was reached, the œsophagus is much more sinuous. Though sometimes situated at the termination of the œsophagus, the cardia is at other times slightly in front of the entrance of the intestine.

As a rule it is easy, unless hidden by the vagina, to detect the exact junction because of the muscular walls, the cuticular lining and, therefore, sharply marked lumen of the œsophagus and cardia and the slightly wider non-muscular intestine (figs. 5, 6, 7, 8, 32 and 34), with irregular indefinite lumen and usually much darker walls. The walls of the cardia are more muscular than those of the remainder of the œsophagus, and the lumen not much greater.

The chyle intestine varies about 0.046 mm. in diameter, its lumen being in parts nearly obliterated. At about 0.207 mm. from the anai opening, where it passes into the rectum, the posterior end of the chyle intestine is suddenly constricted to about one-third its previous diameter.

The rectum (fig. 8) is a much swollen flask or pear-shaped structure, its total length being 0.2 mm., and its maximum diameter 0.082 mm. The lining of the rectum is chitinous, and it contains a considerable quantity of granular material.

Nearly 0.2 mm. in front of the junction of the chyle intestine and the rectum there begins an irregular group of cells (*see* fig. 8), which extends back to slightly behind this plane, and, doubtless, comparable to those found in many other nematodes, though usually less numerous than in this form, and variously described in other forms as ganglion cells, or, more generally, as unicellular glands. They lie in *O. gibsoni* chiefly on the ventral surface, though they extend half-way up the sides of the body, being attached to the body wall. The granular material in the rectum has a similar appearance to the content of the cells now under consideration. Whether these cells are the exact equivalent of the three large pear-shaped cells described by various authors (quoted by Looss in the "Sclerostomes of Horses and Donkeys," in the report of the Egyptian School of Medicine, Cairo, 1901, p. 58) is uncertain, though probable. Their large number in this form makes one hopeful that a further study of them may elucidate their morphological and physiological character—but as only one of the female tails we have obtained is of good histological preservation, and as so far the tail of the female has not been found, or at least recorded, by other observers, we do not wish to use it for section purposes, at all events at present.

Surrounding the body at the level of the anal opening is a muscle band, the fibres of which spread dorsally in a fan-like manner, very similar to that found in other nematodes in a comparable position.

In the anterior end of the body of several worms, but especially clearly in specimen C, were to be seen three small brownish yellow disc-like structures, the largest of which was 0.0189 mm., the others 0.0146 mm. in diameter, lying in the body cavity. They consist of about a dozen highly refractile yellowish granules, which are larger in the larger structures. Their position, in relation to the other organs of the body cavity, is indicated in fig. 6.

Muscular System and Longitudinal Bands.—The division into four quadrants usually seen in a transverse section of a nematode is in *Onchocerca gibsoni* very obscure, and often not really present through the greater part of its length (*see* figs. 32-34). A diagrammatic representation of what appears to be normal for the main length of the male and female worms is given in fig. 36. This shows practically only a dorsal and ventral part of the musculature, separated by more or less distinct lateral bands. Although shown almost symmetrical, these bands are nearly always strongly asymmetrical in the female (*compare* figs. 32-34), that on one side or the other being hardly noticeable. We have not been able to find any definite relationship of these reduced lateral bands to the interior or exterior part of the nodule, such as we thought possible.

When any particular coil is close to the boundary of the worm area, then more often the better developed band is towards the periphery of the nodule, but the reverse is often found towards the centre of the worm mass. The dorsal and ventral median bands are not distinguishable, their position being only detected in rare cases by very small dorsal and median nerve strands (*compare* fig. 36). The whole body wall is very thin, giving a relatively large body cavity, which only occasionally and in parts contains a granular material which nearly fills it, presumably coagulated hæmolymph.

In transverse section the irregular ridges of the cuticle are seen as papillæ-like points here and there on the surface. The hypodermis is usually thin, and embedded on its inner surface are the contractile parts of the muscular elements, which have the general appearance of a radiate border to the hypodermis. The inner protoplasmic parts of the muscles are vesicular, forming irregular meshes on the inner side of the body wall. These characters of the musculature are often hardly distinguishable, so attenuated do they become in the thinning out of the whole wall.

In the anterior part of the bodies of both male and female worms, however, the structure of the body wall more nearly approaches the nematode structure (*compare* fig. 37). This is only to be found, however, in that anterior part of the worms which does not exceed about 0.095 mm. in the male and 0.175 mm. in the female. Here, as will be seen from the figure, especially in the female, the lateral bands are strongly developed, and together occupy about two-thirds of the entire body circumference. Sometimes each shows traces of a division into dorsal and ventral halves.

The dorsal and ventral ridges are only slightly developed, but are very definite. The four small remaining intervals are occupied by the muscle cells, the protoplasmic portions of which are comparatively small. As one passes backwards this well-defined and symmetrical arrangement rapidly becomes lost with the increase in diameter of the worm, the great thinning out of the wall and consequent increase in the size of the body cavity resulting in the marked asymmetry described above.

Nervous System.—(*See* figs. 5, 6, 7, 32-34, 36, and 37.) This together with the excretory system is very difficult to observe, and what one does observe is difficult to interpret. The nerve ring, which is usually indistinct, especially in the male, lies from 0.172 to 0.188 mm. in the male and 0.142 to 0.188 mm. in the female from the anterior end. These variations have no relation to any condition of possible contraction of the worm. The most common distance is about 0.170 mm., that given by Cleland and Johnston, namely, 0.18 mm., being less frequent.

So far as can be determined at present the nerve bands appear to form an irregular plexus around the head, in which what are possibly nerve cells are to be seen. No anal ganglia have been detected. Behind the nerve ring, with its nerve cells, the nerve fibres are arranged as a tiny bundle in the centre of the dorsal and ventral median bands, and in a more or less diffuse manner in the inner parts of the lateral bands (*see* fig. 37). With the change of structure of the longitudinal bands, as we pass backwards along the body, the character of the longitudinal nerves alters also.

Dorsal and ventral nerve strands are present, consisting of very few fibres, six to eight, which lie in the ordinary hypodermis of the body wall, no swollen or projecting bands being present.

The lateral nerve elements are, however, much more developed, though even here often impossible to find with certainty. In general it may be stated that there are two lateral longitudinal nerves more or less well developed on each side, as shown in figs. 33a, b, c, 34, and 36. In the sub-cuticular layer of this region there are also sometimes to be found, even when the lateral nerves are difficult to determine, a row of nuclei (*compare* fig. 33a) which are apparently connected, at all events at intervals, by fibres with the lateral nerve strands. At other times these nerve fibres from the lateral nerves run out very definitely and end in branches immediately under the cuticle, though no sense papillæ have been detected. These nuclei may extend over the whole lateral band or may only show over its dorsal and ventral two-thirds.

Excretory System.—(*See* figs. 6, 7, 32, 33, 34, 35, 36.) This when best defined consists in main part of the body length of a double or single canal (*see* figs. 33a and 33b) which lies between the two lateral nerve strands in the lateral band. Like these nerves, the excretory canals are sometimes hardly distinguishable on one side of the body (*compare* fig. 32), while in the same section the lateral band of the other side may be so vesicular in character (fig. 33c and 34), apparently due to excretory tissue, as to make it difficult to find any hypodermis or sub-cuticular tissue at all, and even on occasion to determine the boundary between this and the protoplasmic meshes of the muscle cells. One of the cavities in this structure near its centre is often more definite than the remainder, and evidently represents a normal excretory passage. Apparently the lateral bands are chiefly composed of what is potentially excretory tissue which may become more or less vesicular, or may be traversed by one or more definite canals that pass along one side of the body. On the other side it may be reduced almost and sometimes quite beyond recognition, at all events at parts. This asymmetry is totally unlike anything which we have been able to find in the literature at our disposal, though possibly it is not unique In that anterior part of the body in which the four longitudinal bands are well defined, the excretory canals are most clearly seen in those parts where the lateral band shows the more marked division into two halves ; the canals are then situated some distance below the cuticle and between the two halves of the lateral bands, and are slit-like in character (*see* fig. 37).

Near the level of the excretory pore two broad projecting ridges from the lateral lines (*see* fig. 35) approach the centre of the body cavity, near which they become much thinner and more sharply defined. They then unite, forming a narrow band almost homogeneous in nature as are the ridges ; this runs ventralwards to the mid-ventral line. In each ridge can be traced a proportionally very small but distinct lumen, the lateral excretory vessel. Each of these is continued down into the median portion, and may further be traced to the very minute excretory pore which opens as described above.

Reproductive System—Male.—So far as we have been able to determine, the male reproductive organs are single throughout their length. The single wide vas deferens crowded with developing sperm occupies a large portion of the body cavity, compressing the intestine. It passes back to open as usual into the cloaca by the ductus ejaculatorius.

The two unequal spicules (*see* fig. 10) in our specimens are respectively 0.148 to 0.155 mm. long, by 0.0078 to 0.01 mm. wide, in the middle of its length, and 0.078 to 0.094 mm. long by 0.0061 to 0.0078 mm. wide. There is thus evidently a variation in the lengths of the spicules, but we do not find such a variation as is indicated by Cleland and Johnston, who have given as the respective lengths of these spicules 0.14 and 0.047 mm., and 0.197 and 0.082 mm. in their two reports. Both are hollow and have the usual funnel-shaped opening at the inner end and closed distal end. The longer spicule, which is the left-hand one, is usually once twisted and has a finely pointed distal end. The right-hand shorter spicule has an enlarged shoe, or boat-shaped outer end, not unlike that seen in such Filariidæ as some species of Oxyspirura, the grooved upper surface serving for a guide for the sharp end of the long spicule.

Female.—The ovaries are double and lead straight into the long and slightly coiled double uterus. The wall of the uterus (fig. 32), when undistended, consists of distinctly nucleated and granular cells surrounded by a very thin fibrous layer. When distended the wall appears as a very thin fibrous one in which nuclei are apparent, cell divisions being apparently lost. The two uteri unite without much change of structure to form a common uterus of remarkably varying length. This in turn opens to the exterior at the vulva by a short muscular vagina. The vagina is seen in specimen C, which was the only infertile one of these six, to be 0.414 mm. long, having close to the vulva an even more muscular swelling (*see* fig. 6). The single uterus, non-muscular or only slightly so, passes back for a distance of 1.38 mm. before dividing into the two uteri corresponding to the two much coiled ovaries. As remarked above, this specimen contains no fertilised eggs or larvæ.

In other cases the total length of the vagina and common uterus varies from 1.656 mm. to 5.10 mm., in each case being crowded with larvæ, as is also one or both halves of the bifurcated uterus. There is, so far as our specimens show, no relationship between the position of the vulva relative to the head and the length of the common uterus.

Development.

By counting the average number of larvæ in a transverse section of known thickness, and calculating the egg-bearing area of the shortest and longest worms measured, we have estimated the number of fertilised eggs and larvæ present in the worm at any one time as certainly not less than 400,000 in the shortest to 2,000,000 in the longest. In the case of those nodules in which the male worm is present with the female the possibility or even probability of nearly continuous, or at least repeated fertilisation enormously increases the reproductive capacity of these worms, a fact which undoubtedly points to the life-history being a very difficult one, with every likelihood of non-completion. As remarked above, very few infertile nodules have been found, and even where fertile very often no sign of the presence or even past presence of a male could be found.

The unsegmented fertilised ovum (*see* fig. 13) is 0.017 mm. by 0.009 mm., the nucleus being large, round, and finely granular. Segmentation proceeds very rapidly, so that in good smears from the cut surface of a fertile nodule the full process of segmentation can be traced.

The first result of segmentation is very commonly met with in such a smear, and this two-celled stage shows very considerable variation in size, even more than shown in the figures (*see* figs. 14 and 14A), namely, from 0.019 mm. by 0.009 mm. to 0.02 mm. by 0.017 mm. Thence division proceeds more or less regularly, as shown in figs. 15-18 : four, five, six, seven, ten, fourteen, sixteen, seventeen, up to thirty-two celled stages being observed; the nuclei in the latter stages becoming smaller and more oval or elliptical. This fully-formed morula or mulberry stage is sometimes common. In the next stage normally the embryo loses the oval form and assumes the almost comma-like stage (fig. 19) found in the development of various other nematode eggs, though here the tail of the comma is very much less pointed than in such forms as *Agchylostoma duodenale* or *Ascaris lumbricoides.* Also we have been unable to detect any such definite difference in size of the nuclei at the two poles, such as is found in some forms, for example, *Stephanurus dentatus.* Successive stages to this (for example, figs. 20 to 25) show a gradual elongation and narrowing of the protoplasmic body of the parasite, this increased length being compensated by a more or less involved coiling of the embryo, which, however, usually comes later to lie in a less complicated manner. The comparatively few large nearly spherical nuclei of the morula and comma stages become converted by rapid division, so that in the stage represented by figs. 22 and 23, in which the well-marked outline is clearly present, there may be as many as six rows of nuclei. The diminishing size and increase in number of the nuclei is shown in the figures, which are all drawn by camera lucida. It will be noted from the figures that in this development there is no division of the general protoplasm into cells corresponding to that of the original nucleus into the numerous nuclei of the later stages. The protoplasm with its nuclei forms at first an oval syncytium, which becomes much elongated into a thread-like syncytium.

In some smears, however, obtained on different occasions, some strange and puzzling appearances were noted. The first of these suggests itself as being a stage immediately succeeding the morula stage, and shows the oval syncytium, the nuclei being arranged in a definite convoluted chain, as represented in fig. 26. A number of similar eggs were noted on several occasions. The second appearance (*see* fig. 27) shows a lobulated protoplasmic mass with a tendency to convolution, of bands of much smaller nuclei, and might be regarded in some way as intermediate between fig. 26 and figs. 24 or 25. The change in structure is apparently due to the longitudinal and transverse division of the nuclei forming the single chain just described, the form of a coiled chain of nuclei now much smaller and more numerous being retained in a more or less definite manner. In the light of present knowledge we cannot but regard these two apparent stages in the development as at least abnormal. If they be not artifacts, which there is no reason to believe they are, then the oval syncytium of the morula stage in these cases must have become converted into the coiled solid cord or protoplasm which forms the fully developed embryo by division and arrangement of the nuclei and an aggregation of the protoplasm around them, the latter splitting in the lines between these linear aggregations of nuclei and protoplasm. So far as we are aware such a method of development is unknown in any other animal, and we cannot yet regard it as a normal method of development. The presence of such stages as shown in figs. 26 and 27, compared with those shown in figs. 19, 20, and 21, is very difficult to understand.

The larva (figs. 28 and 29) is now definitely outlined, and consists for the most part of two, three, or four layers of cells, regularly arranged, but showing here and there spherical nuclei, staining pinkish with Giemsa, as contrasted with the double row of purplish nuclei, of which the body is chiefly composed. At this stage the head is often differentiated, and rarely and indistinctly the beginnings of the V and tali-spots may be detected, becoming more definite very soon. The normal position of the larva in the latter part of this stage is in a flattened open coil, the head being nearest the enveloping egg membrane when present with the tail to the centre of the coil. Its length is usually 0.155 mm. The whole egg measures at this stage 0.043 to 0.045 mm. by 0.03 to 0.039 mm. In contradistinction to many forms the egg of this worm does not appear to possess an egg-shell invariably, or even usually, in its earlier stages, as shown in figs. 13 to 23, a fact which mainly accounts for the absence of empty egg shells, observed and commented on by Cleland and Johnston. Occasionally, however, a delicate homogeneous enveloping membrane, but with more deeply staining spots, is to be seen round the immature larva, for example, fig. 24. Evidently the adaptation of the egg to its environment does not require the constant presence of any special egg shell.

The normal dimensions of the newly-liberated larva are 0.23 to 0.35 mm. long by 0.0031 to 0.0041 mm. wide ; no sheath is apparent. The larvæ when free in the common uterus are somewhat wavy and closely packed together. When free, whether in the surrounding fluid or traversing the fibrous capsule, their body is distinctly undulating, the head being straight and the tail sharply recurved.

The larva is now marked out more or less definitely into five areas. The extreme anterior (0.0025 to 0.0049 mm.) and posterior (0.0093 to 0.0132 mm.) ends are more or less hyaline in appearance, being devoid of nuclei. The distance of these areas from the anterior ends, as seen in a typical larva of 0.25 mm., are, to the V spot, 0.06 mm., thence to w 0.071 mm., thence to x 0.048 mm., thence to the tail spot y 0.031 mm., thence to the tip of the tail 0.04 mm., and these figures may be taken as giving the average position of the areas in question. The extreme anterior end appears rarely to carry a spear-like process which stains more deeply than the rest of this hyaline portion. Immediately succeeding this hyaline head-end are two rows of long elliptical nuclei, one of which is often in advance of the remainder. Just in front of the well-marked spot, about 0.05 mm. from the anterior end, is a group of finely granular cells, evidently the rudiment of the nerve ring. The nuclei are much more densely packed just in front of and just behind the V spot ; behind this again they are more separated, until just behind the indefinite gap often present at w they are most closely arranged. The gap at x is also often very ill-defined, the nuclei being, however, crowded back to and behind the very sharply-marked spot y.

Although there is no sheath present the transverse striations of the surface of the body of the larva may be sometimes clearly seen.

The movements of the larvæ may be well studied in the fluid from a fresh nodule. Under such conditions their movement is seen to be sinuous and also whip-like, certainly progressive, and at times rapidly so.

In our preliminary examinations we constantly observed, on careful incision of the nodule without injury to the adult parasite, a slight oozing of the serous fluid from the worm-area. Examination of this fluid in the majority of cases revealed the presence of free larvæ; only when the parasite was cut were eggs detected. It was further noted that usually scrapings from just within the periphery of the fibrous tissue, when examined microscopically, would show the presence of free larvæ. These observations are confirmed by sections of worm nodules. It is remarkable however, how comparatively few of these larvæ are to be found external to the parasite within the tunnels, even when the larvæ are singularly numerous in the dense capsule. That these larvæ are not squeezed into the fibrous tissue during the process of removal or handling, or carried by the knife during sectioning, or confined to one particular part, is shown by a number of serial sections of a large piece of the peripheral wall of the largest nodule showing no trace of adult parasite. In these sections the larvæ are seen to be very numerous, and just as numerous near the periphery as elsewhere (fig. 30).

Although frequently found lying in close proximity (fig. 31), in no instance have we been able to demonstrate their presence in a blood vessel; often, however, they may be seen within lymph spaces, and it seems to us probable they reach the blood stream by the lymph channels rather than by piercing the much thickened walls of the blood vessels. Like Cleland and Johnston, we have failed to detect any larvæ in the blood of infected animals, even by examination of large quantities after centrifugalising. We suggest that the arteritis, which is such a marked feature in the histology of the large nodules (*see* fig. 30), is probably due to the irritation caused by the presence and movements of the larvæ.

Within the nodule, even twenty-four hours after the death of the host, living larvæ may almost invariably be detected. It is probable from the following evidence that they are not capable of living many days in the free state within the living host. As a result of numerous subcutaneous injections of enormous numbers of freely motile larvæ, eggs, etc., into cattle, examination of aspirated fluid, twenty-four hours later, often showed that most of the larvæ had disappeared; slight movement of some of the remaining larvæ was present, but motility had disappeared in the majority. On the second day, when the fluid was again aspirated, movement of the very few remaining larvæ had entirely ceased. Rarely are eggs found twenty-four hours after injection of such fluid. While this evidence is, of course, not conclusive, it indicates a comparatively brief history of the larvæ in the host of the adult.

Life-History.

That the life-history of these filariæ is an extremely difficult and probably complex one is indicated by a number of factors. There is, first of all, the enormous number of eggs and larvæ (averaging a million) present at one time in the fertile female, in addition to which there is the constant expulsion of free larvæ. This, compared with the comparatively few adults, fifty at most, found even in the most severely affected animal, alone demonstrates that the possibility of an individual larva ever attaining maturity is extremely remote.

Is an intermediary host necessary? By analogy with allied parasites this may almost be taken for granted. The possibility of a free existence must, nevertheless, be considered. Our observations and experiments negative this supposition. For example, we have seen the larvæ do not live longer than thirty-six hours in normal saline, even at blood heat. Further, larvæ sown on plots of grass at about 30° C., in a moist atmosphere, rapidly died, and although frequent examination from twenty-four hours later up to six weeks were made of the grass and soil, nothing that would even suggest a development could be found. Again, on several occasions, we have injected large numbers of living larvæ into the subcutaneous and muscular tissues of young cattle. Subsequent post-mortem examination of one, four months later, failed to detect any indications of the development of a worm nodule. Similar results followed the smearing of larvæ on the skin of the axilla and groin. It should be noted that in none of these cases larvæ could be detected in the blood after inoculation. Desiccation of the larvæ, at blood heat, causes their death in at least twenty-four hours. These observations and experiments seem to answer our question in the affirmative: an intermediary host is required in the development of these filariæ.

Possible Intermediary Hosts.

Carnivora, e.g., Native Dogs (*Dingo*), *Station Dogs, and Wild Pigs.*—These may be excluded. Even the native dog never attacks healthy cattle, and rarely, if ever, devours the carcases of bullocks. Cattle dogs on the stations are few, and rarely accompany the men; the amount of fresh meat with the exception of offal they secure is extremely small, and briskets are seldom, if ever, thrown to them. It would be difficult under any circumstances for any dogs to secure the living parasites.

Wild pigs, which are numerous in some coastal stations, may also be excluded. In any case, we have seen a carcase opened and left lying in the vicinity of a wild-pig camp and remain untouched by these animals.

Ticks.—The ticks may be likewise disposed of. The nodules were observed long before the advent of the tick in Queensland, and are numerous on many stations where the tick is unknown. In any case it is unlikely that the large larvæ of the filariæ would be able to pass into the egg of the tick. Further, the infection, were the parasite tick borne, would be very much greater

Leeches —These offer a possible intermediary. The fact, however, that the nodules are as numerous in dry districts, where stations mainly depend on artesian bores for water, is against the supposition.

Water Crustacea, Etc.—These are, of course, also possible intermediary hosts.

Biting Flies.—These have certainly to be considered very probable intermediaries. As against their operation is the likelihood that, with such widely and easily spread insects, no part of Australia (including Tasmania) would by this time be free of infection by worm nodules ; and, further, one would expect a greater and more general affection in individual animals.

As regards all these possible conveyers, the age incidence is a serious obstacle, and we are seriously inclined to suspect the intermediation of some parasite more liable to attack the younger animal.

The Louse.—This offers the most hopeful possibility. It may be one of the common species, or a new one hitherto undetermined. The louse is a frequent parasite, especially on young cattle, although rarely detected until the host becomes debilitated, when it rapidly increases in numbers, as is the experience of every stockman. Adult cattle are seldom under any conditions troubled to the same extent. The louse is a parasite which, it must be remembered, does not remain stationary. In cattle under station conditions, which are seldom in actual contact with each other, unless when travelled or yarded, the natural means of transmission would be by intermediary of the ground, particularly the camps and places of rest near water. Assuming the louse on swallowing a larva or larvæ loosens its hold and drops off—as we have observed it does under experimental conditions after inoculation of larvæ into a " lousy " cow—on reaching a fresh host the place most readily attacked would be where the skin comes in contact with the ground, and where it is comparatively soft covering loose areolar tissue, and, further, where there is little chance of the parasite being licked off. The regions behind the shoulder and behind the stifle meet these conditions, invariably and constantly touching the ground when the bovine is recumbent. The fact that of the hind quarters the right is the most frequent attacked, and that on this the bullock generally rests, is also suggestive. If, therefore, the louse injects the young filariæ into the subcutaneous tissues immediately after reaching a new host, the argument is fairly complete. At any rate some definite explanation is required to account for these filariæ establishing themselves invariably in the same regions ; and this uniformity of condition is very difficult to understand on any other theory.

The reasons we consider indicative of louse transmission may be summarised as follows :—

1. The constant infection of young animals (one to two years) to an extent equal with that of old.

2. The frequent presence of lice on young animals in debilitated condition due to any cause.

3. The fact that in fat and adult cattle at abattoirs the nodules are practically never found smaller in size than one and a-half centimetres in diameter, even after most careful examination. This indicates a seasonal incidence perhaps corresponding to a more or less recurrent loss of condition, due to circumstances connected with age and possibly food, thus favouring the entrance of the worm.

4. The situation of the nodules under the parts of the skin most readily attacked by the louse when picked up from the ground.

5. The gradual and slow advance of the infection from north to south.

Although, as above, the possibility of other blood-sucking parasites, including the mosquito, acting as intermediary hosts has not been overlooked, we are of opinion that at present the louse is worthy of most attention for these reasons. Should experiments on these lines which we are carrying out prove negative, and another intermediary host require to be sought for, complete proof will be a matter of difficulty, especially in Queensland, where it is impossible to be certain that experimental cattle, unless imported from the far south, are, to commence with, free from any nodule.

Experiments thus far conducted on a heifer badly infested with lice (*Hæmatopinus vituli*), which was injected on several occasions subcutaneously with quantities of living and motile larvæ, eggs, etc., showed that as a result the adult lice drop off the skin within a few hours. That this is not due to the larvæ alone, but rather to the distension of the subcutaneous tissues, is proved by similar effects following injection of sterile normal saline. That the lice may, however, ingest larvæ, and that these may live and grow in the louse, was proved by the discovery of one living and motile larva in the body cavity of one of the lice removed from the skin of the infected area twenty-four hours after injection. This larva was entangled with the malpighian tubes, from which it appeared to be trying to free itself. The passage of lice to and from the injected area was prevented by a ring of tar on a clipped surface. Lice from these inoculated areas have been transferred to a calf, and the results are being awaited with interest.

PROTOZOA PARASITIC IN ONCHOCERCA GIBSONI.

(*See* figs. 32 and 34, *ut. p.*)

In smears made from the worm-area of a cut nodule one may often encounter isolated spindle-shaped cells which are not infrequently arranged in a rosette-like manner, much as is found in the Herpetomonas or Crithidia, as well as other types. In the examination of serial sections through the worm, these may be found in one or both of the genital tubes. A discussion of their morphology, relationships, and life history is reserved for a future paper.

For their assistance and courtesy extended in this investigation, we desire to record our thanks to the Inspectors and other officials of the Department of Agriculture in Queensland, especially to Mr. Orr, Chief Inspector of Stock, and to the managers of the various freezing works; and, in addition, we express our grateful appreciation of the assistance rendered in the preparation of material by Mr. Norman MacDonald, B.V.Sc., Government Research Scholar of this Department.

ADDENDUM.

Since the above was communicated, two papers bearing on this subject of Onchocerciasis in Cattle, that have just appeared in European publications, have been received by us.

The first of these, "Un Nouveau Nematode Parasite du Bœuf," by Professor Neumann, of Toulouse (*Revue Veterinaire*, May, 1910), is of especial interest, dealing as it does with a condition in cattle in Algeria and Tunis, in some respects closely comparable with that herein described, and caused by an allied though quite distinct nematode hitherto unknown, viz., *Onchocerca gutturosa*, Neumann, 1910. The importance of this discovery in cattle in North Africa is considerable from an economic not less than a scientific point of view, as previously to this the " worm nodules " of Australian cattle have been regarded as unique, all other species of Onchocerca being known only from man in Africa, and such animals as are not under ordinary conditions used for food—*e.g.*, the horse, zebra, buffalo, and camel ; or else from parts of cattle not used as food. Neumann considers it possible that the Australian *Onchocerca gibsoni* is the same as that of the Algerian form, but such is not by any means the case. The two species—*O. gutturosa* and *O. gibsoni*—are quite distinct, not only in structure, but also as a rule the position of the nodule, which in the Algerian form is usually on the inner face of the cervical ligament, rarely on the thigh, and apparently never in the sternal region, so that they are not, while thus situated, nearly so objectionable commercially as the nodules formed by *O. gibsoni*.

The second paper, a report to the Local Government Board, London, by Dr. MacFadden and Dr. Leiper (1911), on the Onchocerciasis of Australian Cattle, offers little that had not already been published by Messrs. Cleland and Johnston. In reference to the general anatomy of the nematode, while confirming much that those authors and ourselves have stated, Drs. MacFadden and Leiper in several points agree more closely with ourselves in details in which we have differed from those authors. They have missed the presence of the first pair of caudal papillæ, which are undoubtedly present in the male, and so have incorrectly described the worm as having only six pairs of genital papillæ instead of seven pairs.

The detailed structure of the worm has not been described at all, nor is there any reference to the excretory system, so that we are unable to make any comparisons on these most difficult parts of the subject.

NOTE ADDED OCTOBER, 1911.

While this paper was passing through the press we have had an opportunity of consulting " Enterprise in Tropical Australia " (1846), in which the author, Mr. G. W. Earl, writes of the importation into the settlements at Melville Island and Raffles Bay of " stock from the Dutch town of Coepang, at the south-west extreme of the Island of Timor " (p. 44), apparently *circiter* 1824. He also definitely records (p. 65) that in the year 1840, amongst a number of vessels which brought supplies, including cattle from neighbouring European settlements in the Indian Archipelago, " the ' Lulworth,' an English schooner on a trading voyage among the Indian Islands, . . . brought cattle, horses, and maize from Coepang " to the British settlement at Port Essington, other vessels also following later from Coepang.

Further, we have recently seen a copy of a dispatch by Captain Everard Home, dated from H.M.S. " North Star," 19th April, 1843, which constitutes a report on the Port Essington settlement of that period. In this he mentioned besides buffalo, English cattle, etc., the presence of Indian cattle. We are informed, too, that the descendants of these Indian cattle are now running wild on Coburg Peninsula. In addition to this we have been advised by Mr. H. W. H. Stevens, of Brisbane, and others, that the British-Australian Telegraph Company imported into Port Darwin, about 1872, several cattle from Batavia, that subsequently some of these cattle were turned out and that they made their way back to the Adelaide River, where even to-day their crossbred descendants may be seen, indeed have recently been seen by one of us. Some of these crossbreds were examined and found to be badly infected with Onchocerca nodules, while several buffaloes were examined and found to be unaffected. There has thus been the possibility of the direct introduction of these parasites into Australia along with native Eastern cattle.

It is interesting in this connection to record that Mr. S. L. Symonds, Government Veterinary Surgeon in the Federated Malay States, informs us that he has " only once noted worm nodules in the Federated Malay States similar to those described in Queensland cattle, and these were found in an old Indian bullock." He further states, in response to a communication from us, that "he has examined cattle and buffaloes at the abattoir, but no nodules have been found."

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EXPLANATION OF PLATES.

ALL FIGURES ARE OUTLINED BY THE AID OF CAMERA LUCIDA

Reference letters.

a	anus.
a.p.	adanal papillæ.
b.v.	blood vessels in wall of nodule.
c.	cardia
c.c.	cells of doubtful character.
c'.	indistinct cardia.
c.m.	contractile part of muscle cells.
c.o.	cloacal opening.
c.u.	common uterus.
cut.	cuticle.
d.n.	dorsal nerve fibres.
d.s.	developing sperm in vas deferens.
e.	excretory canal (and excretory tissue generally).
e.b.	excretory bands.
e.p.	excretory pore.

e.x.	exit of worms from common canal.
f.t.	fibrous tissue of nodule.
i.	intestine.
l.	larvæ.
l.b.	lateral band.
l.s.	long spicule.
m.	muscular layer.
m.b.	muscle band.
n.p.	nerve plexus (?)
n.r.	nerve ring.
n.s.	nerve strand.
œ.	œsophagus.
o.p.	oral papillæ.
p.m.	protoplasmic part of muscle cells.
p.p.	pre-anal papillæ.
pt.p	post-anal papillæ.
r.	rectum.
s.	structures of doubtful character.
s.s.	short spicule.
t.	tunnel in nodule.
ut.	single uterus.
ut. o.	uterus with ova.
ut. p.	uterus with protozoan parasites.
va.	vagina.
v.n.	ventral nerve fibres.
vu.	vulva.
xx	boundaries of worm-area in interior part of nodule.
u, v, w, x, y	special points of larvæ.

Description of Figures.

Figure	1.	Photograph of groups of whole nodules.
,,	1A.	Same of four nodules, with large proportionate worm-area.
,,	2.	Same, with small proportionate worm-area. (=*xx*)
,,	3.	Partially dissected worm nodule. x 3.
,,	4.	Two heads. Male and female. Partially dissected out.
,,	4A.	Diagram showing method of coiling.
,,	5.	Head of female, with forward position of vulva. x 124.
,,	6.	Head of female, with backward position of vulva. x 78.
,,	7.	Anterior portion of female worm back to bifurcation of uterus. x 50.
,,	7A.	Head of female, showing papillæ. x 646.
,,	8,	Tail of female. x 96.
,,	9.	Whole male worm ; drawn when living. x 2.
,,	10.	Tail of normal male ; side view. (Thickness of cuticle very slightly exaggerated). x 545.
,,	11.	Tail of male, side view ; with abnormal papillæ. x 568.
,,	12A.	Diagram showing normal position of papillæ.
,,	12B.	Diagram showing abnormal position of papillæ.
,,	13.	Unicellular ovum. x 1060 (approx.).
,, ,,	14. 14A	Two-celled embryo. x 1060.
,,	15.	Four-celled embryo. x 1060.
,,	16.	Seven-celled embryo. x 1060.
,,	17.	Sixteen-celled embryo. x 1060.
,,	18.	Thirty-celled embryo. x 1060.
,,	19.	Thirty-six-celled embryo. "Comma" stage. x 1060.
Figures 20 to 25.		Successive stages in elongation and increase in size and complication of embryo. Fig. 20-22, x 1060. Fig. 23--25, x 1085.
Figure ,,	26. 27.	Abnormal (?) stages in development of embryo. x 1085.
,,	28.	Fully developed free larva from smear. x 610.

Figure 29. Fully developed larva from lymph space, 0.12 mm. from periphery of nodule. x 610.
,, 30. Small portion of section of periphery of much thickened wall of a large nodule, showing its structure and larvæ lying in lymph spaces close to surface. x 100 (approx.)
,, 31. Section of large less thickened artery, showing larvæ in periphery of wall. x 100 (approx.).

,, 32. Transverse section of body of worm lying in tunnel. To show general structure and protozoan parasites lying in one genital tube. x 105.
,, 33A, 33B, 33C. Transverse sections of lateral field, showing variations. x 105.
,, 34. Section to show a symmetry and special development of excretory tissue on one side. x 105.
,, 35. Transverse section through excretory bands carrying excretory canals towards mid-ventral line to excretory pore, as shown by dotted lines compiled from succeeding sections. x 112.
,, 36. Diagram to show general relations of nervous and excretory tracts in greater portion of body.
,, 37. Transverse section through male and female worms (anterior ends) and body of male. x 190.

14.—THE PROBABLE INFLUENCE OF RADIO-ACTIVITY IN

Plates XXII.—XXXVeII.

is an hypothesis of great interest and well worthy of consideration. In no way would such a problem conflict with Darwinism and its allied theories, but it would be an important additional causal factor in the origin of species and in the development of at least some of their primary characteristics.

Radio-activity, that is, the production of α, β or γ rays, was first recognised by its artificial production in the laboratory, but this discovery was soon followed by its recognition in nature in certain metallic ores. Nature's radio-activity has been traced to various radio-active substances, polonium, uranium, thorium, radium and actinium ; all of these give out α activity, all except polonium β activity, but only radium, and probably actinium, create γ activity. Minute quantities of these substances are found in most parts of the world, and also in certain natural springs and waters. All of these elements are undergoing constant change, and there is constant definite loss of particles, which must cause their final dissipation. Radium and uranium have been most studied. Frederick Soddy was the first to hold that uranium changes into radium, and Strutt and Bottwood, by an interesting series of deductions, have proved the life of uranium is 2,500,000 times the life of radium. The most recent calculations as to the life of radium are that it is 1750 years, or that one gramme of radium loses .6 milligramme in weight per annum. It is thus evident that the radio-active elements have a definite life before they pass on into the non-active elements in the evolution of the elements as enunciated primarily by Soddy.

If the radio-active elements are thus dissipating their substance and changing into non-active elements, the production of radio-activity must be waning in nature, and there must also be a definite, if remote, time when it will cease entirely. The quantity of existing radio-active elements must have been greater in the past, prior to their evolution into the commoner elements, and their distribution would naturally have been of far vaster extent than in the present era.

Each radio-active particle fires off radio-activity in all directions, and there must be, so to speak, an atmosphere of radio-activity. In the present state of knowledge, it thus appears that at some future date, millions of years probably, this natural radio-active atmosphere must fail. By reasoning backwards, it is also evident that the natural radio-active atmosphere of the past must have been far more excessive and intense than it is in the present, and in the earliest periods it must have been most excessive.

Some of the physical properties of the different forms of activity are of immediate importance in this paper. α, β and γ rays are all capable of absorption by the interposition, in their course, of screens of various thicknesses, and elemental composition, but the coefficient of absorption for each form of ray varies: α rays as generated by radium are completely absorbed by 7 cms. of air, β rays require up to 4 metres, depending on the hardness of the β rays; but γ rays require great thicknesses of metals to absorb or inhibit their course. α rays are charged with positive electricity, β rays with negative, and both are easily deflected by a magnet, whilst γ rays show no response to similar stimulus, and are not charged with electricity. In addition to the actual production of rays, radium, thorium and actinium give out an emanation, although polonium and uranium do not; this emanation is important, and is a gaseous substance possessing radio-active properties; it is very unstable, and loses half its activity in four days, and is easily and completely absorbed from the atmosphere by certain substances—*e.g.*, cocoanut charcoal. It is also absorbed by water, and underground waters are particularly rich in it.

α and β activity may also be created by the impingement of a γ ray on a metallic molecule, and it is found that the intensity of the activity thus evolved varies with the atomic weight of the molecule bombarded.

Consider now the action of radio-activity on plant and animal life: in general terms this may be stated, that excessive radio-activity totally destroys life, medium radio-activity is irritative and stimulates growth, whilst diminished radio-activity causes no immediate effects, but continued exposure to this attenuated activity causes the cumulative re-action to have effect. This cumulative re-action is mainly effective on the more sensitive highly specialised cells. In fact, the re-action to all forms of radio-activity has a direct relation to the molecular stability of the cellular constituents, and the younger or more highly specialised a cell, the greater is its molecular instability in a general sense. There is also, further, the action of decaying emanations, which causes hyperæmia of the exposed parts, but it must be remembered that the emanations are gaseous and can therefore reach directly the more remote parts of a respiratory apparatus, which can only be reached by radio-activity itself through the body walls, which have naturally an inhibitory effect. Again, it is a general truth that the physiological effects of all irradiations occur where they are absorbed, and in consequence the coefficient of absorption of the different tissues for each form of radio-activity must be remembered.

The proofs of these generalisations are abundant. Danysz found that excessive radio-activity caused convulsions, paralysis and death in 10 days of a mouse, and the effect was due to γ rays, and penetrating β activity. Bacilli anthracis were destroyed in 2-4 hours. A. B. Green found that the radio-activity of 10 mgs. of pure Ra Bromide killed B.C.C. and the spirillum of cholera in six hours. He also found that the micro-organisms killed by irradiation give rise themselves to β activity. Dorn, Baumann and Valentiner, experimenting with 30 mgs. of Ra Bromide, found that all germs submitted to the radio activity were at first arrested in their growth, and finally killed in periods, varying up to ten days.

Zuelzer found in all cases that excessive radio-activity caused death: Pelomyxa was killed in from 10 minutes to 4 hours, amboebae in 3 to 4 hours. Shelled organisms (*e.g.*, difflugia and arcella) were shown to be more resistant; after 10 minutes' exposure to radio-activity their pseudopodia were withdrawn, and they dropped to the bottom of the vessel; after continuing the exposure for three days they were placed in a fresh culture, and in two hours their vitality was completely restored. He found that in small doses radio-activity was a stimulant, in large doses a destroyer. These results have been confirmed by Dreyer, Wilcock and Salmonsen amongst others.

Bohn, experimenting on the larvæ of frogs and Bufo vulgaris, found that development was retarded and pathological monsters were created, many of which died. The characteristic feature of these monsters was that the dermis was very much affected and contorted. This latter is an important point. Perthes obtained similar results by experimenting on Ascaris megalocephala, and Schafer on Rana esculenta.

In the plant kingdom very similar results have been obtained. Gager's most important results are summarised :—

"The early stages of seed germination are accelerated, if stimulation ranges between the minimum and optimum points, otherwise they are retarded. Seeds are less sensitive to the rays, when dry than when soaked When seeds are stimulated during germination, subsequent growth is retarded; but radium rays, acting through soil in which plants are growing, accelerate both germination and subsequent growth of the shoot. The growth of plants is retarded in an atmosphere of decaying radium emanations."

Kornicke found that moderate radio-activity caused excessive growth of the chorophyll portion of a growing plant, and both he and Molisch found that seeds subjected to radio-activity of small amount produced deformed seedlings through a diminution of their heliotropic powers.

Organisms constantly exposed to attenuated radio-activity are affected by what is known as the cumulative re-action. Working collateral with this must be the factor of decaying radium emanations, and it is probable that the effects of these emanations would be more pronounced in a sphere of attenuated activity, since in such a sphere they would not be marked by the stronger and more obvious effects of direct radio-activity. In vascular organisms the effects of the decaying emanations are chiefly evidenced by hyperæmia in the least resisting or most exposed tissues, for example, the skin and the lungs ; this is abundantly proved by Curie, Bouchard, Dorn and Wallstabe. In the higher animals it is also found that constant exposure to attenuated activity produces a marked influence on highly specialised cells, causing loss of function, especially in the organs of generation.

The possibility of the bearing of these facts on the origin of life and species as an important factor seems reasonable.

The primeval earth was probably a molten mass, surrounded by an atmosphere of aqueous vapor. All the conditions then extant prohibited life, as is now well recognised. How far the natural production of radio-activity would be affected by this molten mass it is unnecessary to discuss in this paper, but commencing with the period immediately succeeding this in the earth's history, it would be the period of greatest natural radio-activity from reasons advanced previously. This period commenced as the earth cooled, the aqueous vapor condensed, and vast oceans were formed surrounding land consisting of primeval rock, gneiss or continental granite. At the beginning on this barren land and in the shallower oceans and at all the margins and depths the radio-activity would still have been so excessive that no fauna or flora could be created. But at the surface of the ocean, in the areas where there was considerable depth, the inhibitory effects of the water on the natural radio-activity would be apparent, and thus only in this locale of the globe was it then possible for the primeval life to exist. It is here that geologists have assigned the habitat of the earliest known genera, minute radiolarians (*Spumellaria* and *Nassellaria*) of simple spherical or ellipsoid characters. Any of the primitive organisms, which attempted at first to go close to the bottom of the ocean or drift into shallower waters, lost their protecting shield of water and came within reach of the excessive radio-activity of the earth and were killed, their bodies being rendered α and β active, and were strewn on the floor of the ocean. At the same time many of the organisms must have died from natural causes at the surface, and their dead bodies would sink to the bottom ; these would be non-active. Thus, in course of time, the bottom of the ocean was strewn with dead organisms, partly β active and partly non-active, forming a layer of organic debris, which would possess inhibitory powers of its own over the natural radio-activity. By the increase in the thickness of this layer, which naturally would be variable, the inhibitory effects were more appreciable, and it became possible for living organisms to exist at gradually increasing depths.

The organisms, whose original habitat was the surface of the greatest depths, naturally spread downwards and laterally, and those living organisms which reached the deeper parts of the ocean or the shallower waters, where the layer was still thin, were killed ; where the layer was thicker, were irritated and formed pathological monsters, which lived for some time and died without reproducing their kind ; but where the layer was still thicker, the irritation was very slight and caused slight modifications and increase of growth without inhibiting the power of reproduction. Certain of these modifications and increase of growth would be transmitted to their descendants, and though almost imperceptible probably at first, in the course of centuries the same process on innumerable successive generations would make the modification a permanent characteristic and give rise to a new type. This was the creation of a new genus or species.

During this period of time some of the accumulations of dead organic matter in the depths of the ocean were being moved by the action of the waters and primeval storms nearer and nearer to the edges of the barren lands, until finally the fringe of this land was actually covered by a deposit of this dead organic *debris*. This process was assisted also by organisms dying and falling to the bottom, as the area at the surface in which life was capable of support was increased by the shifting of the deposit further and further towards the land, and so reducing the effects of the earth's natural radio-activity. All this would be a process of numberless centuries, and at the same time also the earth's radio-activity was being very gradually diminished.

It is a general truth that the effects of irradiation are manifested only where the rays are absorbed, and whilst the organisms were of minute size, those rays which were absorbed would be felt by the more vital central cellular elements ; but as the organism increased in size certain rays, depending on their co-efficient of absorption, would be absorbed in the superficies, and this would be irritated ; and those organisms which acquired a proliferation of these cells through the irritation would be more capable of protecting their more vital central elements, and hence have the greater chance of survival ; thus in succeeding generations those with the thinner superficies would be killed off, making the thicker covered organisms more common, until ultimately there was created a type with a primitive epidermis or integument. This was probably the first great influence of radio-activity.

Later, owing to other factors of evolution, or assisted possibly by anaphoretic action of β activity and cataphoretic action of α activity, certain organisms acquired a false covering, *e.g.*, the shell of the primitive shelled organisms. Such coverings gave the organisms, owing to their inhibitory effects, still greater resisting powers when exposed to radio-activity, and enabled such organisms to live in an area of greater radio-activity than their primeval ancestor. At the same time the habits and physical characteristics of such types gave them the power to exist in the rougher shallow waters. The necessary modifications to enable organisms which could exist in the shallower waters to survive on the fringe of the primitive shore was probably the most gradual step. In the shallower waters the effects of radio active emanations were probably for the first time acutely felt, owing to intermittent exposure of portions of an organism to the atmosphere, as is natural in shallow waters, and also to the greater concentration of the emanation in such waters: these emanations would lead to hypersensibility (? hyperæmia) of the superficies of the organism, and this would aid the organism in drawing its supply of oxygen partly direct from the air. Once this modification of a function became a permanent characteristic of a type, the transition to an amphibious existence would not be great.

At the same time, as the creation of a fauna was proceeding, similar steps were occurring in the creation of a flora.

With the establishment of life in part existent on dry land the first great period of the earth's biological history may be regarded as closed, although this is only arbitrary. It was the period of excessive and destructive radio-activity. At the end of this period the natural radio-activity had waned a little, and it was possible for life to exist with weaker radio-active inhibitory screens, and also greater screens were developed; organisms also had become modified, and developed greater resisting powers to radio-activity by means of artificial coverings, *e.g.*, a shell, of false coatings, *e.g.*, the viscous material covering a worm and of integuments.

The secondary period was the imperceptible modification of the primary period. It was the period of irritative radio-activity, the effects of the latter being insufficient to destroy life to the same extent as in the primary, and the effects of irritation therefore became the predominant feature. This was due to the waning of the natural radio-activity combined with the deposition on the primeval barren lands of a radio active screen of dead organic material, which was originally a wind-blown drift from the primitive beach. The dry land would be naturally divided into radio-active areas, varying in intensity from the thickness of this deposit and the amount of radio-active substance present. At the same time it must be remembered that geological changes were progressing through all ages, and evolution of the elements was leading to deposits varying in their composition, distribution and quantity. As the inhibitory effect of the various elements on radio-activity varies directly as their atomic weights, it is evident that the geological changes had considerable influence in the delineation of the radio-active areas and their intensity and form of activity. Thus as life spread on the dry land it was exposed to all degrees and types of activity; it also came more acutely within the sphere of influence of α activity, which can travel through 7 cms. of air, but less than one cm. of water. This was the period of the creation of a gigantic fauna and flora.

As soon as organisms had developed their primitive vascular system the effects of radio emanations on the *cul-de-sac*, which comparative anatomists assign as the progenitor of the lungs, would be to render its lining walls hyperæmic, and here no actual radio-activity could act, except filtered through the body walls. This hyperæmic *cul-de-sac* would increase the organism's power of assimilation of oxygen direct from the atmosphere, until in place of the primitive amphibian a purely aerobic type was established, and life was capable of support on dry land.

Life once established on dry land was for the first time acutely within the sphere of all forms of radio-activity—*i.e.*, α, β, and activity due to the fact that α activity has its greatest scope in the atmosphere, penetrating 7 cms. of air; but different individuals were exposed to widely different intensities of activity as they spread over the surface of the earth and exhibited corresponding degrees of reaction, since the intensity of activity in any locale depended on the amount of radio-active substance present, the thickness of the organic deposit, and the degree of evolution of elements possessing high atomic weights and corresponding inhibitory powers. The exposure of groups of individuals to different intensities during succeeding generations naturally caused different modifications in the progeny, although descended from the one species, and this must have been a factor in evolution leading to the establishment of different types for different localities.

The α activity caused reactions only in the superficies of an organism due to the coefficient of absorption, and the effects were an increase in the superficies, causing a thickened integument; and probably the positive electric charge of α activity had a kataphoretic action, and by the ionisation of various salts in the superficies aided life then extant in developing the enormously thickened dermal coverings which were characteristic of this age.

Irritative reaction to radio-activity was then predominant. Bohn, Perthes and Schafer have shown that in a single generation pathological monsters of increased size with thickened, contorted skins are evolved after exposure to radio-irritation in the laboratory. It is therefore probable that successive generations exposed in nature to activity, similar though diminished in order not to destroy the reproductive power, increased in size, and radio-irritation was probably an important factor in the general increased size of the fauna of this period.

As organisms increased in size they were *ipso facto* in greater part removed from the sphere of α activity, and were exposed solely to β and γ activity except in their distal parts or when their habits brought them close to the ground. These distal parts ultimately became the only areas which exhibited the characteristics of α irritation, *c.f.*, the legs of birds and the hoofs of the ungulents.

The development of further appendages—*e.g.*, hair or feathers possessing inhibitory powers and of new habits, *e.g.*, flight, enabling the primitive serpent-like bird to exist mainly outside the sphere of action of α and soft and medium β activity or swift motion, enabling the possessor to cross rapidly acutely radio-active areas—all modified the reaction to radio-activity in different ways by exposing the organisms to different intensities of activity. In new spheres of activity, not only were different reactions effected, but the results of former reactions were discarded as useless, *c.f.*, the thickened epidermis of the primitive bird.

It must now be remembered that α, soft medium and hard β, and γ activity individually possess gradually increasing co-efficients of absorption. Further, taking the rays emitted from radium in the laboratory as an example, α rays constitute 90 per cent. of the radiations, β 9 per cent., and γ 1 per cent.; it is evident that α rays are the commonest, and γ rays the rarest. This proportion in nature is still more accentuated by polonium giving α rays only and radium and actinum alone causing γ rays. From these facts it is clear that as the fauna increased in size and developed thickened superficies, their central parts received less and less radio-activity, and in consequence were enabled to develop more highly specialised cells of less molecular stability, being further removed from the destructive influence of irradiation, and the natural evolution of organs of special function was only slightly malverted.

Following the natural laws of evolution the minor special organs reached perfection before the more highly specialised, and the last to become evolved to any considerable degree were the special centres of the nervous system. After noting the results of Danysz, London, and others on the experimental reaction of the nervous system to irradiation, it is reasonable to assume that the development of the brain was inhibited whilst radio-activity was excessive, and high mentality was incapable of development, and the mental characteristics of the period were slow cerebration, similar to that produced in the laboratory by London, with the mental functions restricted to the vital processes of life and the simpler instincts. Those types which developed the more thickened and completely enclosed bony carapace had the greater chance of mental development.

During this and the preceding period it is probable that life was exposed to few accidents to health, since it has been shown in the laboratory that the virulence of the micro-organisms of disease is attenuated and the toxicity of animal poisons, *e.g.*, snake venom is destroyed by radio-activity, and this was probably reproduced in nature. As a result the normal period of life was extended with, as a natural sequence, greater time for development.

During this period vast changes occurred on the earth's surface, and areas of comparative safety from radio-activity were created, the most important being the deposit of the coal beds, which strongly filtered radio-activity itself and absorbed the emanations.

1

Two groups of nodules.

ONCHOCERCA GIBSONI.

1 A

Four nodules cut in half to show large proportionate worm-area and thin fibrous capsule.

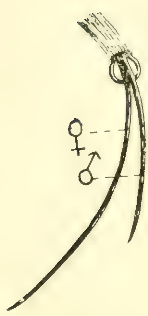
ONCHOCERCA GIBSONI.

2

Large nodule cut in middle, showing small area occupied by parasite (xx).

ONCHOCERCA GIBSONI.

3



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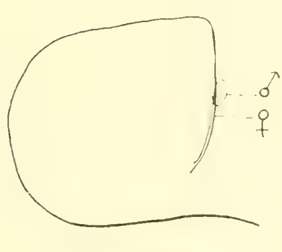
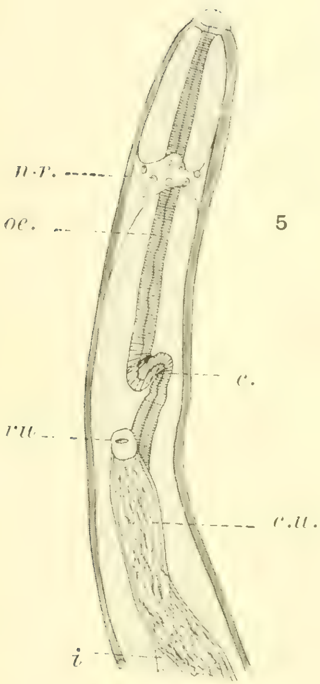


4A

3. Nodule in which capsule wall is almost entirely dissected away, exposing the male and female heads lying together in one tunnel at *ex.*
4. The two heads magnified.
4A. Diagram illustrating relative position of male ♂, and of anterior end of female ♀

ONCHOCERCA GIBSONI.



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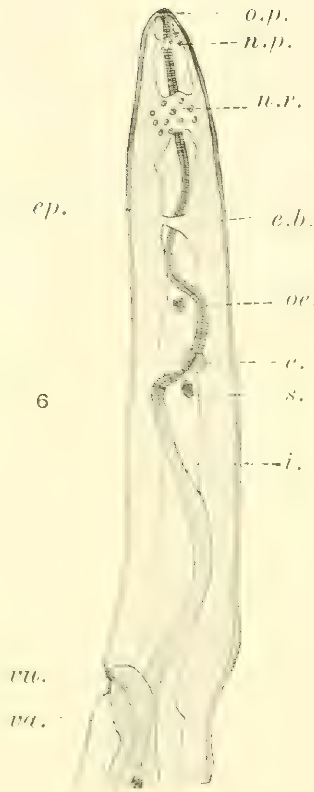
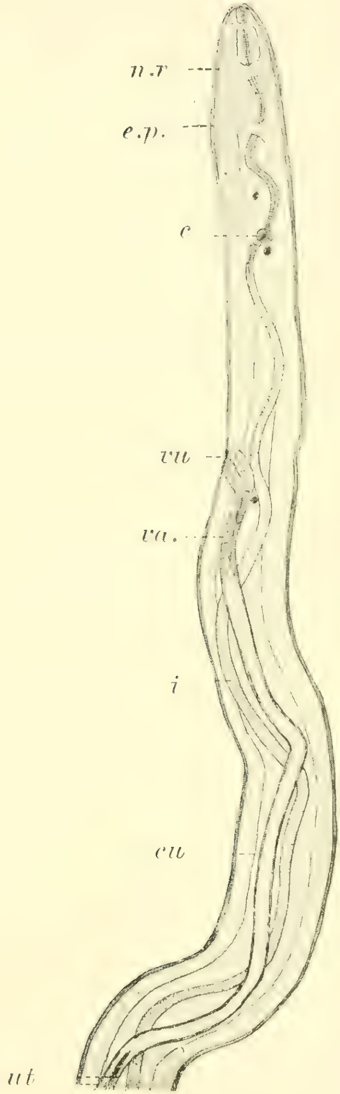


6

5 and 6. Views of two heads of females seen in optical section, showing variations in structure and in relative position of various parts.

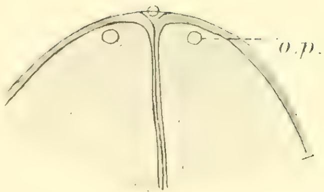
ONCHOCERCA GIBSONI.



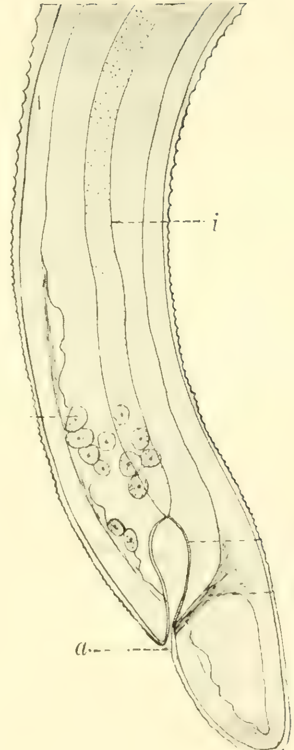
7

Same female head as fig. 6, showing long common uterus (cu).

ONCHOCERCA GIBSONI.



7A



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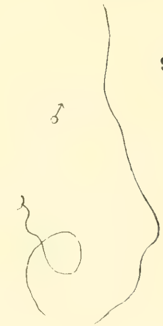
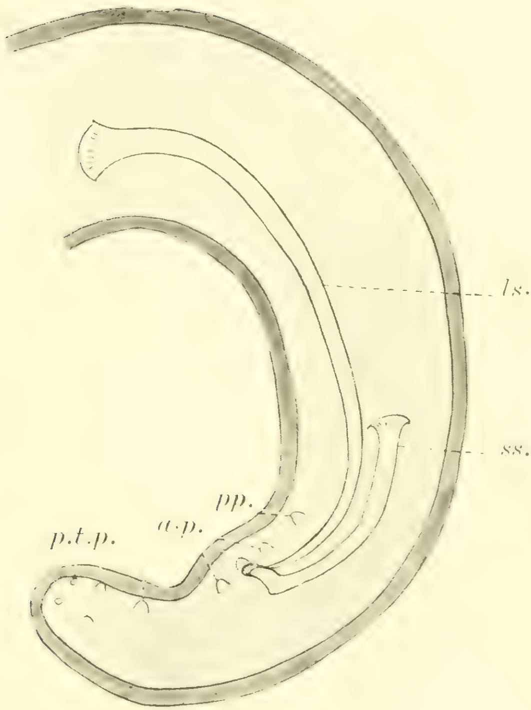


9

ONCHOCERCA GIBSONI.

7A. Enlarged view of mouth region, showing three papillæ (much magnified). 8. Tail of female. 9. Complete male.

10



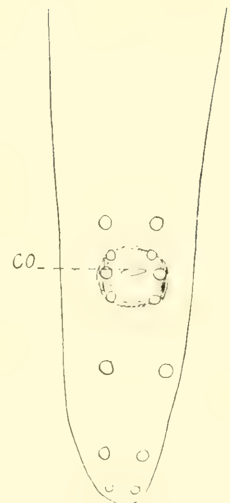
Tail of male seen in side view, showing papillæ and spicules.

ONCHOCERCA GIBSONI.

11

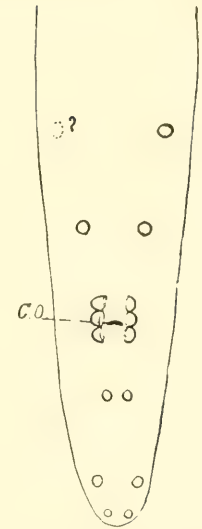
11. Side view of abnormal tail of male.

12A



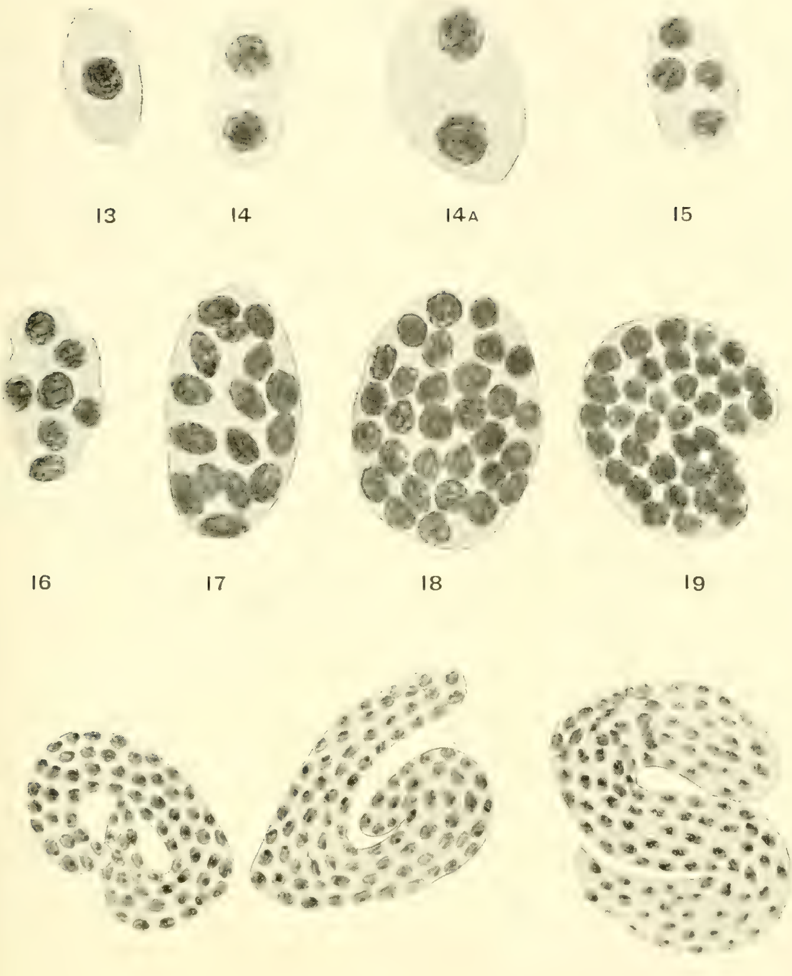
12A. Ventral view of normal tail of male.

12B



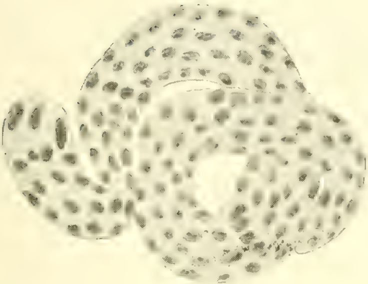
12B. Ventral view of abnormal tail of male.

ONCHOCERCA GIBSONI.



13-22. Consecutive stages in development of egg (13) to rudely outlined larva (22).

ONCHOCERCA GIBSONI.



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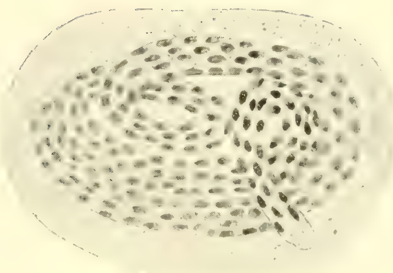

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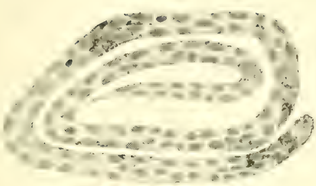

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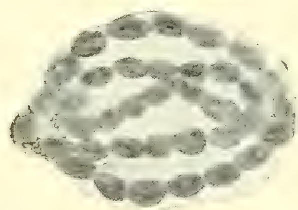

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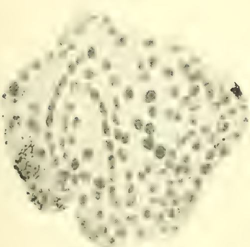
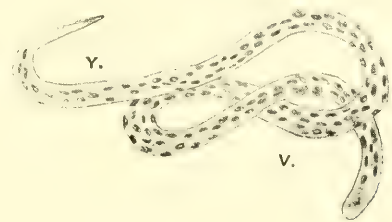


27

23-25. Subsequent stages in development of larva.
26, 27. Abnormally developed eggs.

ONCHOCERCA GIBSONI.

28

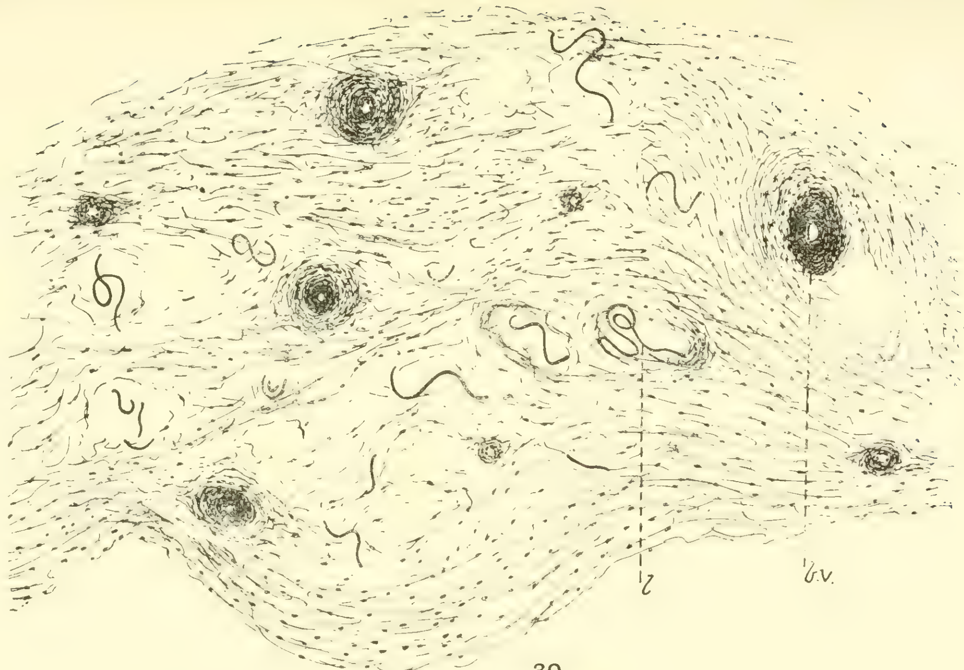


29

28, 29. Mature larvæ.

(23. From fluid around worm. 29. From periphery of fibrous capsule of nodule.)

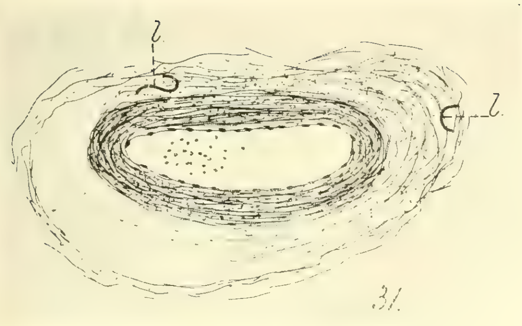
ONCHOCERCA GIBSONI.



30

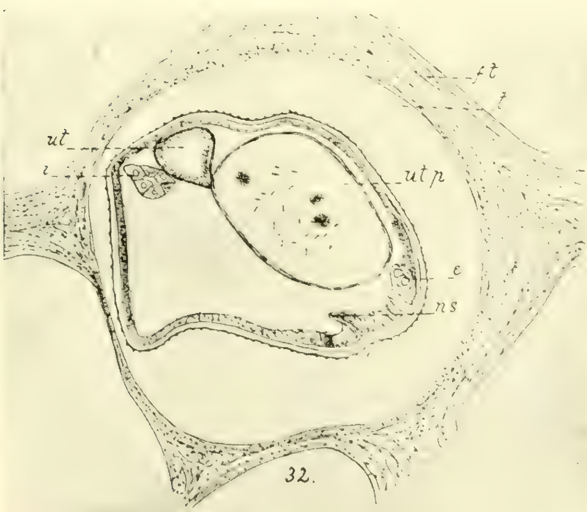
Small portion of extreme periphery of very large nodule, with thick fibrous capsule, showing larvæ (*l*), and arterioles with much-thickened walls.

ONCHOCERCA GIBSONI.



31

33A

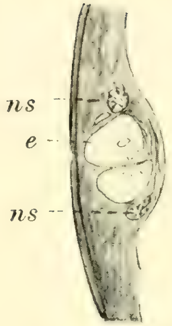


32

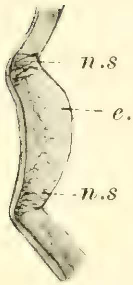
31. Section of artery in nodule wall, showing parts ot two larvæ in wall of artery.

32. Section through female worm in tunnel, in middle of body—*i.* intestine: *ut.* uteri: *ut. p.* uterus with parasite.

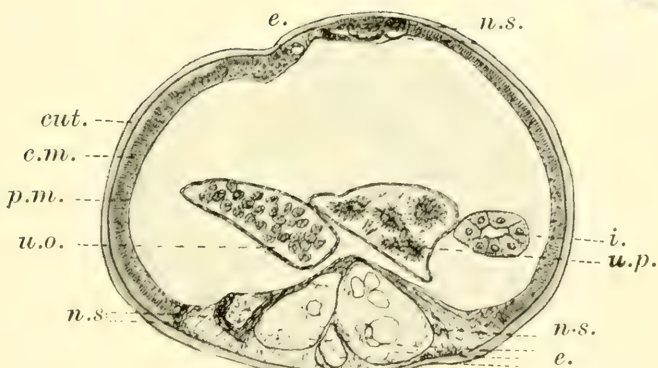
33A. Small part of body wall, to show lateral field—with nerves and excretory canal.



33B



33C

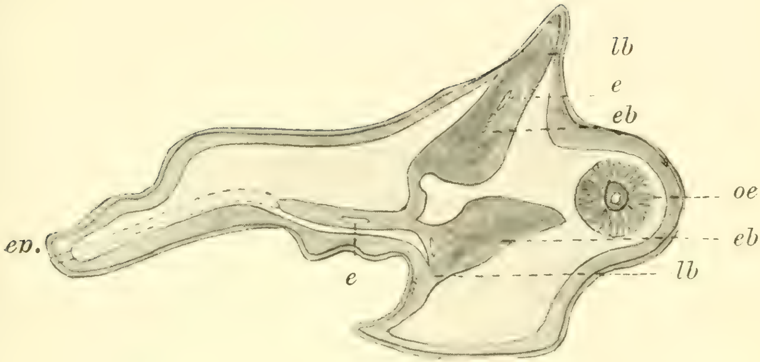


34

33B, 33C. To show different character of lateral field as seen in different parts of worm—*e*, excretory tissue; *n.s.*, nerve strands.

34. Transverse section of female worm showing asymmetrical nature of lateral fields and two uteri—one containing eggs, the other parasites.

Onchocerca Gibsoni.



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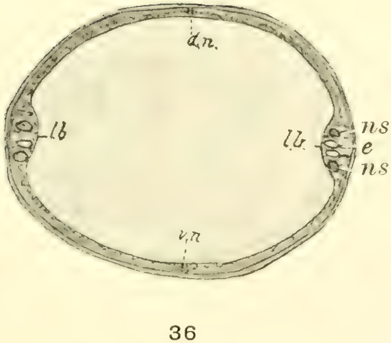

36

35. Transverse section of worm, to show privation of lateral excretory canals to form single tube opening in a subsequent section at *ep*.

36. Diagrammatic representation of normal body wall of *O. gibsoni*, the asymmetry being greatly diminished.

At the close of this period the fauna had reached their greatest physical development with the dawn of psychical processes. The surface of the dry land had undergone great changes from the evolution of the elements, and the deposition of organic material and a varied flora was evolved. Life was divided into numberless genera and species allocated to different locales.

As before, there was no sharp line of demarcation between the secondary and tertiary periods. The tertiary period might be considered as continued to the present day, and is the period of cumulative re-action, as in this form irradiation was effective mainly; the natural radio-activity has waned further and enormous radio-active screens have developed. The characteristics of this period are the loss of certain radio-active protectives of individuals, the diminution of size, greater vascularity and the development of mentality.

During this period the necessity for thick dermal coverings as a radio-active shield has gradually declined with the waning of the natural radio activity and were discarded as life with thinner coverings became capable of support, but certain survivals continue to the present day, *c.f.* elephant, hippopotamus. The constant irritation at all periods of growth also declined with, *pari passu,* a decline in the size of the fauna.

The period of life was gradually diminished as the chance of accident to health was increased by the development of greater virulency in the micro-organisms of disease and the increased toxicity of animal poisons, which occurred with the decline of the natural radio-activity.

The development of greater vascularity, especially in the superficies, was rendered simpler. It is proved that excessive radio-activity has the effect of producing intermittent localised constrictions in the blood vessels, which are naturally more effective in the smaller channels, and the removal from its influence by the decline would promote development.

The development of mentality would also be materially aided by the decline, when the results of the experiments of London, Danysz, and others are noted.

That a certain amount of radio-activity is essential to life seems probable. In the evolution of the elements it seems that those of high atomic weight are evolved first; the effect of the deposit of such elements on natural radio-activity would be to easily screen off the radiant energy, but at the same time as such reaction takes place the elemental substance itself emits secondary radiant energy, and the intensity of this is directly proportional to the atomic weight. Thus the localities where least radio-activity is present would not be those where the strongest individual absorbent was present, but where vast deposits of elemental substance of low atomic weight occurred sufficient to absorb the natural radio-activity by the thickness of the deposit, and in so doing not emitting further radiant energy of any appreciable intensity. Such areas are found in deserts with the deposits of silicates (Si., at. wt. 28·2,) and here life is practically non-existant.

In this paper, although the possible changes have been rapidly noted, the production of any modification and the formation of a characteristic is not assumed to be rapid and apparent, but took thousands of years to produce, and the words of Fk. Soddy, that " only those changes which require an æon for completion remain with us still," can be aptly extended to the past as well as to the present.

To conclude, I have only been able to briefly suggest the possibilities of the hypothesis, as many of the propositions noted are capable of expansion into a paper by themselves, and this paper would have been too evtensive. I have been unable to touch on the evolution of the floral kingdom for similar reasons, although it admits many interesting theories. Finally, I hope this hypothesis, even in this condensed form, will meet with favourable considera. tion, which I think it merits.

14.—SOME EFFECTS OF THE GASES DISSOLVED IN ARTESIAN WATER ON TROUT, THEIR EGGS AND FRY.

By C. COLERIDGE FARR, D.Sc., Professor of Physics in the Canterbury College, Christchurch, New Zealand.

Some eighteen months ago the council of the Canterbury Philosophical Institute set up a committee to examine and report upon the various problems presented by the artesian water system of Christchurch. One of the questions which suggested itself was an examination of the water for radio-active constituents, and it fell to the author and his assistant, Mr. D. C. Florance, M.A., M.Sc., and Mr. D. B. McLeod, M.A., to undertake the work. The facts which have come to light, though possibly having no connection with radio-activity, are the outcome of the investigation, and it is thus that the author finds himself in the somewhat curious position of presenting a paper for the consideration of biologists, a task which he enters upon with considerable trepidation.

The Canterbury artesian water system is extensive, and as far as dissolved salts are concerned extremely pure, so pure indeed that it is used for many chemical purposes for which distilled water is generally considered necessary. A typical analysis illustrated this. It is obtained by simply driving pipes through the bed of shingle and sand, and the whole deposit of which the Canterbury plains are built up to depths which range from about 80 feet to 800 feet. The deeper the penetration of the pipe, the more copious the flow and the greater also its surface head. These artesian wells are extremely abundant about Christchurch, one, or somewhere perhaps two, being found on any section upon which a house has been built.

An examination of this water by Mr. Florance and the author showed it to be fairly rich in radium emanation, a result not at all surprising when one bears in mind that radium appears to be widespread in small quantities throughout the crust of the earth.

To show the contents of the radio-activity the following figures taken as example from a paper by Farr and Florance[1] may be quoted :—

	Depth.	Leak per Minute.
Museum well	262	197
Waltham School	326	223
No. 1 well, Acclimatisation Garden ..	70	143
2 ,, ,, ,, ...	70	135
3 ,, ,, ,, ...	70	143

Many others of the Christchurch wells were examined and all found raidio-active ; but as those above comprise all that will subsequently be referred to, these are all that need now be given. The mode employed to indicate the radio-activity is quite arbitrary, being the rate in scale divisions per minute of the motion of the leaf of an electroscope across the field.

For the purpose of subsequent comparison with other water it will be well to state that the maximum radium emanation content of a standard solution of radium received from Professor Rutherford, and containing $3{\cdot}925 \times 10^{-10}$ gramme of radium, gave a leak of 64 scale divisions per minute.

It may also be of interest to give at the same time the radium emanation content of some of the famous Continental springs. Thus :—

Plonbices, source Vauquelin	376
,, iron des Capucin	787
Aix les Bains, No. 1	461
,, ,, No. 2	257
Born des Saviej, source Le Lynne	169

In the case of the Christchurch water the effect is due to radium emanation, and no dissolved radium was discovered in the water, and in every case a litre of water was used.

As, therefore, the Christchurch water is radio-active to a degree comparable with that of other subterranean sources of supply, a search was made for any effects which might possibly be due to radium emanation, etc. Naturally, the trout inhabiting the streams fed by these wells were examined as being likely to show any effects which were to be found. Several very remarkable results, were discovered, which, whether they be ascribable to

1 *Trans. N.Z. Inst.*, Vol. XLII., page 186.

radium emanation or not, at least do not appear to be well known, as is indicated by a discussion taking place at the Linnean Society of New South Wales in April, 1909, and in the Sydney newspapers in May, 1909, with reference to the fish found in the waterhole formed by the Corella bore. It seems certain that one of the effects now to be described (No. 2) is identical with one there discussed in New South Wales. The effects resulting under certain conditions from the use of artesian water are four in number, and will be first stated and then discussed :—

(1) Death of fish confined near the outflow.

(2) Protrusion of eyeball—pop-eye.

(3) Death of trout eggs before hatching.

(4) Trouble in the yolk sac stage, known locally as " blue swelling."

(1) It was soon found that the Christchurch water was fatal to a large percentage of fish confined near the outflow of the well. Thus, of seven yearling trout placed in the " sand box " with the artesian water running out of the pipe directly on to the bottom of the box and flowing out at the top, one died in three days, two more in four days, two more in five days, whilst the remaining two were alive after seven days, when they were removed in an apparently healthy condition. Emanation content, 197.

As the conditions of life in the galvanised iron box, with a strong stream of water running through it, were certainly not comfortable, a further lot of ten trout were confined in a concrete tank, into which the water flowed from the Museum well sand box, at the same time eight yearling trout were put into the sand box. The fish died in large numbers and in quite a short time in both places of confinement, and there can be no doubt that this is a general result of confining fish in close proximity to the outflow from the well.

(2) Protrusion of the Eyeball.—In fish which survived more than seven or eight days in confinement close to the outflow, it was noticed that the eye began to protrude, and the advent of this disease, known as " pop-eye," seemed to prevent death from supervening, as on several occasions a fish which survived out of a batch of seven or eight was kept for many days still in the same place until its eyes became so bad that it was considered that the experiment had proceeded far enough, and the fish was killed. The disease was, I consider, most likely the cause of the eyeless fish being found in the water flowing from the New South Wales bore, as the eyes of several fish kept in the Christchurch waters were in such a state that a slight knock would have taken them out of the sockets, and as these fish were practically blind, had they been kept a little longer or been in a place where they would be likely to bump against rough obstacles, they would almost certainly have lost their

eyes altogether. The disease has been examined to some extent by Marsh and Goreham[1], more especially under some special conditions of sea water, and they ascribe both No. 1, death of fish, and (2) pop-eye, to excess of dissolved gas, chiefly nitrogen, in the water. I may here say that both the fatal effect of the water and its pop-eye producing properties diminish and finally cease with perfect æration.

(3) As is natural of trout eggs placed in the hatching trays, a certain number die. It was alleged, however, by Mr. Rides, the curator of the fish hatchery here, that more eggs died in trays near the outflow than in those exposed to more aerated water. Experiments confirming this will be quoted.

(4) Blue swelling is a disease of the yolk sac, and is, according to Mr. Rides, more common in Christchurch than in any other hatchery of which he has any information. A light bluish appendage forms on the yolk sac that is filled with some fluid, and which, as the young fish is unable to absorb it, is almost always fatal. It has been cured by pinching the bluish appendage and so letting the fluid pass out, but this is an impracticable method where many thousand young and active trout have to be examined.

We have since shown that all these four separate effects possess this in common, viz., they all tend to diminish with greater aeration. They must therefore be due to the presence of some deleterious gas, or to the absence of oxygen. Experiments were therefore made to ascertain the manner in which the gas content altered with rippling over obstacles and at the same time noting the variation in the various effects under observation.

For the investigation of effects to (1) and (2), death and pop-eye, we first confined eight fish in the sand box of the Museum well and ten fish in a concrete box into which the water runs after flowing out of the sand box. In six days six out of eight had died in the sand box, and four out of ten in the concrete boxes, in which we endeavoured rather unsuccessfully to confine the trout. These fish were very lively when first put in, and escaped surprisingly. Thus the results are not altogether satisfactory, except that we can certainly say that the death rate diminished with recession from the well, though it occurred to an abnormal extent even in box four, in which three fish out of ten, which we attempted to secure, died in fifteen days.

Dr. Chilton made a slight examination of these dead fish, and in some cases found gas emboli in the gill filament, though he did not find it in all.

In fish which survived a week in either of the two boxes nearest the well, pop-eye almost invariably made its appearance, though more markedly in the sand box than in the others.

We have recorded one case of pop-eye in the third box from the well, though none in the fourth.

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1 *Report Bureau of Fisheries*, 1904, Washington.

The mean of several determination of the gaseous constituent in these four boxes gave the following results :—

Box 1.

Nitrogen, argon, etc.	18.52	cc. per litre	N.T.P.
Oxygen	4.30	,,	,,
Carbon dioxide ..	1.19	,,	,,
Radium emanation..	197	arbitrary units	,,

Box 2.

Nitrogen	17.76	c.c. per litre	N.T.P.
Oxygen	5.27	,,	,,
Carbon dioxide ..	1.40	,,	,,
Radium emanation..	179	arbitrary units	,,

Box 3.

Nitrogen	17.81	c.c. per litre	N.T.P.
Oxygen	5.00	,,	,,
Carbon dioxide ..	0.95	,,	,,
Radium emanation..	164	arbitrary units	,,

Box 4.

Nitrogen	17.51	c.c. per litre	N.T.P.
Oxygen	5.24	,,	,,
Carbon dioxide ..	1.03	,,	,,
Radium emanation..	150	arbitrary units	,,

The carbon dioxide includes besides free carbonic acid that giving off from bicarbonate on heating, whilst tests made for sulphuretted hydrogen and sulphur dioxide showed no appreciable quantity of either.

Experiment at the Fish Hatchery.

A good deal of attention was paid to the effect of artesian water on the hatching of trout and on very young trout. The first set of experiments were conducted in a set of five pairs of boxes, the two boxes in each pair being similarly placed with regard to the well, the water in which was therefore ærated to the same extent. The water flowed from the first pair into the second over a fall of about four inches, and then to the third over a similar fall, and so on. Seven thousand five hundred " eyed " eggs were placed in each box, making 15,000 in each pair, and the number of eggs which died were counted. The following table gives the number of eggs so dying before hatching, along with data regarding the gases. The figures are for 15,000 eggs.

Box.	Dead Eggs.	Hatched.	Ra. em.	Dissolved Gases.	Blue Swelling.
1	6,675	8,325	126	N. = 16.82 O. = 5.34 Co_2. = 1.80	1,626
2	5,232	8,768	111		1,269
3	4,650	10,350	95		1,584
4	4,713	10,287	83	N. = 15.98	1,358
5	3,852	11,748	69	O. = 5.68 Co_2. = 1.88	1,557

The last column contains the numbers of young trout in each pair of boxes which subsequently developed blue-swelling.

Consideration of this table shows several things. In the first place the number of dead eggs is abnormally large even in the fifth pair of boxes. This is certainly due to overcrowding. The practice of the fish hatchery has been to put only about 2000 eggs in a box, and here there were 7500. This was done intentionally with a view to producing a high death rate. In the second place it shows that fewer eggs die as the water, by rippling and falling, loses nitrogen, gains oxygen, and loses radium emanation, and in fact becomes more like water exposed freely to the air for a considerable time. If the number of the eggs dying in the upper box be called 100 and the radium emanation in the pair be also taken as 100, and the number for the other boxes be reduced correspondingly a rather striking similitude exhibits itself thus :—

First pair boxes	100	dead eggs	100	Ra. em.
Second ,, ...	79	,,	88	,,
Third ,, ...	69	,,	75	,,
Fourth ,, ...	70	,,	66	,,
Fifth ,, ...	48	,,	55	,,

The table does not, however, shew, at any rate markedly and conclusively, that blue-swelling is also a disease dependent on æration, but experiments now to be described show this.

The results just given were obtained in the winter of 1909 during the trout hatching season in June and July, and no further opportunity for further work occurred until the hatching season in 1910. This year we were fortunate in finding two wells closely adjacent to one another, and yet possessing an entirely different radium emanation content. We made a careful examination to ascertain if there were any differences in the amounts of the other dissolved gases, with the results which will be given. One of these wells was that previously used, and the other supplied a set of eight pairs of boxes. In these experiments, however, only one side of the set of boxes was generally used. If any eggs were put in the other box of a pair the figures for these are given in brackets. The result of experiments with these two wells are given below in tabular form.[1]

[1] Farr and McLeod, Trans. N. Z. Inst. 1910, p. 56.

WELL No. 1. SUPPLYING SET OF 5 PAIRS HATCHING BOXES.

Box No.	Emanation.	Gas Content.	2000 Brown Trout.		2500 Rainbow Trout
			Eggs.	Blue Swelling.	Blue Swelling.
1	126	N = 16·35 O = 4·30 Co_2 = 2·60	252 (254)	70 (72)	102
2	111		302 (224)	68 (72)	88 (87)
3	95		167	41	73
4	83		214	33	71
5	69	N = 15·35 O = 5·45 Co_2 = 2·53	184	29 (28)	58 (57)

WELL No. 2. SUPPLYING SET OF 8 BOXES.

1	78	N = 16·31 O = 4·76 Co_2 = 2·37	156	34	97
2	75	N = 16·00 O = 5·15 Co_2 = 2·45	163	38	144
3	73		184	35	80
4	74		185	36	87
5			198	33	70
6			154	38	57
7	36	N = 15·0 O = 6·35 Co_2 = 2·40	191	31	52
8			172	30	37

It will be seen from the radium emanation content that the first of these wells was the same as used in the hatchery last year. The gas content of this well is least, and this is probably due to the fact that what we wanted was to detect any difference in the gas content of the two walls rather than to determine absolutely the amount of the dissolved gases. For this purpose the water under examination was always boiled vigorously for an hour, whereas on the previous citation of gas content, it was boiled till the last trace of gas was driven out—a process occupying some three or four hours.

It will also be seen that whilst, as has been said, the two wells differed markedly in radium emanation, they are exceedingly alike in nitrogen content, whilst they differ in oxygen and in carbon dioxide. As most of the carbonic acid is in the form of bicarbonate, the well only containing a very small amount of free carb., the difference is not important. There is evidence therefore that if the table shows any difference in the behaviour of the wells either to eggs or newly-hatched trout, that difference must be ascribable either to radium emanation or to oxygen. In the first and fifth columns of the table relating to each well will be found headings marked "Eggs" and "Blue-swelling." These columns give the number of eggs dying before hatching and the number of cases of blue-swelling subsequently developed in the yolk sac stage when 2,000 healthy brown trout ova from river fish were put in the box to which the figure refers. The results are therefore comparable. Now, I think, it will be seen that whilst there may be a decrease in the number of dead eggs as we go from box to box in the series supplied from well No. 1, yet it cannot be said that there is such a decrease in the series of boxes supplied by well No. 2. The difference is not marked, and may be accidental, but taken in conjunction with the previously-given figure relating to the egg dying from well No. 1, where the decrease in mortality was, most marked, the figures point conclusively to the fact that a large number of eggs die in the hatching boxes owing to the water being insufficiently ærated, whatever we may mean exactly by that expression.

Now, turning to column five in the two wells, viz., that headed "blue-swelling," I do not think it can be doubted but that the figures show a marked difference. In Well No. 1 they began with 70, with a check in the parallel box of 72; in the fifth box they fall to 29 with a check of 28 Indeed we have no right to expect such an evenly decreasing series of figures as were obtained. On the other hand, over the series of eight boxes in No. 2 well, cases of blue-swelling amongst young trout hatched from these 2000 brown trout eggs hardly show any variation at all. It may be considered, however, the last column of each well, which is also headed blue-swelling, whilst they support the conclusion that blue-swelling is a disease that is due to want of "æration," do not enable us to reject "excess of nitrogen" from the meaning of that expression. These series of results, however, were from a very different class of fish from the others. They refer to 2500 rainbow trout fry, a "pond" fish, and one much more delicate than brown trout. By a pond fish is meant that the eggs from which these fry were obtained were stripped from fish kept in confinement in the hatching pond, whereas the brown trout eggs were obtained from fish inhabiting rapidly flowing streams. Besides, whilst the brown trout eggs refer actually to the hatching from 2000 ova, the numbers of rainbow fry actually placed in the boxes of No. 2 well were, owing to scarcity of fry, only 1000, and the results were multiplied by 2.5 to make them comparable with No. 1 well. The figures, therefore, in this the sixth column for each of the two wells are for the first of the reasons given above not at all comparable with the figure in the fifth column for the same well, and for the second reason the figures in the sixth column of the two wells are not strictly comparable with each other..

The conclusions arrived at in this paper are as follow. There is abundant evidence (not all given here) to show that there are four separate and distinct effects upon trout in various stages of their development, due to want of "æration" in the waters of the Christchurch artesian water system. These are:—

1. Death of yearling fish.
2. Pop-eye, where death does not supervene.
3. Mortality in the egg stage.
4. Blue-swelling in the yolk sac stage.

Of these, there is some evidence to indicate that the first two are due to excess of gas, unless it be that the gas emboli and the gas imprisoned behind the eye which causes the eye to protrude are secondary effects. With regard to the third and fourth, if it be admitted that there is any difference in the behaviour of the two wells considered towards the egg hatched and hatching in their water, then these effects must be ascribed either to want of oxygen or to radium emanation. It is for biologists and physiologists, knowing the character of these two gases, to say which of them is most likely to cause such a disease as blue-swelling.

My apologies are perhaps due for drawing any conclusions from details so meagre. My excuse for doing so is that owing to the shortness of the hatchery season and the impossibility of placing the whole hatchery in the hands of experimenters only a few results can be obtained in a year. My reason for bringing the subject (one of New Zealand rather than Australian importance) before the Australasian Association is the interest aroused in and the theory promulgated on the discovery of eyeless fish in the waters of the Corella bore.

Our most sincere thanks are due to the authorities of the Canterbury Acclimatisation Society for the interest they have taken in the work, and to Mr. C. Rides in particular for the great care he has taken in counting the number of individuals affected in the various experiments.

REPORT OF THE RESEARCH COMMITTEE (SECTION D) FOR THE BIOLOGICAL AND HYDROGRAPHICAL STUDY OF THE NEW ZEALAND COAST.

List of Members.—Prof. A. P. W. Thomas, M.A., F.L.S.; A. Hamilton; Dr. W. B. Benham, D.Sc., F.R.S.; Edgar R. Waite, F.L.S.; Prof. C. Chilton, M.A., D.Sc. (Hon. Secretary and Convener).

REPORT.

This Committee was appointed at the Dunedin meeting of the Association in 1904, and a sum of £50 was voted for its expenses. Since that time the Committee has carried out the investigations entrusted to it so far as possible, and though it has seldom been possible for the Committee as a whole to make a joint expedition, owing to the fact that the members are scattered throughout New Zealand, advantage has been taken by individual members of the opportunities offered by other expeditions, and a considerable amount of useful work has thus been carried out. Full reports, with statements of accounts, were sent in to the Adelaide meeting in 1907, and to the Brisbane meeting in 1909, and at each meeting the committee was reappointed and the unexpended balance of the grant reassigned to it. As the report sent in to the Brisbane meeting has for some reason not been printed in the records of that meeting, it will be desirable to include in the present report an account of all the work that has been done since the report presented to the Adelaide meeting, and printed in the report of that meeting on page 288.

The most important work was that carried out in connection with the "Nora Niven" trawling expedition, fitted out by the New Zealand Government in 1907, for the investigation of the marine fisheries of New Zealand. Mr. Waite, a member of the Committee, accompanied the "Nora Niven" and made collections of as many of the different groups of the marine animals as possible, and duly recorded the soundings, nature of the sea bottom, etc., at all the different stations, and in this manner a large amount of information was gained with regard to the sea bottom immediately around New Zealand. A general account of the "Nora Niven" expedition is given by Mr. Waite in the Records of the Canterbury Museum, vol. I., No. 2, and in the same publication there are reports by different authors on some of the collections made. Other groups have since been worked out, and a full list of the papers dealing with these, together with other papers arising from the work of the Committee, is appended to this report.

In November, 1907, an expedition was fitted out by the Philosophical Institute of Canterbury to visit the subantarctic islands to the south of New Zealand, and was accompanied by three members of the Committee. During the expedition, additional soundings and collections were made, the results of which have been published in detail in the papers by different authors in the "Subantarctic Islands of New Zealand," two vols., issued December 22nd, 1909. The one bearing most directly with the work of the Committee is the report on the Foraminifera by Mr. F. Chapman. The material was obtained mainly from one or two dredgings between the Auckland Islands and New Zealand, and Mr. Chapman's report deals with 168 species, of which 103 species are new to the New Zealand region. A number of forms belonging to the other groups of animals were obtained by the dredgings taken during the expedition and are included in the reports by the various authors.

In December, 1908, two members of the Committee, accompanied a party consisting mainly of members of the Canterbury College staff, on a short trip to the West Coast Sounds of New Zealand, and a number of dredgings were obtained during this trip; the Foraminifera and smaller forms obtained have not yet been fully worked out, but the few molluscas that were taken have been identified by Mr. Suter, who finds among them several additions to New Zealand fauna.

Since then there has been no opportunity afforded to the Committee of making further investigations directly, but it is hoped that the Antarctic Expedition's ship "Terra Nova" will be available for work in this direction on her return from the Antarctic regions in 1911. No opportunity has been lost of impressing upon those connected with the Antarctic Expeditions visiting New Zealand and upon other authorities the importance of taking soundings along the New Zealand continental shelf whenever opportunity offers, and in response to a request made on the suggestion of the Philosophical Institute of Canterbury by the Premier of New Zealand, the Commander-in-chief of the Australasian station has given instructions that His Majesty's ships visiting the islands to the south of New Zealand are to take soundings on every opportunity. The Committee trusts that the Association will assist in every way the efforts thus being made by the Committee for the more complete investigation of the continental shelf of New Zealand.

The statement of accounts attached hereto shows that there is a balance of £13 7s. still in the hands of the Committee. In view of the importance of the work entrusted to the Committee and of the opportunities likely to be afforded in the near future for further prosecution of the investigations, the Committee recommends that the members be reappointed and that the balance be reassigned to it, and that a further grant of £25 be placed at its disposal.

CHAS. CHILTON,
Hon. Sec. and Convener.

LIST OF PAPERS DEALING WITH THE WORK OF THE COMMITTEE.

1. "Results of Dredging on the Continental Shelf of New Zealand," by Charles Hedley (Trans. N.Z. Inst., vol. XXXVIII, pp. 68-76).
2. "On the Foraminifera and Ostracoda obtained off Great Barrier Island, New Zealand," by Frederic Chapman (Trans. N.Z. Inst., vol. XXXVIII, pp. 77 to 112).
3. "Report on Some Crustacea Dredged off the Coast of Auckland," by Chas. Chilton, M.A., D.Sc., F.L.S. (Trans. N.Z. Inst., vol. XXXVIII, pp. 269 to 273).
4. "Results of Dredging on the Continental Shelf of New Zealand," by R. Murdock and H. Suter (Trans. N.Z. Inst., vol. XXXVIII, pp. 278 to 305).
5. "Results of Dredging on the Continental Shelf of New Zealand," by W. H. Webster (Trans. N.Z. Inst., vol. XXXVIII, pp. 305 to 308.

6. Scientific Results of the New Zealand Government Trawling Expedition, 1907 ("Records Canterbury Museum, vol. I, part 2").
    - i Introduction—Edgar R. Waite, F.L.S., pp. 45 to 64. Pls. I to VI and chart.
    - ii Algæ—Robt. M. Laing, M.A., pp. 65 to 70.
    - iii Annelida and Sipunculoidea—W. B. Benham, D.Sc., F.R.S., pp. 71 to 82. Figs. 1 to 5.
    - iv Echinoderma—W. B. Benham, D.Sc., F.R.S., pp. 83 to 116. Pls. VII to XI.
    - v Mollusca, Part I—Henry Suter, pp. 117 to 130. Pl. XII
    - vi Pisces, Part I—Edgar R. Waite, F.L.S., pp. 131 to 156. Pls. XIII to XXIII.
    - vii Pisces, Part II—Edgar R. Waite, F.L.S. Pp. 157 to 272. Pls. XXIV to LVII.
    - viii Mollusca, Part II—Henry Suter. Pp. 273 to 284.
    - ix Crustacea—Chas. Chilton, M.A., D.Sc., F.L.S. Pp. 285 to 312, Pl. LVIII.
7. "Report on the Foraminifera from the Sub-Antarctic Islands of New Zealand," by Frederick Chapman, F.R.M.S. (Sub-ant. Islands, N.Z., vol. I, pp. 312 to 371).

(Balance Sheet reproduced. See Index).

Section E

COLONIAL HISTORICAL RESEARCH

ADDRESS BY THE PRESIDENT:

Professor G. C. HENDERSON, M.A.

Professor of History in the University of Adelaide.

In the arrangement of subjects for discussion in this Association it has been decided to combine Geography and History in one Section. In view of this, the subject which naturally suggested itself to my mind was "the influence of geography upon history," with special reference, perhaps, to the history of Australia and New Zealand. On reflection, however, I decided to invite your attention to the consideration of a subject that seemed to me of more pressing interest just now, not only to historical students, but also to those of the general public who are interested in the history of their country.

It is over 120 years since the first British settlement was founded in Australia. More than half a century ago representative and responsible government was granted to the colonies, and a little more than a decade has passed since the political union of the States was attained by the institution of a Federal system of Government. The making of Australia is now a legitimate subject of historical investigation, and it is the object of this paper to indicate why and how that should be undertaken in a systematic and scientific way.

I use the words systematic and scientific deliberately. There is a species of history written with bias, which really belongs to the literature of politics, religion, or polemics. The only comprehensive history of Australia that is based upon a perusal of original and reliable material is vitiated from beginning to end by the author's determination to prove that the aborigines were victimised by rapacious politicians and squatters. The student of history will find reference in that work to documents that may be of great service in the compilation of an authentic record ; but let me say at once, to avoid any misunderstanding, that in my opinion Rusden's book is not history ; he has prepared a brief extending over 2,090 pages. I do not argue that the historian, or any other writer, can entirely conceal his own personality. Directly or indirectly there is self-revelation in all good work ; but the historian is not an advocate. His attitude of mind approximates more closely to that of the dramatic than the lyrical poet. He may take the liberty of explaining and elucidating, but always with strict regard to the paramount importance of impartiality. In the preparation of his thesis the student of original historical documents knows neither employer nor capitalist, Radical nor Conservative, Catholic nor Protestant, Buddhist nor Christian.

It is necessary to emphasise this at the beginning, not only because there is difference of opinion upon the subject, but also because the writer in the short time he has been able to devote to colonial history has been astonished to find how many pseudo-historical works have been written in defence of this theory or that ; in denunciation or vindication of this individual or that. I am not unmindful of the importance of writing history in such a way as to arouse public interest ; literary style is as useful here as in almost any other department of learning. It had been all the better for history if Dr. Stubbs had written with the finer-pointed pen of John Richard Green. But literary style is one thing and prejudice quite another. Books written under the influence of party feeling or religious bias may be far more interesting to the average reader than impartial scientific records, but their foundations are no better than quicksands, and at one blow the whole structure may be precipitated in ruin. The academic or scientific attitude of mind is the only safe one—in the kind of history at least which I intend to discuss in this paper.

I am well aware that careful students in different parts of the Commonwealth have applied, and are applying themselves in a scientific way to special subjects in Colonial history, but their efforts are sporadic. The time has come when something more systematic might be undertaken, and the Universities are, in my opinion, the proper places to do it. In the arrangement of courses at present the work done is valuable, but it is preliminary. A professor or lecturer delivers courses of lectures throughout the year, and one or two books are prescribed. The student who passes at the end of the year must satisfy the examiner that he has assimilated a fair amount of the information imparted to him in these ways.

For the honours degree the student is thrown more upon his own resources. Works written by such eminent authorities as Stubbs, Maitland, and Gardiner are prescribed, and if the candidate gives evidence of natural ability in acquiring and using the knowledge supplied by them, he is awarded a class according to the discretion of the examiner.

As a preliminary training for the higher and more difficult work of research, such courses have, in my opinion, great value. The student learns much about methods of historical inquiry, and, apart from the definite knowledge which he acquires, some important convictions are borne in upon his mind.

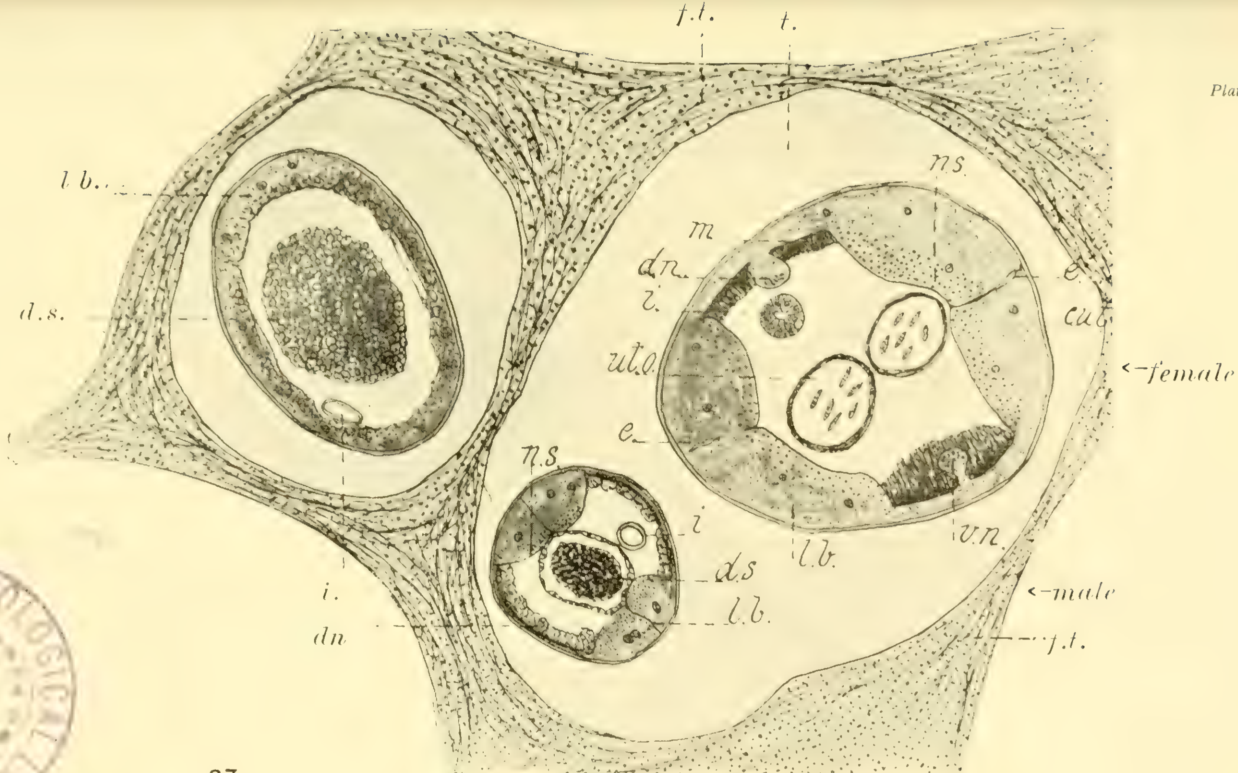
I am not yet converted to the belief that "evolution is the lord of all our thought," unless it be admitted that in the development of self-conscious beings the laws which are applicable to one stage are inapplicable to another ; in other words, that development is qualitative as well as quantitative. But with this reservation I am very much alive indeed to the importance of evolution, not only as a key to historical investigation, but also as a means to the training of sane, well-balanced minds.

It is much to be desired that students should undergo a process of training in which they discover, without being told, that the history of man is the record of a development ; that there are streams of tendency flowing through an age ; that revolutions come involving mutations more or less sudden, with a new order of things; that there is a logic of fact as well as of reason; and that the great facts of history may be like the great facts of human nature—outward manifestations of great laws working in and through the national mind.

It is the recognition of such fundamental truths as these that will make history a truly scientific study. "Let us look into events," Cromwell would say, "surely they mean somewhat." Mr. Seeley, in his great and stirring lectures on the Expansion of England, did look into events, and he found that they meant intensely and meant well for the Empire. The result was an ordered, scientific treatment of a great mass of facts with which the student is familiar in the history of the 18th century. In ordinary textbooks the history of that century is a record of barren, disconnected facts, dull beyond description ; in the pages of Mr. Seeley's little book we get a most illuminating chapter in the history of British Imperialism. Seeley's method was scientific, and it furnishes one illustration of the change that is coming over historical investigation. No student is qualified to enter upon original reasearch until he has read and studied enough in general history to believe in the possibility of a scientific interpretation of history, or to give good reason why he does not.

It is also to be desired that before students settle down to the more minute investigation of original research they should have made the acquaintance of men like Francis of Assisi and Oliver Cromwell. It would be all the better if they had read enough to make friends of such men—better for them morally and spiritually ; for as Edward Caird used to say, "Souls grow more by contact with souls than by all other means," and no such great and lofty souls will be met with in the history of the Commonwealth of Australia or, so far as I know, of any of the colonies.

And yet, great as are the advantages to be derived from the study of general history, that study is, when viewed as part of an educational course, simply preparatory. Honor students and pass students are alike in this—they are working under the immediate direction of others, not only as regards method, but even in the arrangement of the material for study ; and instead of making up their own minds they are obliged by the necessities of the case to



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Transverse section through two tunnels in nodule, showing male and female anterior ends in one tunnel and middle region of male in the other.

ONCHOCERCA GIBSONI.

accept the opinion of others. The "honors" man in our Universities may make up his own mind within prescribed limits, these limits being the facts that other men choose to put before them. In the case of Stubbs, Maitland, and Gardiner we believe these facts to be well chosen ; but the essential point is that they are chosen ; and in the best kind of historical work, the work we hope to do one day, and may I think begin even now in a small way, the student makes up his own mind and chooses for himself.

I believe in the paramount importance of original historical research, because any University that is worthy of the name ought to add something to the stock of the world's knowledge, not only through its professors and lecturers, but also its picked students. I believe in it, further, because original research developes qualities rare and valuable in the minds of the students which cannot be developed by study in the more elementary stages. We may understand what these qualities are by a few observations on the character of the work.

Instead of the material being at hand and arranged for him, the student has to find it, and blessed is the man who is able to find it without heart-sickness and weariness because of the obstacles placed in his way by red-tape officials and fearful administrators. Sometimes these obstacles may be insuperable ; but in any case the student must have patience, industry, tact and a restrained vocabulary. Having collected his material his next business is to read until he has a nascent consciousness of the scheme of his subject ; and a sense of proportion which will enable him to distinguish between the important and the trivial, the relevant and irrelevant. Then his reading may proceed more rapidly. Up to this point every fact has importance, beyond it he follows a policy of exclusion. He keeps an open mind concerning facts that may force him to modify his early sense of proportion ; but for all that, the task of arranging his material, of marshalling his facts in accordance with the plan that has been gradually maturing, becomes a necessity. The end is dimly in sight so far as the attainment of what he considers truth is concerned, and the back of his work is broken. There remains the constructive work. The argument must be worked up in such a way as to give it artistic merit, and the stamp of individuality : a thesis is not a collection of notes ; it is or should be a unity.

Here, then, in brief, are some of the advantages of research over the more ordinary courses in general history : instead of finding material ready to hand the student has to find it himself ; instead of having it all arranged by some master mind, he has to evolve a scheme for himself ; instead of accepting another's interpretation, he uses the material to supply answers to his own questions, and he ends by putting something before the world which has the impress of his own thought and personality upon it. In all this the student is exercising and developing initiative and self-reliance to such an extent that the character of the work done may be reasonably regarded as distinct in quality from that which is done by the pass or honors student.

There is another argument in favour of research which is important enough to justify the emphasis of special consideration. Historical research, in common with all other forms of original research, exerts a quickening influence on what might be called "The vital quality of the soul." It is impossible to indicate the precise significance of such a statement as this, but some suggestion by way of analogy may be offered. The research student is a discoverer as well as an explorer ; he seeks his way through dense woods and tangled forests of fact hitherto untrodden, and in his more ambitious undertakings, "voyages through strange seas of thought alone." His trail is the lone trail, and the more genuine his research the more lonely the trail is and the greater the opportunity of extending the boundaries of knowledge. There is a peculiar fascination about the work of a discoverer, a kind of gleam on the distant horizon which illumines his path with romantic splendour. And once having caught sight of the gleam he is eager to follow, follow, follow. Rudyard Kipling in "The Explorer," and Robert Service in the "Call of the Wild" from the Songs of a Sourdough, have written in powerful verse of the fine impassioned fervour of the discoverer which transmutes danger and difficulty into golden opportunity. Of such fervour the research student has his share—less ecstatic it may be than the discoverer, but genuine and intense notwithstanding, and that fervour or enthusiasm has high educational value. It is the man who lives on the borderland of his subject who not only preserves a keen and stirring interest in his work, but is able also to arouse a similar interest in those whose training may be committed to his care. Public opinion in Australia demands that the leading men in our Universities shall devote a large proportion of their time to teaching. The value of research work as a means of inspiration to the teacher, and therefore indirectly to the students, is all too likely to be overlooked. Research is the best and most important work that can be done in a University, and a University in which the teachers and picked students have no time or opportunity for undertaking it is a University without the chance of inhaling the bracing air of the mountain tops. Its pulsations are likely to become slower and fainter, and it may even become dead at heart. This is the last and most important reason why original research in one form or another should be regarded as the fulfilment and consummation of the study of general history in "pass" work and "honors" work of our Universities.

If so much be allowed the practical question at once arises—Have we the men and the material to do this work ? I think so.

Among the courses offered for honours in history there might be one in which the student presents himself for examination in General Imperial and Colonial History, and prepares a thesis on a period or special subject in the history of the State to which he belongs. Of such a course the thesis would be the most important part, and if the work done in preparation for it is to be of the nature of genuine historical research the period must be a very limited one. Much will depend upon the importance of the period, but it ought not, I think, to extend over more than five years on an average. The examiner would need to satisfy himself that the work in preparation for the thesis had been faithfully done, by calling upon the student to produce his notes on the original material once every three months. But the chief difficulty in carrying out this scheme would arise from the fact that very few students in the undergraduate stage are likely to possess the maturity of judgment which is indispensable to such work.

Another and better way would be to establish scholarships for research into the history of the States, or Commonwealth, or adjacent colonies, somewhat on the lines of the research scholarships in Science recently established in connection with the Melbourne University. Such scholarships might be awarded to students who have done promising work inside or outside the University, and who have the time and the desire to continue their studies. I am disposed to favour the open scholarship, because there are so many men and women deeply interested in the history of their country who have not been able to go to a University, or have long since passed through it. And if *bona-fide* students with recommendations from the proper authorities can be found the material for study is now available.

This statement could not have been made five years ago. There always has been some available material in the public libraries of the different States of the Commonwealth. There were blue books, commissions of inquiry, pamphlets, papers more or less scientific on subjects of local interest, calendars, magazines, daily papers, journals, and the like, all of which have their value as historical documents. But there are documents far more valuable than any of these, and without which no reliable history of any of the States can be written. They are the despatches that passed between the Governors of the colonies and the Secretaries of State in London. These despatches are to the body of original material for purposes of research what the backbone is to the human frame. You cannot construct a history of permanent value without them.

I am aware that some of these despatches have been printed from time to time and placed before the public. The Trustees of the Mitchell Library are the fortunate possessors of duplicates in manuscript of the despatches from the Governor of New South Wales throughout the period extending from 1813-1855. This is a valuable collection, but even they only deal with a part of the history of one of the States; and, so far as I am aware, there is no other public institution in any part of the Commonwealth which possesses anything like so many in manuscript form.

The despatches in their entirety are preserved in the Record Office, London, but duplicates of them are kept at Government House in each of the States of the Commonwealth, and until within the past five years it was well nigh impossible to get access to them except by express authority of the Secretary of State. There was and still is good reason for exercising caution. These despatches contain evidence that sometimes affects the reputations of men now dead, but whose families are still alive and occupying important positions of trust and social responsibility. Naturally enough the Governors, who are the guardians of these despatches, are anxious that these important documents shall not be placed at the disposal of those whose judgment is immature or whose discretion could not be relied upon. A man who did not know where to draw the line between personal scandal and scientific information could make mischief.

Within the past five years, however, the matter has been under the consideration of the Secretary of State for the Colonies, and since the visit of Sir Charles Lucas to these parts important changes have been made. The responsibility of throwing open the despatch room at Government House has been shifted partly on to the shoulders of the local Government, and it is now possible for picked men to get access to the despatches in the Government Houses of the States, up to a specified date, provided it is clear to the Governor and his responsible advisers that they are reliable and efficient students who will use and not abuse the privileges extended to them.

This is a valuable concession, but something more might be done, and I think could be done, if the governing bodies of the Public Libraries throughout the Commonwealth were to make a joint petition to the Secretary of State requesting that duplicates of all despatches up to a date fixed upon should be transferred from Government House to the Public Library in each State. It is not to be expected that despatches of a recent date shall be placed indiscriminately before the public ; but a date can always be fixed by the Imperial authorities, beyond which political feeling is hardly likely to be reckoned with. Duplicates of all the despatches written before that date might with great profit to students be placed in some public institution ; not only the ordinary despatches, but those also which are marked "confidential" and "private." As to "secret" despatches, I should be inclined to say that none of them ought to be made public without the personal inspection and sanction of the Governor.

In discussing the material for scientific research in history it will be clear that I am recommending a course which constitutes a departure from the traditional syllabus of Oxford and Cambridge, where the honours student is expected to devote himself to original work in a period of British or Continental history. I do so advisedly.

To begin with, the "original work" done in the honours school of history at Oxford and Cambridge is not original at all. Specific books are prescribed, and the trail has been followed by dozens and even hundreds of students long ago. In this regard the course which I have mapped out is superior. The research would be more genuine, because the student would have to find the material, and estimate the relative values of the authorities or documents himself.

No doubt there is plenty of genuine original research still to be done in England and the Continent. But for students in the Commonwealth the material for research into European subjects is not available, and even if it were, the equipment in scholarship necessary for the prosecution of such research is beyond us at present, and any attempt to undertake it would hardly be anything more than an ambition upon paper for many years to come. How many students trained in our Universities are qualified to read and discuss documents in old French and mediæval Latin, and give to the world a creditable thesis based upon the study of those documents? We had better leave that class of work to scholars on the other side of the world. There are plenty there to do it, and do it much better than we can hope to do. Universities in Great Britain and Europe are much more adequately staffed than ours are, and public opinion in the Commonwealth is not yet sufficiently aroused to the importance of research to justify the division of chairs and the extension of the tutorial system, which would enable us to turn out men properly equipped for genuine research into the history of any European country. It would seem to me, therefore, that it is far better for use to modify the syllabus of the older Universities in such a way as to suit our own needs, provided we can be sure of the quality of the work that we propose to do, and of the standard that must be attained before academic distinction is conferred. It will be admitted, I hope, that there are some reasons put forward in this paper for considering that the need for Colonial Historical research exists. I may add to this that there is no comparison between the amount of research into the history of European countries and that of the colonies and the British Empire. And among the self-governing dominions of the Empire there is none in which so little has been done in a scientific and systematic way to explain its history as in the Commonwealth of Australia.

My argument may be summed up in a few words. The time has arrived when the history of the Commonwealth should be undertaken in a systematic and scientific way, and the institutions through which that might be done are the Universities. The historical work done there at present is preparatory, and should find its fulfilment in research. The best material for research is now available up to a specified date, and by means of scholarships, and especially open scholarships, the right men can be found to do it.

PAPERS READ IN SECTION E

1.—THE EARLY DISCOVERY OF AUSTRALIA: AND THE REASON FOR A "NO MAN'S LAND" ON THIS CONTINENT OF OURS.

By GEO. COLLINGRIDGE.

A FEW years ago I received a letter from my friend, the late R. H. Major, who was then considered the greatest authority on all questions relating to discovery, and especially discovery relating to Australia.

If you will allow me I will read that letter to you, because in dealing with a subject, difficult and abstruse as the present one is, this letter may serve as my excuse for the retrospective manner in which I have prepared this paper.

Corona d' Italia,
Via Palestro 4,
Florence, March 28th, 1890.

Dear Sir,—

Your very kind letter and accompanying number of the "Centennial Magazine," sent to my address in London, have just reached me here, and I beg you to accept my best thanks for them.

I have read your article with great interest, and seeing that great obscurity surrounds the actual explorations on which the early sixteenth century maps of Australia are founded, minutely critical observations on individual expressions occurring on them are of great interest, and, in the endeavour to progress from the unknown into the known, one is never sure what fresh stepping stone may not be gained sight of by means of any slight glimmer of new light.

Another interesting problem lies before you, if you care to follow it out, in tracing the value of the word "*Quabesegmesce.*"

At present my own mind is fully occupied with another subject; but in the event of your happily lighting on any fresh tracts, it would always be a great pleasure to me if you would do me the favour to let me hear of them.

Faithfully yours,

R. H. MAJOR.

The Unknown.—In the first part of this paper I shall show, by means of retrospective glances at various maps that have appeared from time to time, that this great continent of ours was discovered by unknown Portuguese and Spanish navigators at a very early period.

I say unknown, because their expeditions were not put on record, or, if they were, those records still lie buried in the archives of Torre do Tombo, in Portugal, and Simancas, in Spain. The Portuguese proverb, "Nao ha Segredo que tarde on cedo nao sega descoberto" (No one has a secret that sooner or later shall not be discovered), may some day come true with reference to them. For the present, however, one must, as Major puts it, content oneself with "progressing from the unknown into the known." Then fresh discoveries will result.

In the present instance, after showing by means of maps that Australia was discovered at an early period by the Portugeuse and Spaniards (and we must always remember that maps constitute the greatest evidence of land discovery), I shall, in the second part of this paper, refer briefly to the great discoveries of de Queiroz and Torres, the last of the great Portuguese and Spanish navigators

Map No. 1, 1911.—If we look at a recent map of Australia we shall find on it certain features and certain names, the importance of which, with reference to discovery, is not generally understood or heeded in any way. Let us take a rapid trip right round this continent and consider some of these peculiarities.

Starting from Cape York, and a little to the south-east of it lies a little picturesque island bearing the name *Cairncross* Island. Having vainly endeavoured to find the origin of that name in the various accounts of early surveys and discoveries, some years ago I advertised a handsome reward to anyone who should be able to solve the mystery connected with it. I got no answer. I continued to advertise for some time—for a long time ; I increased the amount offered, but all my efforts remained useless. The name, placed as it is, at the summit of the continent, is full of suggestion, because it was the custom of both Portuguese and Spanish navigators to erect stone crosses or cruciform cairns on islands and coasts discovered by them.

But let us pass on. We come, lower down, to Cape Tribulation. This is near the spot where Lieutenant Cook's ship the "Endeavour" nearly came to grief. Lieutenant Cook should have been more careful, for his shipmate, Joseph Banks, had in his possession an old document, amongst others given to him by Dalrymple, relating to early Spanish and Portuguese navigators in these waters, on which this part of the coast of Queensland was marked as "Coste Dangereuse" (dangerous coast).

Following our southerly course amidst the breakers and shoals we come to Broad Sound, Cook examined this part of the coast very carefully in search of a bay, and he anchored near an island at the entrance to the Sound. The navigation here is very intricate. This is the Lost Bay of the old Lusitano-Spanish charts. Torres, in the year 1606 endeavoured to reach it, but was compelled to abandon his attempt, owing to contrary currents ; the same currents were encountered by Cook, who, on that account, gave the name Repulse Bay to this part of the coast

Further south we reach the tropic of Capricorn. With reference to this important latitude, I need only mention that it is very accurately given in the old charts that we shall come to by and by, and also that the numerous islands in these parts will be found duly charted; the coast bearing the name of "The coast of many Islands."

The next name of importance is Botany Bay. Everyone knows that Cook called this bay "Stingray Bay," owing to the numerous and large fish of that kind found there. Joseph Banks made a splendid collection of plants at this place, and, it is said, the name Botany Bay was given to the picturesque locality on that account. It is quite possible. But it is also quite possible that Banks, seeing the name "Coste des Herbaiges" on one of the old documents to which I have alluded, though fit to leave the name as it occurred, although on the Lusitano-Spanish charts it is set down somewhat to the north of Botany Bay.

We come now to Gabo Island. Can anyone suggest a likely origin for this name? Personally, I have failed; but, strangely enough, Cabo Hermoso, Handsome Cape, appears at this place on the same old charts mentioned above. Handsome Cape would correspond with Wilson's Promontory, one of the most striking headlands along the eastern coast of Australia.

Before passing on to the south of Tasmania, I may mention that the old charts give a name for the straits now known as "Bass Straits;" it is called Baye Neusve (New Bay).

I must also point out that an old narrative, albeit very incomplete and anonymous, appears to refer to this part of the world, and puts on record the loss of a ship on a passage or strait situated in 45° of south latitude. Now, at Warnambool, on the coast of Victoria, an old mahogany vessel, locally known as the Spanish wreck, once only half-buried in the sand, still lies there, although now completely silted up, and a friend of mine down there informs me that shortly efforts will be made to bring to light this old relic of the past. In connection with this matter we must remember that many other relics exist along the coasts of Australia, and, quite recently Mr. Law Hargraves has read before the A. Hist. Society some very interesting papers showing that early navigators had landed on these shores long before the advent of the Anglo-Saxon.

We come now to Piedra Blanca. This is an old inscription, preserved to this day on modern charts, and can only refer to some early Lusitano-Spanish charting. The words mean Mewstone, or literally White-stone, and indicate some basaltic rocks at the southernmost end of Tasmania.

With regard to the south coast of Australia it is not astonishing that no trace of nomenclature is to be found thereon; obviously there should be none, for on all the old charts Australia and Antarctic are one.

When de Queiroz took possession of the southern regions, his words were: "I take possession of all the lands which I sighted and am going to sight, and of all this region of the south as far as the Pole, which from this time shall be called Australia del Espiritu Santo."

MAP No. 2.—We are now on the western coast of Australia. The first name that occurs is Rottnest Island. This island is plainly shown on the old Lusitano-Spanish charts, but bears a strange name that has led to some stranger mistakes. It is called "Hame de Sille." It is a curious jumble that I have not been able to decipher.

Now, in those days navigators and geographers were constantly in search of more or less fictitious islands, among which the "Island of Men" and the "Island of Women" had been sought for in vain. Could this be one of the lost islands? The old-fashioned letter ſ resembling an "f" made Hame de Sille look like Hame de fille, and a French geographer jumped at the conclusion that the word was fille and that he had found the long-lost island. He called it accordingly I. des filles—Island of Girls. The Dutch translated the name on their charts, appropriating other national discoveries as was their wont. They called it Meisje Eylandt, but instead of the girls that they expected to see the island peopled with they found it over-run with beautiful creatures, it is true, but, alas, of the small wallaby kind—that pretty brindled kind peculiar to the outlying islands of Western Australia. It goes without saying that they did not know of the term wallaby, and taking those pretty creatures for overgrown rats—they described them as being as large as a cat—they called the island Rat Island or Rats' Nest, and Rottnest is the Dutch form thereof, preserved to this day.

Houtman's Abrolhos—this is another Dutch puzzle. Houtman was certainly a Dutchman, but the word Abrolhos is Portuguese and refers to the nature of the reef. In making inquiries about Houtman, I found there were two brothers of that name. At an early stage of their career, long before they came out to Java with the first fleeters, they were commissioned by Dutch merchants to go to Portugal and make inquiries about Portuguese maps and voyages to the East. It is uncertain which brother has his name commemorated in connection with this reef, and as no mention of either brother having ever been near them occurs in history it is most likely that the name was substituted for some Portuguese name that held the honour of priority.

Pt. Cloates is a name equally puzzling. It is evidently a corruption, probably of the French word Roches, which itself is derived from Roccos, and may refer to the gigantic Roc described by Marco Polo. It belonged at one time to a far outlying island that was reported to exist off the part of the western coast of Australia, where the name is now to be found. Cloates Island is often mentioned in early narratives. Some sea captains sighted it and gave vivid descriptions of its beauty; whereas others sailed backwards and forwards over the position that it was supposed to occupy without ever setting their eyes on it. Finally Captain

Phillip P. King, who so carefully surveyed the western shores of Australia in the early days of settlement, being unable to locate the island after many attempts, gave the name to the westernmost point of Australia, where it is now placed in memory of the past. It is most likely that the island that bore the original name has subsided.

Shoal Bay is the next name we come to. It is the Terra Anegada, or Submerged Land, of the old Portuguese charts. Shoal Bay occurs on this shallowest and apparently most submerged portion of the north-west coast—a coast so shallow that, owing to the difficulties of approach, portions of it have not yet been surveyed. The term submerged land is, therefore, a most appropriate one, as the name, Shoal Bay, given by Phillip P. King, in the same locality bears testimony. The inundated appearance noticed by many is due greatly to the extraordinary rise and fall of the tides along this part of the coast. P. P. King, when at anchor in Camden Bay, close by in 1821, says —" At the anchorage the flood did not seem to run at a greater rate than $1\frac{1}{2}$ miles an hour, but it ebbed two miles, and fell 37 feet, which is the greatest rise and fall we had yet found. It is probable that from the intricate nature of the coast that these high tides are common to all the neighbourhood."

Now further to the north we come to the Gold Coast of old Portuguese charts. The correctness of this term was eventually understood when the rush to the Kimberley gold field broke out. In this part of Australia P. P. King found that the natives spoke a peculiar language, which he could not make out, but which he put on record in his book, and which I found to be Portuguese.

When the Dutch made what they thought—or pretended to think—were first discoveries in the neighbourhood of what is now Port Darwin, they called the broad sound that occurs there Van Diemen's Bay, but, as often happened with them, they left a portion of the appellation in Portuguese—baya.

In the Gulf of Carpentaria occurs a Portuguese nautical phrase, " Anda ne barcha "—no boats go here - the discovery of which phrase enabled me to establish the Portuguese origin of the Dauphin chart. (I must mention here for those who are not acquainted with these old French charts of Portuguese and Spanish origin that the one that came to be called the " Dauphin Chart " —the oldest of the set of 7—was so called by R. H. Major, because it was executed in the time of Francis I. of France for his son, the Dauphin, afterwards Henri II. The chart in course of time came into the possession of Edward Harley, Earl of Oxford, after whose death it was stolen by one of his servants. Subsequently it was purchased by Joseph Banks, who, after some years, presented it to the British Museum in 1790. Copies of these old and rare documents were made at a cost of £300 for the Sydney and other Free Libraries.)

I have said that the discovery that I made of the Portuguese phrase " Anda ne barcha " enabled me to establish the Portuguese origin of this chart, or, better still, of its prototype, since the phrase, correctly spelt, appears on this the oldest known chart of Australia, having been set down mechanically by the copyist, who evidently mistook it for the names of two islands in the Gulf.

Curiously enough the same phrase appears on the other charts of the same school, but the orthography is so corrupted as to render the meaning of it unintelligible except to the reader of the correct form on the Dauphin chart. This phrase, not having been noticed by any of the critics who have for the last century commented upon these curious old documents, and the other names on the Dauphin chart being principally French, the conclusion was that the chart was of French origin, and that the honour of priority of Australian maritime discovery was due to that nation. The phrase " Anda ne barcha " upsets that theory and, furthermore, points to the prior existence of a Portuguese prototype, from which all these charts have been copied. It also shows that the Dauphin chart was not copied from any of the known copies, since in them the phrase is corrupted, but that, on the contrary, it was copied from an original Portuguese chart, which has either been destroyed or has not yet come to light.

All the above goes to prove that the Portuguese and Spaniards were the discoverers of this continent, for they could not have charted it so carefully and accurately unless they had seen it.

I come now to the sub-title of this paper, and shall endeavour to give a reason for a " No Man's Land " on this continent of ours, which reason will be one also that I shall venture to offer for the non-occupancy of the Northern Territory—the all-important question nowadays for Australians.

Is it not strange that on a continent that has been occupied by our people for over a century there should have existed right down through its centre from north to south a vast tract of country, presenting an open door 1200 miles wide open to the teeming seafaring populations of the north ? Is it not strange that this vast tract of country should have been unclaimed from the very day we set foot in Australia, and is still undeveloped in its northern parts ? If one looks into the matter carefully there is absolutely no valid reason amongs all those that have been given from time to time to account for this state of things.

The interior of Australia was once thought to be covered with water—I do not refer to pre-historical times, but to days of early settlement ; a later account made it a howling desert of sand. Facts have proved that these early ideas were entirely wrong, and even quite recently it has been found difficult to dispel all the false notions entertained anent this, the best, the healthiest, richest, and most fertile of all the Australias.

No, the reason for its non-occupancy is far behind and beyond all the reasons given hitherto. It dates back to the days of Pope Alexander. Had it not been for Pope Alexander's line of demarcation Port Darwin might have become the front door and capital of Australia, and, facing as it does the greatest population of the globe, the question of Australian naval bases would have been settled for all time.

Some years ago I suggested in an article to be published in a leading Sydney magazine that the naval bases of Australia should be at three different points, or one of three different points, namely, Port Darwin, Cairns, and Port Curtis. My article was refused because at the time the proprietors of that magazine were following the narrow views that pre-emptive rights suggest the booming of Sydney " as the most suitable place."

Now, however, I am glad to see that the Sydney press, which also held peculiarly parochial views, have altered them. I am also pleased to notice that my views coincide with those of Admiral Henderson, and hope that no narrow spirit will be allowed to inferfere with what should be decided on this all-important point.

But with regard to pre-emptive rights, I wish to show how it came to pass that the Northern Territory has been so neglected. A few years ago it was called Alexandra Land—not in honour of Pope Alexander, that was only a coincidence—but simply because there was a difficulty in finding a name for it, and some one suggested the name of Queen Alexandra.

Let us go back to the year 1834. At that time the Territory was known as " No Man's Land," and extended from the Bay that became known as Port Darwin to the Great Australian Bight. You will notice (see map No. 2) that South Australia had not reached across the gap, and although the Swan River Settlement only occupied a small portion of Western Australia, the Territory then known by the latter name extended as far as the 129th Meridian—whereas New South Wales extended from north to south, Queensland and Victoria being unknown quantities.

(Map No. 3.) Now, going farther back into the misty past, let us say to the year 1825, the Australian Territory is limited to New South Wales and Van Diemen's Land. What is now Western Australia was New Holland, and, presumably, belonged to the Dutch, but the vast empty space, the No Man's Land, divided the Dutch area from the New South Welshmen's. Nobody wanted it apparently.

In the year 1788, when New South Wales was settled, and in 1770, just after Cook's voyage, the features are the same, with the exception that Van Diemen's Land was joined to New South Wales. Bass had not yet discovered the Straits.

EXPLANATION OF PLATES XXXIX. AND XL.

Maps illustrating Discovery of Australia.

Shall we make a further step back—back to the years of Dutch maritime supremacy, when Tasman circumnavigated this great Terra Australis, sailing in a very roundabout way for fear of breakers along the coasts and dreaded giants on land. The map bearing date 1644 gives us an idea of what the southern continent was like in the minds of the Dutchmen of the period. Nova Guinea is included, for although Torres had passed through the Straits 18 years before, the Dutch either ignored the fact, had forgotten it, or purposely concealed it. The western shore and the western shores only of the present day York Peninsula were set down and the country named Carpentaria. The eastern half of the Continent was known as Terra Australis, and, as you will notice, the western half, in this map, bears the name *Hollandia Nova*.

The first features of " No Man's Land " being the overlapping disputed territory between Pope Alexander's line of demarcation and the extreme limit afterwards claimed by the Portugese, and which became the Dutch East India line of demarcation, hence the East Indies and the West Indies—the line which Phillip, the first Governor of New South Wales, was instructed to observe as the limit of the possessions claimed by the English Government.

We must now take a big step back into the dark period of history, when the Great Southern Continent was rising upon the gaze of the world like a new moon, the greater part of whose disk lies in black shadow. A period replete with the romance of bygone days, when the terrors of the deep still held sway and the mariner was loth to lose sight of the shore and enter the sea of darkness with its dreaded currents, ever flowing south towards icy regions from which there was no return.

1530. We are away back in the first half of the sixteenth century.

Dauphin Chart.—The map shown here is a copy of the Dauphin Chart of Australia, then known as " Jave la Grande " (the Great Java), a term given to it by the inhabitants of the islands to the north of Australia, according to the great Venetian traveller, Marco Polo.

Australia has been called the " Land of Paradox." Now, when looking on this chart, one is confronted with the greatest paradox of all those hitherto contributed. Between the two lines of demarcation shown here lies the most coveted portion of the Globe, a portion for which the great maritime powers fought for strenuously, and this is precisely the region which up to the present day has been going a-begging—nobody wants it. Let us hope that it will not always be so, at any rate now; if we don't take possession of it, somebody else will. Big slices of the earth are much sought after nowadays.

2.—DISCOVERY OF PITCAIRN ISLAND— MUTINY OF THE "BOUNTY"—LIFE OF THE MUTINEERS ON PITCAIRN AND THEIR REMOVAL TO NORFOLK ISLAND.

By A. C. MACDONALD, F.R.G.S.

A LITTLE less than a century and a half ago the existence of Otaheite was totally unknown alike to navigators of Europe and the savages of the South Seas. It is the largest of that group called the Society Islands, which stretch away east by south, dotting the bosom of the Pacific as with emeralds and coral for the space of 2,000 miles. Otaheite, so celebrated in the voyages of Captain Cook, and so remarkable for its natural beauties, lies about 17 degrees south latitude and 149 degrees west longitude. Nearly the last of this series of enchanting islets is Pitcairn Island, about 25 degrees 30 minutes south latitude and 139 degrees 30 minutes west longitude. It is an outlying and inconsiderable island, beyond the path of the great seaway of commerce. It has an almost ever sunny clime, and nature scatters her gifts with lavish hand.

At a distance of 45 miles it appeared at first as a high spiral rock rising out of the sea, but on drawing nearer to its shores it was seen to be a perfect island, seven miles in circumference and over 1,000 feet high. Owing to stormy weather at the time a landing could not be effected, and the discovery was briefly noted in the logbook of the "Swallow."

It was on the 4th of April, 1789, that the ill-fated "Bounty," another vessel which hoisted British colours, and commanded by Lieutenant Bligh, left Otaheite laden with 1,015 living plants of the breadfruit tree, with which the Imperial Government had proposed to enrich our West Indian Colonies. Her homeward voyage seemed likely to be prosperous.

Commander Bligh was, unfortunately, of an unhappy disposition—exacting, imperious, despotic. He had neither the art nor grace to mingle sympathy with rigid discipline, and he contrived to destroy that unity of feeling which is the best security for the harmonious working of every machinery of Government, whether on shipboard or the larger vessel of State.

There was on board the "Bounty," acting in the capacity of master's mate, one Fletcher Christian, a young man who came of a respectable family in the north of England ; he had excellent talents, but his temper was hot and revengeful. Christian determined to be revenged on Bligh for the insults heaped upon himself and others, and conspired with some of the crew to seize the vessel.

The mutiny broke out on the night of the 27th April, 1789. As morning approached, Christian, who was officer of the watch, accompanied by three others, entered the Commander's cabin and seized Bligh while he was asleep. After binding him, Bligh was placed in a boat with nineteen others who had not participated in the mutiny. They were given twine, canvas, lines, sails, cordage, a 28-gallon cask of water, a small store of rum and wine, together with a quadrant and compass, and were then cut adrift. They were then near the Tonga Islands (Sofoa, 19 degrees south latitude 184 degrees east longitude). After 41 days' extreme suffering they reached the Island of Timor (9 degrees south latitude 125 degrees east longitude), a distance of 3,618 nautical miles from where they were cast off the "Bounty."

Let us now follow the mutineers. They are, of course, now cut off from old England— and so Christian heads the "Bounty once again towards the enchanting shores of Otaheite. A dilemma presents itself; how shall they account to the natives for the absence of the Commander and so many of his men? A lie must be invented to deceive the simple-minded children of nature; it is soon told. They had met with Captain Cook, the islanders' old friend, and Lieutenant Bligh and some of their comrades had rejoined him.

Fearing that the frail boat may reach some island, and the mutiny become known, they consult, and flight is determined upon. The mutineers consequently seek a more secure retreat. Leaving some of the crew behind they again set sail, taking with them twelve Tahitian women and twelve Tahitian men; of the former, nine were wives of the sailors. Mutual recriminations ensue. Fletcher Christian grows moody, fitful and impatient. They cruise about Toobonai, and to divert their thoughts into healthier channels Christian orders a fort to be erected, but progress is slow.

Once more the anchor is hove and the "Bounty" takes flight. At last, standing right across their path, are the peaks of Pitcairn, which will be to them the Patmos of expiation. Its rock-bound coast is difficult of accsss, and can only be approached with certain tides and state of the weather.

Council is held, and the die is cast. A party proceeds to unship their goods and carry them ashore. Amongst other things, some books are not forgotten, but little heed they how these are to generate into glorious life and fruitfulness. The last boat has left the ship, but before leaving a brand is applied to the fated vessel.

Christian, still haunted with the dread of discovery from some Government vessel sent in pursuit, erects a kind of fort on an elevated spot from whence to observe any ship that might approach the island. The Otahetians, watching their opportunity, took Christian and four of his comrades unawares and killed them. Between the mutineers that remained and the six Tahitian men a civil war now raged; the more astute and better armed whites naturally in the end exterminated their unfortunate antagonists.

One of the mutineers had learned the art of distillation in the Fatherland, and in an evil hour he sought out a native plant, the juice of which, as containing saccharine matter, was adapted to his purpose. In consequence, two of the men became almost perpetually drunk, and finally destroyed themselves.

In Pitcairn all was dark. The old generation, mutually butchered by the sword, or self immolated by intemperance, had passed away. The two survivors of the mutineers, destined to be the nursing fathers of this young generation, were, singularly enough, called Adams and Young. The latter, a midshipman, did not long survive, and so the care of this little community devolved solely upon Adams.

John Adams had been originally an errand boy in London. In this capacity he had meritoriously taught himself to read. I recorded the fact that when the stores were landed from the "Bounty," some books were amongst them. One day Adams stumbled upon a volume. It was a Bible. The seed of truth is sown in the soul of that erring one, "And the wicked man has turned away from the wickedness he hath done."

In 1831, 41 years after arrival of the mutineers from Otaheite to Pitcairn Island, notwithstanding the tragedies I have enumerated, the population had increased to 187. The island had in the meantime been visited by one or more vessels—in other words, it had been re-discovered. But of the population in 1831, 153 of the 187 made a disastrous migration to Tahiti, leaving only 34 at Pitcairn. Later on, according to Bishop Selwyn, "a number of well-meaning people in England had taken up their case with that enthusiasm which is always lavished on the heroes of a romantic story and of blemished escutcheon, and which honest and prosaic people have to go without."

In December, 1852, a despatch was sent from Downing Street by Sir John Pakington to Governor Denison of New South Wales, in which the latter was requested to furnish a report showing what arrangements would be necessary for the evacuation of Norfolk Island as a convict depôt and for the reception of the people of Pitcairn. In May, 1855, the convicts were withdrawn from Norfolk Island, and the removal of the Pitcairn Islanders being rendered necessary in consequence of their peculiar form of Government—a kind of modified communism—which required that every family should occupy the same quantity of land, it was seen that if this went on much longer the portion allotted to each family would be utterly inadequate to sustain it, nearly the whole of the cultivatable land on Pitcairn being already occupied.

In August, 1855, Captain Freemantle was despatched by Governor Denison to Pitcairn to ascertain the will of the people. The matter was fully discussed, and on the day following the meeting of the Pitcairners the majority decided in favour of removal to Norfolk Island. On the 22nd April, 1856, the "Morayshire" (Captain Mathews) arrived at Pitcairn, and eleven days later sailed for Norfolk Island, and landed on the 9th June the whole of the population, consisting of 40 adult males, 47 adult females, 54 boys and 53 girls. Here I must leave them.

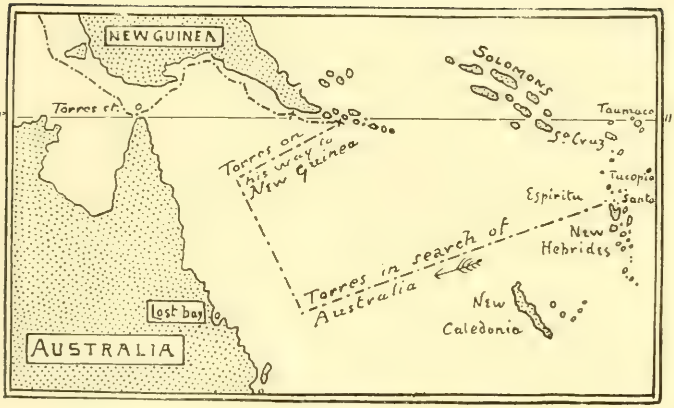

FIG. 1

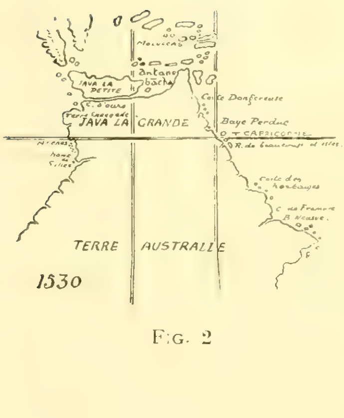

FIG. 2

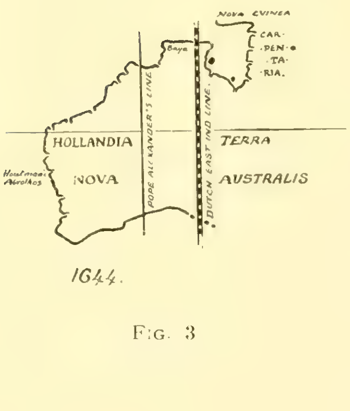

FIG. 3

EARLY DISCOVERY OF AUSTRALIA.

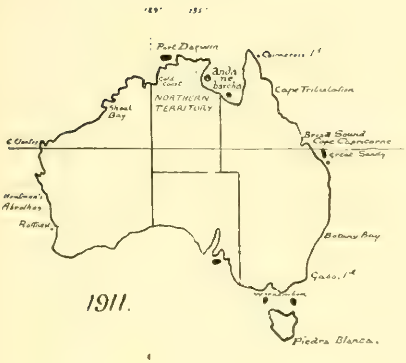

FIG. 1.

FIG. 2.

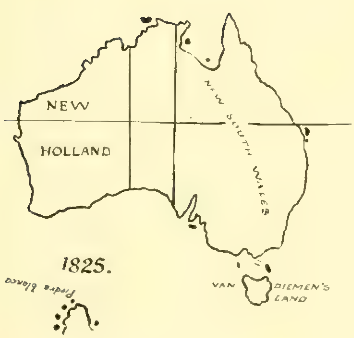

FIG. 3

FIG. 4

EARLY DISCOVERY OF AUSTRALIA.

3.—AN EXPLORATION IN NEW GUINEA.

By DONALD MACKAY, F.R.G.S.

I LEFT Sydney on June the 28th, 1908, with the object of exploring the Purari River to its source. My object was chiefly to locate metalliferous country, and at the same time make any observations that might in some small way add to our knowledge of little known New Guinea. I enlisted the services of Mr. Little, a well-known pioneer, to recruit the necessary native carriers. To the Federal Government I am indebted for the use of scientific instruments. My plan was to depend on the Government steamer, the "Merry England," to land my party at the mouth of, or rather at one of the many mouths, of the Purari, and then to follow the river in boats as far as practicable, making excursions from base camps to the east and west. As the Purari some one hundred miles from its source turns sharply from a general north and south direction to an east and west course, it seemed at one time feasible to strike southwards from our most westerly camp. As it happened, I had to return to the sea by practically the route as that taken on the forward journey. I travelled via Brisbane and Cooktown, arriving at Samarai on July the 6th.

When some twenty miles from Port Moresby we passed through a light rain. Port Moresby is in the Papuan dry belt, and this dry belt extends some 60 miles west as far as Yule Island. Yet here only 20 miles out to sea it rains nearly every day.

On reaching Port Moresby I found Mr. Little still away recruiting. The "Merry England" was also away with the acting Governor on board. As the s.s. Moresby was sailing for Samarai I decided to go on to that "Garden of Papua," where I should meet Little and my "boys." These last I saw for the first time as they filed off the ship at Samarai, and they looked a wild and a woolly crowd, especially the "Tufi boys" from Cape Nelson, with their hair hanging in long ringlets.

On returning to Port Moresby I met with my first disappointment. I learned that the captain of the "Merrie England" could not at this season of the year undertake to land my party at the Purari. A message came in from Mr. Higginson, the resident Magistrate of the Gulf Division, to say that he was waiting to render us assistance at the Purari, but he added that great seas had been breaking on the coast for the past month and no whale boat could live in the surf. Mr. Bowden and the Mission Fathers at Yule Island were equally pessimistic. I therefore decided to make the journey from Yule Island by land, and from Yule Island I made my real start. The party consisted of Mr. Little, Mr. A. E. Pratt, surveyor, Mr. Ichborne, collector, myself and 84 carriers.

The 140 mile tramp from Yule Island was particularly trying on my "boys," and I had considerable difficulty in keeping them going. Walking on sand along beaches, in the direct sun, was a new experience for them. On this coastal trip we were frequently blocked by the difficulty of crossing rivers, and there was little that was new to observe. At the village of Diapu we saw a settlement noted for the number of children. They came around in droves, and were kept at a distance only by an exhibition of juggling with his false teeth by one of our party.

At another village, on the Lacey River, we engaged some youths in an archery competition, and they showed no mean skill, when pieces of tobacco were the prizes. Some village dandies were spectators, and in their way were curiosities, for they looked like exaggerated wasps with their waists tightened to the last inch. Some old men from this village who were paddling a canoe seemed to take a keen satisfaction in taking out their nose sticks every few minutes and washing them.

On our arrival at Motu Motu we were welcomed by 100 or more plumed or painted warriors, men of exceptional physique, which I think are the best types of natives one sees along this coast; they shouted, and danced around us in quite an alarming manner, and then it was a case of shaking hands all roun . They brought pigs, cocoanuts and native foods in abundance. It turned out that there was a big dance at the village (these native dances often last for several days and nights and only terminate through physical exhaustion and the food supply becoming scanty); this accounted for their elaborate costumes and the quantity of pigments that were plastered on their faces. After our evening meal we went into the village, where about 100 performers were engaged in the dance. The men were decked in gorgeous apparel, especially headgear, some of the headdresses being many feet high; they are made of wickerwork, which is covered with bright coloured feathers, the plumes of the Raggiana bird of Paradise being much in favour. Round their ankles they wore a kind of frilled anklets made out of grass and fibre; the women only wear Ramise (a kind of grass petticoat) and ornaments round their necks. The orchestra consisted of tom toms, a stick some six inches in diameter at either end and narrowing at the centre. It is about 2 feet 6 inches long, and over each of the hollowed ends iguana skins are tightly stretched. The dancing ground was in a square in the centre of the village, some 40 yards long by 20 broad; the dancers massed at one end, and then, headed by the master of ceremonies, who walked backwards in front of the dancers as they advanced up tha square holding a blazing torch made of dry palm leaves high above his head, The dancers formed regular and complicated figures, keeping excellent time coming to the end of the arena; they reversed and repeated the same performance *ad lib.* The houses that surrounded the dancing ground are all two-storied and were crowded with silent admirers.

On the Purari Delta I saw a type of canoe not known further east. They are of a distinct type from any canoes east from here; they are made in all sizes up to 40 feet long and about 2 ft. 6 in. wide; the ends are cut away and quite open. Across the end is put a small bank of mud, and if the water is rough a boy sits on his haunches in front of the mud to prevent the water from washing it away. I could hear no certain reason why the ends were cut away—some think to make it easier to bail out, but on the other hand it is much more easy for the water to get in.

As one goes west along the coast it is seen that the native dress grows more scant, and the natives do not seem to be as good a type. At Maipua on the Delta the men, though well built, are shorter and the women are very small, and for natives have poor chest development. The women only wear a small grass covering, which does not extend round either side of the thigh, and the men only an apology for a covering, which would not protect them from the law anywhere on the fringe of civilisation. They do not go in for much personal adornment, though nose-bones are fairly common amongst the men.

The River Purari has of course been visited and written up, but it is safe to say that although we could recognise familiar palms, canes, and creepers, breadfruit, pandanus, etc., there are many new trees and shrubs waiting the work of a botanist. The whole of the country along the "Mouths" is typical delta land, and it looks as if it might be submerged at any time. It was August 16th before we came to a point where regular banks rise above the stream.

To give some idea of the difficulty of ascending the Purari in canoes, it took the expedition 21 days from Maipua to Beroie, which is 140 miles; and on the return trip with double canoes, made by the carriers, we did the same distance in three days. In the upper reaches of this river, when it is in flood, which seems to be generally the case, the current runs approximately eight miles per hour.

Animal life did not assert itself, but we captured a cuscus, and parrots, Goura pigeons, king-fishers and horn-bills showed themselves. We got two water hens apparently identical with those in New South Wales. Myriads of insects infest every camp in Papua, and scrub leeches are not the least worry to be reckoned with.

Towards the head of the delta we measured the Purari proper, and the river width worked out at about 475 yards with a current of some three miles per hour. We reached the locality where Sir William MacGregor charted the Island of Abukiru, only to find the island had disappeared. It was here that Sir William MacGregor got samples of good coal. A short distance up sandstone showed in the banks of the river. From the junction of the Auri River new ground was broken, and on September 7th we reached Sir William MacGregor's furthest. From this point forward until we returned to the same point on January 12th the country was new.

From the standpoint of a prospector, the country is disappointing. The most plentiful rock is limestone. This is clearly of considerable thickness, for it shows itself in deep gorges and impassable cliffs. Frequently water courses disappear into fissures and limestone caves are much in evidence. Taking a bird's eye view of the country explored, it looks one never ending series of steep valleys and knife-top ridges. There is little or no level ground. Clearly the country is being eroded at a rapid rate. The abundance of limestone and sandstone and the absence of granites and porphyries or massive igneous rocks all help with an abundant rainfall to bring about this result. There is a true slate cropping out, but it is not so plentiful as sandstone. Although frequent tests were made, no gold was found in any "wash" beyond Sir William MacGregor's farthest. The occurrence of coal may have some day an economic importance. West of the head waters of the Purari pieces of coal were noted in the creeks. A seam of coal 9 feet thick was seen near the head of that river, and the country about Abukiru Island has every appearance of being coal-bearing. Pebbles of basalt were seen in the water courses, indicating probably basalt capped ranges.

We reached a point from which we could make out a valley, evidently the head of the Kikori, a river 70 miles west of the Purari, but it was useless to attempt to follow down the rough limestone gorges. After more than one attempt to push out west, we were convinced that to cross to the Fly River or to any of the nearer streams that lead to the coast was a prize for some more fortunate explorer.

As an illustration of the climate on the Upper Purari, I may say that in seven consecutive days I measured a total of 11 inches of rain. Under such conditions is it any wonder that the face of this country is carved into gorges and chasms, and that the limestones are cut down and caves eroded?

From July 30th to October 20th we never once got a view of the moon, clouds, fogs, or mists shutting out the view. For 25 consecutive nights no stars were visible and no star observations could be taken.

On the whole the natives were not troublesome, though, as may be expected, at times they became aggressive. During the trip only one "boy" was killed outright, and three others wounded by arrows. On one occasion only they made a night attack.

The natives we met near Beroie are physically fine men; they live in small palm-leaf shelters; though we saw the ruins of one two-storeyed house and the remains of deserted gardens. The tallest of these men was about 5 ft. 7 in., broad, and deep-chested. They wear nose ornaments, which are made of the spines of the cassowary wing, fixed in a small cane-grass cylinder, which is passed through the central division of the nose, the spines extending on either side about four inches. They also thread a long spine through the point of the nose, which curves upwards towards the forehead. The natives who adorn themselves in this way have not been met with elsewhere in New Guinea. They wear ear-rings made from the same sort of spines, necklaces of cane-grass seeds, cassowary feathers adorn their hair, and they wear armlets of lawyer cane (these, I understand, are used for fire-making), also a variety of ornaments hung round their necks.

The Samia natives are somewhat similar; but some of them carry a lance five feet long made of black palm, as well as bow and arrows.

West of the Purari watershed we found the natives much more numerous, having substantial houses some 130 feet long, big gardens, in which they grow yams, beans, sugarcane, tobacco, taro and ginger. These natives are hardly so tall, but heavily built, with broad faces tapering to the forehead, which is low. They wear broad arrow-proof belts that cannot be taken off, and from a string round their necks are suspended dried human hands, feet, human jaws, the top of human skulls, etc.

The natives from Beroie to our furthest point have a very offensive smell, which one can detect in the bush for a considerable time after they have gone. When away from their villages even the smallest boy carries a bow and bundle of arrows, often of three kinds. Those for warfare are barbed and bone-pointed. Pig arrows have broad bamboo points, and fish arrows with four to six separate points. Some also carry a stone-headed club, and occasionally a stone tomahawk, the blade of which is set at an angle of 45 deg. to the handle.

Game is scarce. We saw a few wallabies, cassowary and pigs. Fish are fairly numerous as far as Hathoi Gorge, catfish and mullet being the most plentiful, the latter up to 18 inches long. In the upper reaches of the river the fish are small, and are caught by the natives in big wickerwork traps. Carpet snakes are also plentiful ; they are generally found coiled up in the trees along the river bank, the largest we shot being 15 feet. Alligators are seldom seen ; never above Hathoi Gorge. Miserable, undersized dogs were often seen with the natives.

We found sufficient sago palms to keep the carriers in food in the country from Beroie to our furthest point west. The local natives instead of cooking it as the coastal tribes do, moisten the flour with water and then ram it into a length of bamboo, which is placed over a fire, and when cooked the bamboo is stripped off, leaving a glutinous stick of pinkish-coloured sago.

At one of our camps 13 natives came in, seven men, one carrying a picanniny, and five women, who seemed very shy. They were about 4 feet 7 inches in height, with short hair. The body was covered from neck to knee with a loose garment made of native cloth, the edges being frayed out. They had a broad band across their foreheads ; from this was suspended a woven bag, resting on the back, and is used for carrying food, etc. Little, walking round to the other side of the camp, caused them to leave, much to my sorrow, as I desired to take a photo of them. They imagined he was going to cut off their retreat.

One fact stands out regarding the natives we saw. They cultivate the soil, and do so with considerable skill, but can only be described in their present state as the cruellest and most bloodthirsty savages. They know no pity to a captured enemy, nor for that matter to any man.

I brought back collections of birds, insects, and native implements, all of which have been placed at the disposal of scientific men. My unaided effort may not be altogether in vain if I have been able to add even a little to our growing knowledge of one of the last inhabited regions that remains to be explored on this earth.

LECTURES

On the evening of Tuesday, January 10th, the President of the Section (Professor C. C. Henderson, M.A.) delivered a lecture in the Great Hall of the University before the Association, entitled "The Mutation Theory of Evolution in History."

Following is an abstract ;—

The publication of Charles Darwin's "Origin of Species" in 1859 was the greatest event in the reign of Queen Victoria. The idea of evolution, known to the ancient Greeks, was rediscovered and put so plainly and convincingly that in less than a decade principles of the doctrine of evolution were known even to people who were without systematic scientific training. Not only in the more strictly scientific world, but also throughout the realms of learning generally, that book exercised an influence which can only be described as stupendous. From 1870 onwards evolutionary philosophy has pervaded all departments of intellectual activity, and it has stimulated patient and painstaking research in all directions.

That research, extending now for over half a century since the publication of the "Origin of Species," has so far justified the conclusions of the great naturalist that his reputation as one of the world's greatest thinkers is assured. He was great, however, not only because of the positive assertions which he made in regard to evolution, but also because of the splendid restraint which he exercised in the application of the principles he had discovered.

There are no reformers so ardent as newly-made converts, and it has frequently happened in the history of mankind that devoted pupils have evinced a ready disposition to apply the master's principles in a much more thorough-going fashion than that master himself dared to do. So it has been in the history of evolution. Darwin recognised the possibility of change by sudden and spontaneous production of new forms from the old stock, as well as by the gradual accumulation of ever present and ever fluctuating variations. Many of his followers have not only emphasised the latter at the expense of the former method, but they have also ventured to apply the principles of that theory to the development of the political, social and spiritual history of mankind.

As a student of history I am convinced that they are wrong in so doing, and it is on this point that I wish to engage your attention this evening. Physical evolution, or evolution in the organic world, is one thing ; psychical evolution or evolution of human life and affairs is another and a very different thing. I want to try and make as clear as I can, avoiding all technical language wherever it is possible, that you cannot apply the current theory of organic evolution to the history of the English people or for that matter of any other race of human beings.

I am encouraged to state my views the more boldly because the current theory of evolution has already been challenged by eminent scientists whose researches have taken them no further than the confines of the vegetable and animal kingdom. There are now two distinct theories of organic evolution. In the current theory the idea of continuity or steady progress is the one usually emphasised. "Organic evolution," says Karl Pearson, "is the progressive change of living forms usually associated with the development of complex forms from one or more simple forms." This definition will do as well as any other for our purpose. It indicates clearly enough a gradual progress from the simple to the more complex.

In opposition to this theory is the mutation or saltation theory of evolution which affirms that, even in the organic world, development is not continuous; but "that sudden mutation is the normal way in which nature produces new species and varieties"—that there are *breaks*, *abrupt changes*, or *leaps*. Of this theory Hugo de Vries is one of the most powerful exponents at the present time. In the preface to his work on "Species and Varieties; their Origin and Mutation," he contrasts the two theories in these words — "The current belief assumes that species are slowly changed into new types. In contradiction to this conception the theory of mutation assumes that new species and varieties are produced from existing forms by sudden leaps."

Now if such a theory as the mutation theory is applicable at all to the development of plant life, where the cosmic process works without challenge, it ought not to be very difficult to show that it is far more obviously and extensively applicable to the development of intelligent beings for whom, as Huxley says, in his Romanes lecture in 1893, "Social progress means a checking of the cosmic process at every step, and the substitution for it of another which may be called the ethical process." The phrase "cosmic process" has been subjected to searching criticism. It is somewhat vague, though not more so than phrases generally are which attempt to express the nature of ultimate forces. But whether we reject the phrase or not, distinctions between the organic world and the world of human beings can be put into words plain enough. Man is endowed with self-consciousness, animals and plants are not; man looks before and after, animals and plants do not; man has the power of reflecting on his own impulses and pronouncing them good or bad, animals and plants have not; man has the power of constructing ideals and regulating his life by constant reference to these ideals, animals and plants have not.

All these are essential differences between the organic and the human world which ought to make us far more cautious than Herbert Spencer ever was in applying the principles of organic evolution to the social and political development of man. They are differences that point constrainedly, if not quite conclusively, to the existence of a spontaneous independent principle in the mind by virtue of which man may challenge experience and tradition, resist them, overcome them, and start anew on his journey with the beacon-light of idealism to guide him. It is at such times of struggle that breaks have come and will come in the evolution of human affairs ; that new varieties are and will be produced from existing forms by sudden leaps.

Let us test the truth of this observation by one or two illustrations—one from the development of man's spiritual life, the other from the political development of men in the mass.

In all religious revivals there may be found individulals who pass through an intense inward experience commonly called conversion. There was such a revival in Europe in the thirteenth century, and another in England in the seventeenth century. St. Francis of Assisi may be selected from the former ; John Bunyan from the latter.

I do not pretend to know precisely what is meant by the term conversion, but it is clear enough to me from a study of the lives of these men that conversion marked a distinct break in the continuity of their inward development. In the life of St. Francis of Assisi that critical period is marked clearly enough by his mystical marriage with the Lady Poverty, which Giotto has represented in a famous allegorical fresco above the altarpiece in the Lower Church at Assisi.

Francis was the son of a wealthy cloth merchant, and up to that time he had lived according to the ordinary experience and traditions of the youth of his class. He dressed expensively, fared sumptuously, played, rioted, and regaled his boon companions with costly suppers extending late into the night. There was nothing vicious in his early life ; it was simply the ordinary gay and self-indulgent life of a young man who liked to be generous —with his father's money.

Then came the resolution to wed the Lady Poverty on that eventful night after the last boisterous supper, and, with it, a distinct break with past experience. Instead of fine raiment, he is contented with—nay, has preference for—rags ; instead of buying and selling for gain, he throws away what money he has or gives it to beggars. His devotion to the Lady Poverty is as absolute as anything human can be. He rejects privilege of all kinds, and instead of seeking personal glory, his one ambition from that time onwards is to be the poorest man in Italy. In a word, the gay, revelling, luxurious son of Peter Bernadone had emerged from a spiritual crisis with an invincible determination to follow the rule of the Holy Gospel literally and in very deed.

Now it is not necessary to argue that so great a change was effected in a few weeks or even a few months. It may have taken a year or even two years, but even if we allow the maximum that the best historical evidence can justfy it still remains true that while certain characteristics remained very much the same there was an abrupt and fundamental change in this young man's life, which can only be described in terms of the mutation or saltation theory by the word "break" or "leap."

It is, of course, highly desirable at this stage that I should state as clearly as I can what I mean by "break" or "leap." I mean this :—Up to the time of his mystical marriage Francis was following tradition ; after that time he had an ideal before him, turned his back upon tradition and followed that ideal faithfully—so faithfully that he who would explain the life of St. Francis of Assisi after that marriage, must understand it rather by reference to the Lady Poverty than by reference to past experience. To put the same thing in more scientific language, one might say that the change which came with his conversion was qualitative, not merely quantitative, and that the laws which were applicable to the stage of his development before conversion cannot be applied to the stage of his development which followed conversion. The difference between the two stages is the difference between innocent self-indulgence on the one hand and strenuous self-sacrifice on the other.

The same reasoning may be applied in the case of John Bunyan. It is not necessary to suppose that the blaspheming tinker of Bedford was as bad before his conversion as he paints himself in the "Life and Death of Mr. Badman." Nevertheless it is as true of him as of Oliver Cromwell that conversion marked a distinct break in the development of his spiritual life. Both turned their backs on the past, both set their faces toward an ideal. Henceforth their lives were regulated more by reference to that ideal than by reference to tradition or past experience.

As in the spiritual lives of individuals, so is it in the history of nations. We have, I believe, an excellent example in the imperial experience of our own time. From the days of the Roman Emperors until within the past twenty-five years empire has implied domination or sovereignty of one power and subordination on the part of the other powers comprised within the imperial unity. In the British Empire of to-day the idea of sovereignty has been abandoned. Instead of it we have a conception of empire fundamentally and essentially different—an association of free Commonwealths, one of them being the United Kingdom. For such an empire as this there is no precedent in the history of England or of Europe. If we would understand how fundamental and abrupt is the change in our imperial scheme of thought within the past 25 years we have only to draw two diagrams, as Richard Jebb has done in his lecture before the Royal Colonial Institute on "Twelve Months of Imperial Evolution,"[1] and compare them. Under the old conception of empire the self-governing dominions revolved like satellites round the United Kingdom. Under the new imperialism the United

1 Printed in the Journal of the Royal Colonial Institute, Dec., 1907.

Kingdom is no longer at the centre. It has taken its place on the orbit as one of the dominions, revolving like Canada, Australia, New Zealand and South Africa round the British Crown. This is a change of the most fundamental character, involving a scheme of administration entirely without precedent.

We have only to glance at some of the practical suggestions that have been made in the past few decades to realise the futility of attempting to use traditional imperial machinery for administering the British Empire, as we understand it and think of it to-day. In Charles II.'s time colonial affairs were administered by a committee of the Privy Council. It has been proposed, therefore, to revive the imperial authority of that council and include within it Agents-General from the colonies. Another proposal was made to expand the House of Lords. A third, to make use of the House of Commons by admitting representatives from the outlying parts of the empire.

Apart from all detailed objections to such schemes—and they are manifold — Lord Milner has exposed their futility in an article contributed to the "Standard of Empire" on the "Meaning of the Wider Patriotism." "The failure of past attempts at imperial organisation is due to our imperfect grasp of the wider patriotism," he says. "In practice we are always slipping back to that antiquated conception of the Mother Country as the centre of a political system with the younger States revolving round it as satellites. Against that conception the growing pride and sense of independence of the younger States revolts. That revolt is sometimes falsely regarded as evidence of a desire for separation. But the two things are not really identical. Indeed it may be said that the spirit of independence in the several States is a necessary stage in the evolution of a new form of union." Precisely. That is the language of a man who has had colonial as well as British experience, and who knows that whatever be the constitution ultimately contrived for uniting the Empire, it must be a constitution which works in harmony with the rising sense of nationality that prevails in Canada, Australia, New Zealand, and South Africa.

But it is in the assertion of this sense of nationality that we find the vital principle of the new imperialism which makes the empire of to-day so essentially different from any other empire of the past 2000 years. Hitherto nationality and empire have been incompatible. It was the rise of nations in the middle ages that undermined the Imperial Dominion of the House of Hohenstauffen. In the Spanish, French, and Dutch Empires of modern times there was no thought of recognising, much less encouraging, national aspirations ; and though statesmen of the 18th century knew it not, on either side of the Atlantic, it was at root the assertion of nationality that underlay the struggle of the American colonists against England. Not even Pitt had any idea then that nationality in America was compatible with imperial sovereignty in England.

Nor can any such enlightened view be found in the speeches delivered by Burke on American Taxation. It is not too much to say that there were no British statesmen who had any idea of such a combination of national and imperial principles until after the accession of Disraeli to power in the seventies of last century.

But since that time—a time so recent—our views of empire have fundamentally changed. Instead of regarding empire and nationality as incompatible, statesmen in all parts of the empire are inclining to the belief that nationality or dominion self-government is a necessary stage in the development of Imperial unity. Such a change effected within the past 25 years at the end of an imperial experience starting with Angevin Kings, cannot be explained otherwise than by a theory of breaks or leaps in the process of evolution. The new stage of imperial development is so essentially different from any other stage that has preceded it that he who would seek to unite the British Empire must do so, not by reference to traditional methods of imperial administration, but rather by reference to the new ideal of empire expressed in the phrase—"A free association of Commonwealths." In other words it is not by using the Privy Council, the House of Lords, or the House of Commons, or any other part of the constitution of England that imperial unity will be brought about, but rather by the use of some unprecedented institution—such an institution perhaps as we may expect to develop from the conferences of Premiers in London, which began as recently as 1887. The principles underlying such an institution need not conflict with the principles underlying new imperialism. That is why, I think, we are justified in hoping much from these conferences that now take place periodically in London.

In my illustrations I have directed your attention more particularly to spiritual and political progress. Had I cared or had I chosen to revert to the present condition of unrest in the United Kingdom I might have illustrated my point by reference to social progress. But it is unnecessary to multiply illustrations. The careful student of history will find them in any authentic record of England's development. There is more continuity in the constitutional history of England than in any other department of history; but constitutional history would serve my purpose too. There is a sense in which we may talk about the growth of the constitution, but every student who has looked carefully into constitutional history will agree with Mr. Dicey[1] that such language is metaphorical only, and, if taken literally, is absurd. "Constitutions do not resemble trees, which once planted are aye growing while men are sleeping. In every stage of their existence they are made what they are by human voluntary agency." The more closely we look into constitutional history the more fully we realise the inadequacy of the current theory of evolution to explain it. You must allow for breaks or sudden leaps in the production of new forms. The difference between these new forms and the old

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1 "The Law of the Constitution," by A. V. Dicey, p. 183.

does not consist merely in the amplification or diminution of existing qualities. It is a change in idea and in equilibrium. And this is as true of the advent of Cabinet government in the 18th century as it is of the new imperialism of the 20th century. The unity of constitutional history is not to be explained in terms of "linear fluctuations," rather it is a unity that manifests itself in successive forms that differ fundamentally and qualitatively from each other.

In offering these illustrations for your consideration I have dwelt exclusively on the sudden change in equilibrium and idea, because they are matters of paramount importance. It would be ill advised in a lecture of one hour's duration to attempt to show that they present all the other characteristics of a genuine mutation: that they come unexpectedly, and that they come to stay—they are stable and are not to be swamped by overcrossing.

But while the mutation theory may be supported by reference to any department of the history of human affairs, it forces itself most frequently and imperatively upon us when we contemplate man's ethical and spiritual development.

It is clear from his "Data of Ethics" that Mr. Herbert Spencer found no insuperable difficulty in applying the current theory of evolution here as elsewhere; but Huxley did, and I believe that, of the more serious students of evolutionary thought, 99 out of every 100 would agree that Huxley was the more reliable exponent of evolution. No man fought more strenuously for Darwinianism than Huxley in the early days of bitter and prejudiced opposition; but it was Huxley who in 1893 delivered the Romanes lecture on "Ethics and Evolution," and the argument of that lecture is well known to a majority of my audience. It would be interesting reading for those who still argue that the current theory of organic evolution is sufficient to explain man's moral and spiritual development. In the last half-dozen pages of that lecture he scouts the idea that "because animals and plants have advanced in perfection of organisation by means of the struggle for existence, and the consequent "survival of the fittest," that "therefore, men in society, men as ethical beings must look to the same process to help them towards perfection"; and he falls back upon a "fund of energy operating intelligently" within man, to wage battle with this cosmic process in the interests of social progress. Whether men profess to believe in this or not they have undoubtedly acted up to it in recent times. In England and in the self-governing dominions the doctrine of laisser-faire has been superseded by the doctrine of state initiative.

And if we turn from Huxley to a greater and more profound thinker we shall find even stronger support for the argument of this lecture. In his volumes on "The Evolution of Religion," Edward Caird, the late master of Balliol College, Oxford, has taken a general survey of the religions of mankind, and the argument throughout is that the evolution of man's spiritual life cannot be treated in the same way as organic evolution. Instead of there being a steady progression from simple to more complex forms, he continually affirms that the laws which are applicable to one stage of man's spiritual development may not be, and usually are not, applicable to another and later stage, that "humanity is a genus that has no proper species," and that the new factor of self-consciousness in humanity is supremely important. Throughout the "Evolution of Religion" it is made quite clear that man is not only a part of the organic world, but that he has spiritual endowments which qualify him for citizenship in "a kingdom that is not of this world." He is not only a developed animal, he is made in the image of God, and the development of such a being is not to be explained by gradual accumulations of ever fluctuating variations.

And here in all probability is to be found the explanation of that protracted and sometimes bitter controversy between science and religion since the publication of the Origin of Species in 1859. Few people will care to deny that the champions of the organic theory of evolution have rendered invaluable service not only to science but even to religion. They have challenged and laid low many a doctrine that was little better than a superstition; they have forced religious men to discriminate more carefully between what is metaphorically and what is literally true; and they have converted many an ignorant dogmatist into an earnest and reasonable seeker after truth. But it must not be imagined that victory has been all on one side. By no means. The evidence of poetry, history philosophy, and reasoning religion is stronger than ever it was in support of the essential differences between organic and human life. There has been in the past and still is a strong disposition on the part of many scientific men to explain away these differences, or at least to discount their significance. There is more difference, we are told, between the full-grown man and a new-born babe than there is between a man and an ape! It is statements such as these that reveal the danger of specialising, and show how necessary it is to supplement biological research with psychological study. Surely it must be that the men who make such statements have allowed themselves but scant time to reflect upon the mighty possibilities of human nature as against mere brute nature; the latent capacities of the newly christened William Shakespeare as against the eternal limitations of the most promising chimpanzee!

No wonder students of man's spiritual development have risen in revolt against such declarations as these, which cannot but fall janglingly discordant on the ears of any student who has given honest and careful thought to the philosophy of Thomas Hill Green or the strenuous verse of Robert Browning. For my part I have but little hesitation in saying that I think there is more truth about the essential quality of human nature in Green's "Political Obligations," or in the ringing stanzas of "Rabbi Ben Ezra" than is likely to be found in the pages of any biologist who tries to explain the spiritual life and development of man in terms of organic evolution. In the evolution of life man is a great mutation.

> " A spark disturbs our clod
> Nearer we hold of God,
> Who gives than of His tribes that take I must believe."

If that is true, then a great deal that has been written by orthodox scientists on the question of man's development is founded in error.

In so far as they have affirmed the universality of man's thought, his unsatisfied craving after greater perfection of being, his power to erect himself above himself, and, generally, the special endowment of god-like faculties on the higher side of his nature religious men have been amply justified ; and if ever the long standing quarrel between science and religion is to be amicably settled it must be, I believe, by the scientists' recognition of the validity of these contentions.

There is some reason to think that we are already on the way to such a reconciliation. It would appear from recent pronouncements that some of the leading thinkers in the medical and biological professions are disposed to reckon with the influence of mind over body more frankly and fully than they have done before. That is, in my opinion, the right way to a clearer recognition of the distinction between the organic and the human world which is the crux of the argument that I have tried to present to you. The further scientists travel in that direction the more obvious it will become that it is the mutation rather than the current theory of evolution that is applicable to the development of human life and affairs.

On the morning of January 11th, Dr. DOUGLAS MAWSON delivered a lecture before Sections E and C on the Proposed Australian Antarctic Expedition, 1911.

Following is a brief abstract :—

For many years past expeditions from Australia have been contemplated, but never realised. Australian support has, nevertheless, from time to time greatly aided British exploration in Antarctica. It is not that the spirit of enterprise is lacking ; the apparent apathy is due to the unfamiliar conditions of the South Polar regions and the absence, until recently, of reliable data relating thereto.

The bearing of Antarctica meteorology on our Australian weather is acknowledged by most meteorologists, and it is only along the particular coast to be investigated by this expedition that a suitable far south station could be erected. No attempt has been made to visit this coast since 1840. From a scientific point of view there is no other part of the Antarctic which so much deserves examination. There is also considerable prospect of an economic return from whale and seal products and from guano and mineral wealth.

The geographical position of this land privileges Australians in taking advantage of economic products, and renders the collection of scientific data therefrom obligatory upon us. On the South American side the Argentine Government is making rapid strides. They now have two permanent recording high latitude meteorological stations in Antarctica waters.

Australians are just as well fitted constitutionally to stand the vigorous conditions of life in high latitudes as are people of colder climates. The Australian contingent accompanying Sir Ernest Shackleton on his recent expedition showed what could be done by Australians with no previous experience of Polar work. Now that we have gained this experience, it would be a pity for Australia to lose the advantage of it. I spent the first half of last year in Europe discussing the subject with the leading Polar explorers, and inquiring into all details requisite for an Antarctic expedition. This was to be aimed at : Scientific and economic investigations of that great unexplored mountainous coast lying due south of Australia.

Sir Ernest Shackleton aided in the preliminary steps, the first act being the public notification of the intention of an expedition to this area. This was done in March last, thereby securing the region against competition on the basis of etiquette. Arrangements for co-operation in the scientific work have been discussed with Captain Scott, now exploring that portion of Antarctica adjoining the area referred to on the east.

In the first instance Sir Ernest Shackleton had hoped to command an expedition to this area, but private reasons prevent him, and he has arranged to support me in the inauguration of this Australian expedition.

No period in the history of Polar exploration has been so favourable for the accomplishment of great achievements as in the present, culminating in the motor sledge just invented. The despatch of an Australian expedition will be an important episode in our history, for it is an undertaking which, at least, will stimulate the spirit of maritime enterprise ; this is an indespensable element of national greatness.

Few people were aware of the fact that the coast of Antarctica lays nearer to Hobart than Melbourne to Perth. It was, indeed, within telegraphic range of the new wireless station at The Bluff. In summer time navigation was no more hindered than along a great portion of the coast of Alaska. The Antarctic continent occupied the immense area of 5,470,000 square miles, in addition to which there was an area of about 850,000 square miles of unknown

Antarctic Ocean. The chain of the Andes ran right down there and constituted the backbone of the Antarctic continent, which was as large as Australia and Europe combined. Its coasts abounded with animal life, and surely its mountains were blessed with universal resources at least equally with other countries. It towered from the sea in great rocky ranges, only giving place to the uninterrupted tract of ice in the interior. It held among its fossil strata secrets specially interesting to Australians.

If ever in the history of Australia an expedition is to set out under favourable circumstances and with a future well assured of success, it must be immediate. No time is to be lost. So surely as it lapses for a moment foreign nations will step in and secure this most valuable portion of the Antarctic continent for themselves, and for ever from the control of Australia. I am fully prepared, and preliminary arrangements have been made to set out from Australia in November next.

The work will take 17 months—one winter and two summers, or, possibly, two winters and three summers—before the realisation of one of the greatest scientific events in the history of Australia, viz., the meeting of the British Association for the Advancement of Science in 1914, at the invitation of the Commonwealth Government, a grant of £10,000 having been put aside for the entertainment of the oversea visitors. The importance to Australia of being able to present the results of such an expedition at the meeting cannot be overestimated.

The large sum of money required is a great barrier to the enterprise. It will mean a total sum of £40,000. This is, however, no insuperable obstacle. Indeed many wealthy Australians would not feel the loss of the whole amount. In smaller sums it would not require the co-operation of many individuals to secure the doing of deeds that would build for themselves an everlasting name, and produce books full of the stir and achievement of a new era of effort and progress greater than any in the past.

There across the water is the vast continent beckoning, in the words of Service :—

"Long have I waited, lonely, shunned as a thing accurst,
Monstrous, moody, pathetic, the last of the lands and the first."

Section F

ANTHROPOLOGY and PHILOLOGY

ADDRESS BY THE PRESIDENT:

EDWARD TREGEAR

(Dept. of Labour, Wellington, N.Z.)

[The text of the Address was not available at the time of going to press].

PAPERS READ IN SECTION F.

1.—THE CONCEPTIONAL THEORY OF THE ORIGIN OF TOTEMISM.

By the REVD. GEORGE BROWN, D.D.

ONE of the most valuable books ever published on this subject is undoubtedly Dr. Frazer's great work on Totemism and Exogamy, which has recently been issued by Messrs. Macmillan & Co. It is scarcely possible to over-estimate the importance and value of the vast stores of information which Dr. Frazer has accumulated and given to the world. The Ethnographical Survey of Totemism, which forms the principal portion of the work, fully accomplishes the aim of the author "to provide students with what may be called a digest or corpus of totemism and exogamy," and the reader is filled with wonder how any single man could have gathered together such a large number of facts from so many countries and from so large an area.

Dr. Frazer, for reasons given, has discarded his former views of the origin of totemism, and now finds what he considers to be a complete and adequate explanation of the origin of totemism in what he calls the conceptional theory. What is meant by this will, I think, be made clear by the following extract from the author's "Summary and Conclusion," vol. 4, pp. 57-8. After giving reasons why, after mature reflection, he had abandoned other theories as unsatisfactory, he says :—

"After long reflection it occurred to me that the simple idea, the primitive superstition at the root of totemism, may perhaps be found in the mode by which the Central Australian aborigines still determine the totems of every man, woman and child of the tribe. That mode rests on a primitive theory of conception. Ignorant of the true causes of childbirth, they imagine that a child only enters into a woman at the moment when she first feels it stirring in her womb, and accordingly they have to explain to themselves why it should enter her body at that particular moment. Necessarily it has come from outside, and therefore from something which the woman herself may have seen or felt immediately before she knew herself to be with child. The theory of the Central Australians is that a spirit child has made its way into her from the nearest of those trees, rocks, water-pools, or other natural features at which the spirits of the dead are waiting to be born again ; and since only the spirits of people of one particular totem are believed to congregate at any one spot, and the natives well know what totemic spirits haunt each hallowed plot of ground, a woman has no difficulty in determining the totem of her unborn child. If the child enters her, that is, if she felt her womb quickened, near a tree haunted by spirits of Kangaroo people, then her child will be of the kangaroo totem ; if she felt the first premonitions of maternity near a rock tenanted by spirits of Emu people, then her child will be of the emu totem ; and so on throughout the whole length of the totemic gamut. This is not a matter of speculation. It is the belief held universally by all the tribes of Central and Northern Australia, so far as these beliefs are known to us."

This theory, however, does not explain "the relation in which groups of people stand to species of things," because that which the woman imagined to enter her body at conception was not an animal, plant, or what not, but only "the spirit of a human child which has an animal, a plant, a stone, or what not for its totem. Had the woman supposed that what passed into her at the critical moment was an animal, a plant, a stone, or what not, and that when her child was born it would be that animal, plant, or stone in human form, then we should have a complete explanation of totemism." The essence of totemism, Dr. Frazer says, consists in the identification of a man with a thing—whether an animal, a plant, or what not ; that if a man believed himself to be the very thing—whether animal, plant, or anything else—which had entered his mother's womb at conception and had issued from it at childbirth, the identification would be complete. "Accordingly I conjectured," he says, "that the Central Australian beliefs as to conception are but one remove from absolute primitive totemism, which, on my theory, ought to consist in nothing more or less than in a belief that women are impregnated without the help of men by something which enters their womb at the moment when they first feel it quickened, for such a belief would perfectly explain the essence of totemism—that is, the identification of groups of people with groups of things."

Dr. Frazer then says :—

"We conclude, then, that the ultimate source of totemism is a savage ignorance of the physical process by which men and animals reproduce their kinds ; in particular it is an ignorance of the part played by the male in the generation of offspring. Surprising as such ignorance may seem to the civilised mind, a little reflection will probably convince us that, if mankind has indeed been evolved from lower forms of animal life, there must have been a period in the history of our race when ignorance of paternity was universal among men. The part played by the mother in the production of offspring is obvious to the senses and cannot but be perceived even by the animals; but the part played by the father is far less obvious and is indeed a matter of inference only, not of perception. How could the infantine intelligence of the primitive savage perceive that the child which comes from the womb is the fruit of the seed which was sowed there nine months before? He is ignorant, as we know from the example of the Australian aborigines, of the simple truth that a seed sowed in the earth will spring up and bear fruit. How then could he infer that children are the result of a similar process?" He also says that while a savage could not for long ages divine the truth as to the way in which children come into the world, it was inevitable that he should form a theory about it; that the most natural theory was that the child only enters into the mother's womb at the moment when she first feels it stirring within her; that, if at that moment the woman saw a kangaroo, butterfly, parrot, or other animal, or plant which struck her fancy and perhaps mysteriously vanished, such animal or plant "might easily be identified by her with the child in her womb. Such maternal fancies, so natural and seemingly so universal, appear to be the root of totemism."

These long extracts, which I have deemed it necessary to give, state, I think, the reasons for the conceptional theory as the origin of totemism as completely as is possible in the compass of a short paper.

It will be well to remember in the consideration of this matter that in trying to account for totemism, or indeed for any primitive custom, there is a great danger of our crediting primitive men with reasons for any particular custom which never influenced them at all, and of supplying them with motives for their conduct and actions for which they never felt any necessity, We are in danger, in fact, of considering the conduct and explaining the actions of primitive men, or of men in primitive conditions, to-day, by the experience and knowledge of our 20th century civilisation. It may be assumed as a very safe rule that the simplest and most apparent reasons are those which most probably influenced primitive men.

For the origin of totemism we must, I think, go back to a period far earlier than that which is indicated by the conceptional idea. That belongs to a later stage of development and, as I at present believe, was confined to a very limited area. We must go back to the time when man first became conscious of the existence of a power, or powers, outside of himself, greater than he, and yet a power or powers with which he was intimately connected and which he could in some way influence and use for his own benefit or for the benefit or injury of others. How that consciousness was created or evolved is a matter with which I am not at present concerned. I myself, whilst accepting all the facts, and believing some of the theories, of evolution and quite prepared to find some day that, so far as the body of man is concerned, every proof has been given of our ascent from the most primitive forms of life, also believe, with Mr. A. R. Wallace and many others, that in everything which differentiates man from all other animals he is a special creation of God. I believe this, amongst other reasons which I need not mention now, because he alone has the religious instinct, and that this is found amongst men everywhere, even in the very lowest states of culture. But whatever opinions there may be on this matter, there is, I think, a consensus of opinion that the belief in magic is the first stage in the development of the religious instinct, and it is in the belief and practice of magic that we find, in my opinion, the origin of totemism.

In considering this subject I have often put myself, as far as possible, in the place of a primitive man, and with the knowledge I have of native modes of thought, I have tried to mark out the probable lines of development. I assume, in the first place, that primitive men were conscious that they occupied a superior position to all other animals and that they were conscious also of the possession of powers which were capable of increased development and use. These men stood in awe of many of the great powers of nature, and yet knew that in some cases they themselves could control and use those powers. They were, at the same time, conscious that there was some mysterious connection between those powers and themselves. Amongst such peoples there would ever and again be some man possessed of more intelligence, or cunning, than his fellows—a man who, by the repeated assertion of his powers of magic, gained by his special and intimate connection with supernatural powers, at length succeeded in inducing many of his people to believe that he actually possessed them, and who probably honestly believed that he did indeed in some way really exercise supernatural power. I have often known men in Melanesia, where there are no hereditary chiefs, wield great influence, and exercise great power, simply because they so persistently claimed that they possessed exceptional powers of magic that men at length believed their assertions.

Then, in the case of such a man as I have described, the necessity would soon be felt that, in order to make manifest the reality of the connection with, and control of, these supernatural powers, there must be some means of communication between them and the individual—some channel through which the magic power could be conveyed and received, and that this should be of such a nature as to be apparent to the individual and also to the people themselves. The object chosen would be an animal, plant, stone or what not. This which we call a totem was, in the first instance, the choice of the individual, and with this he associated himself in the close bonds of relationship. Probably no belief has been so persistent as that of the intimate association between the totems and the members of the respective clans. Men still call the totem "our relative," as they did in past ages, and still believe that they are connected with it in the closest manner possible. The belief which men in primitive stages of culture still have that they can project themselves into certain animals, and that those animals can also be used as mediums for the transmission to them of supernatural power, is the same belief which actuated primitive men in the choice of their totems. I have given elsewhere[1] the account of an incident which occurred in New Britain, showing that there are men to-day who still believe that they can become part of other objects. A sorcerer was visiting a sick man, and whilst he was doing so " a large eagle-hawk came soaring past the house, and Kaplen, my hunter, was going to shoot it ; but the doctor jumped up, in evident alarm, and said, " Oh, don't shoot ; that is my spirit (niog literally, my shadow) ; if you shoot that, I will die." He then told the old man, " If you see a rat to-night, don't drive it away, it is my spirit (niog), or a snake which will come to-night, that also is niog." The eagle-hawk was not the totem of the sorcerer, but he believed in his power to associate himself with it and to use it for his own purposes. This belief has continued from the days when primitive men chose their first totems, and is in complete harmony with one of the essential features of totemism, which is that of the identification of the individual or the clan with his or their totem.

The result of the continued assertion by an individual, such as I have described, of the possession or supernatural powers, the alleged proof given by him of the means of his communication with them through the animal or bird chosen, aided, no doubt, by some lucky results following upon the exercise of some of his powers, would very soon establish a belief in the reality of his powers. Such a man would, in all probability, be able to pass on some of his influence and power to his brother, son, or other member of his family who would, of course, use the same totem, and so we have the development of hereditary totems from those chosen by individuals. It is assumed, also, that other men would follow the example of the man I have described with varying measures of success : that there would therefore be several totem animals or plants some of which would not go beyond the choice of the individual who selected them, but others would become hereditary, as in the first instance. I think it is very probable that the survival of some of these totems is due to the fact of their being adopted as the totems of the exogamous classes, though I quite agree with Dr. Frazer that there is no necessary connection between the totem clans and the exogamous classes.

It is not possible, I think, to fix any period in which the individual totems became hereditary and the common property of the clan. In some cases they would become so almost from the beginning ; in others only after the death of some great sorcerer ; and in many instances they would never become hereditary. As a rule, however, totemism in Australia and Melanesia developed regularly to hereditary clan totems, with some few exceptions.

This theory of the origin of totemism accounts for all the facts as simply and as completely as is claimed for the conceptional theory.[2] It, also, explains why people abstain from killing, eating,

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[1] " Melanesians and Polynesians," p. 177.
[2] " Totemism and Exogamy," vol. 4, p. 60.

or injuring their totems ; why some people on the other hand occasionally eat a portion of their totem ; why people are often supposed to partake of the qualities and character of their totems ; why men often claim to exercise a magical power over their totems ; why people believe themselves to be descended from their totemic animals or plants ; and, why totemic peoples aften confuse their ancestors with their totems.

In contra-distinction to this theory Dr. Frazer strongly affirms that the conceptional theory not only explains the origin of totemism, but is also a sufficient explanation of all the facts and fancies connected with it. This theory is practically based on the assumption that a savage does not connect pregnancy with a sexual act ; that a woman is not aware that she is pregnant until she feels the child stirring in her womb ; that she then imagines that something has entered into her ; and that she fixes upon something near her at that critical moment and imagines that the spirit of a kangaroo, emu, or other animal has entered into her, or that the spirit of a gum tree, or even of the yam which she was eating, " had, so to say, struck root and grown up in her."

The evidence for this is principally derived from Spencer and Gillen's works on the natives of Central Australia, and especially on the beliefs of the Arunta and adjoining tribes. These people are in a very primitive condition, and are described as being in a state of " savage ignorance of the physical process by which men and animals reproduce their kinds," and in particular of " the part played by the male in the generation of offspring." From this it is assumed that this " ignorance of the true source of childbirth was common among all races of men, and that it is indeed but one remove from absolutely primitive totemism," which " ought to consist in nothing more or less than in a belief that women are impregnated without the help of men by something which enters their womb at the moment when they first feel it quickened," and therefore, " in the identification of a man with a thing, whether an animal, a plant, or what not," and in the " identification of groups of peoples to groups of things."

I think, however, as already stated, that we shall have to look further back to the origin of the custom. The conceptional theory may, and probably does, apply to a stage in the development of totemism in certain areas, such as those in which the investigations of Messrs. Spencer and Gillen were conducted, but even in those areas it does not appear to be " the ultimate source of totemism." Assuming, for the present, that it were clearly proved that the natives are indeed " ignorant of the true causes of child-birth " ; that a woman only knows that she is pregnant when she feels the child stirring in her womb ; and that she fully believes that if she feels this when " near a tree haunted by spirits of kangaroo people, then her child will be of the kangaroo totem." This does not, I submit, amount to an explanation of the origin of totemism, for we have still to account for the antecedent belief in totem spirits ;

in their power to enter into a woman ; in the capacity of the woman to receive them ; and for the fact that there were totem centres already existing, places sacred to kangaroo, or other spirits, at each of which " only the spirit of one particular totem," who were waiting to be born again could congregate, and from which a spirit child could enter the woman. There must, in fact, have been totems before the totemic spirit could enter into the womb of a woman.

I do not, however, think that it necessarily follows that because the Arunta and a few other scattered tribes had certain ideas on these matters, we must therefore take it for granted that the development of totemism has proceeded on the same lines amongst tribes who lived in a very different environment, for, even if we admit the evolution of man from very primitive conditions, it is still certain that this has been carried out in varying and greatly differing environments. The Central Australian tribes are nomad peoples, living in almost complete isolation, far inland, and in localities where the conditions of life are often very unfavourable. The development of such peoples would naturally be slow, and their ideas upon many things would certainly be crude indeed. The fact, as stated, that they have no adequate conception of the causes of pregnancy and do not associate it with sexual intercourse is so abnormal and so contrary to all experience that we must assume some reasons for it which are not yet apparent, and seek for further information. It is, therefore, unfortunate, I think, that Dr. Frazer rejected the evidence of Dr. C. Strehlow as being tainted, especially as he has subsequently quoted him in another place. I do not know what Dr. Strehlow's views are on the subject under consideration, but I understand that he has lived among the Arunta natives for years ; that he knows their language well, and that he has published a book on the folklore of the Arunta and Central Australian tribes. The reasons given by Dr. Frazer's correspondent, which caused him to abstain from making use of Dr. Strehlow's information would, to my personal knowledge, compel us to reject much valuable information which has hitherto been regarded as trustworthy. Some of the most careful observers of the manners and customs of the native races have been the missionaries who lived and laboured among them, and as a rule even those who have little sympathy with them in their work have readily acknowledged the value of their contributions to anthropological science. The fact of a man's condemning a heathen custom need not and does not, I think, make his description of it untrustworthy.

But whatever may be the beliefs of the Central Australian tribes on these matters I do not think that there ever was a stage in the development of man when such ignorance was universal. Anyone who has lived for any great length of time among natives will know well that they are very close observers of nature and of all organic life. Let anyone go, for instance, with a South Sea islander into the dense forests of the island on which he lives and he will find that the native can readily give him the name of every tree, plant, flower, animal, bird, or insect, about which he may make inquiries, and in most cases he will, even if only a boy, give him the life-history of the plant and a full description of the life and habits of the animal. I have lived among natives for many years and I have never even heard of any doubt whatever as to the connection of pregnancy with sexual intercourse. I landed in New Britain when there was not a single white man resident in any part of that large group, and the people were not in any way affected by foreign ideas or influence, and I feel certain that either I or those who were afterwards associated with me would have known if such ignorance existed, or if the people had ever held such a belief. In the case of the Samoans also their genealogies as carefully preserved by them recognise the action of the male in the production of offspring as clearly as do the writers in the fifth chapter of Genesis and the first chapter of St. Matthew's gospel. They profess indeed to narrate the story of the origin of man and to give the genealogies of their kings and princes from the first man. These genealogies always take the form of married couples and their progeny. A long list of them will be found in "Samoa" by Dr. Turner (p. 4). Whatever value may be attached to these traditions it is certain that they are very old and that there is no trace in them of any ignorance in the far past "of the part played by the male in the generation of offspring."

With regard to the Central and Northern Australian tribes it is, I think, quite true that many of them believe that a spirit-child from some of the places at which the spirits of the dead are waiting to be born again enters into a woman's womb at the time when she first feels it quickened; but this does not, I think, necessarily imply that they were ignorant of the true cause of child-birth, for the belief that a totemic spirit enters the womb at that critical time may be consistently held together with an accurate conception of the true cause of pregnancy. It is a well-known fact that nearly all sacred places are forbidden to women except, among some peoples, on very rare occasions and for a very limited time, when some ceremonies are being performed, and a woman would certainly be very much afraid to go near any of those sacred places, which were supposed to be haunted or tenanted by the spirits of kangaroo or emu people, unless there was some compelling reason for doing so. That reason, in my opinion, would be that, knowing herself to be pregnant (as all women do) she went to the sacred place in order that the totem of her child might be fixed by the entering in to her of a spirit of one of the kangaroo, emu, or other peoples which congregated at that place, and that if she felt the quickening of the child in her womb whilst she was there she knew that the object of her visit was accomplished. The fact of the woman going to one of those sacred places instead of carefully avoiding it does not, in my opinion, show that she was in any ignorance of the part played by the male and its resultant consequences, but that being conscious of those consequences in her own person she then took the necessary steps to fix the totem of her child. This action is also quite consistent with native ideas and modes of thought. It recognises the part played by the male and also the part played by the spirits, as it is only the spirit of the kangaroo or emu child which is supposed to enter the woman; and it is, I think, a more reasonable supposition than that of complete ignorance of the part played by the male, which is regarded as being the origin of totemism.

Dr. Frazer finds the "missing link" between the Central Australian beliefs and "absolutely primitive totemism" in the beliefs and customs of the people of the Banks Islands, as described by Dr. Rivers. These people, it is said, identify themselves with certain animals or fruits, and believe that they partake of the qualities and character of those animals or fruits, and refuse to eat them on the grounds that in doing so they would practically be eating themselves. Dr. Frazer says (Vol. 4, p. 59) :—"The reason they give for holding this belief and observing this conduct is that their mothers were impregnated by the entrance into their womb of spirit animals or spirit fruit, and that they themselves are nothing but the particular animal or plant which effected a lodgment in their mother and in due time was born into the world with a superficial and deceptive resemblance to a human being. This is not called totemism, but nevertheless it appears to be totemism in all its pristine simplicity. Theoretically it is an explanation of childbirth resting on a belief that conception can take place without cohabitation; practically, it is respect paid to species of animals, plants, or other natural objects on the ground of their assumed identity with human beings." If this is "totemism in all its pristine simplicity," it is evident that ignorance of the part played by the male is not the ultimate source of totemism, for Dr. Rivers states (Vol. 2, pp. 90-91) :—"I could not find out what interval usually elapses between the disappearance of the animal and the birth of the child, but this does not seem to be regarded as a matter of importance, for it was clear that this belief was not accompanied by any ignorance of the physical role of the human father, and that the father played the same part in conception." This is quite in accord with the opinion which I have already expressed.

The arguments for the conceptional theory as being the origin of totemism would have greater force if they could be confined to the question of the origin of totemism among the Arunta and kindred tribes, but in discussing the subject of the origin of a custom which is so widely observed as totemism, all arguments used must not only explain the origin of the custom among peoples in limited areas and living in very peculiar and primitive conditions, but must also be applicable to the whole of the totemic peoples. The conceptional theory of the origin of totemism rests on the assumption that primitive peoples do not know that the intercourse of the sexes is the cause of offspring and that they attribute pregnancy to the entering in to the woman of a totemic spirit. The explanation given for this astounding ignorance of natural causation among some of those Central Australian tribes is that "the interval which elapses between the act of impregnation and the first symptoms of pregnancy is sufficient to prevent savage man from perceiving the connection between the two": that because some sexual unions are barren "he is driven to; account for pregnancy and childbirth in some other way"; and that some of these peoples are so ignorant that they do not even know that a seed sowed in the earth will spring up and bear fruit, and therefore could not be expected "to perceive that the child which comes forth from the womb is the fruit of the seed which was sowed there nine long months before." These arguments may have some weight and importance so far as they apply to nomad races like the Central Australian tribes, but even in the case of those peoples they do not, in my judgment, account for the origin of the totemic idea, nor do they show how hereditary totemism originated from those conceptional fallacies. The explanation given is still more unsatisfactory when applied to the case of other totemic peoples living in widely different conditions to those in which the central Australian tribes live. If the conceptional theory really explains the origin of totemism, then all totemic peoples, at one time, must have been in the same state of ignorance of the cause and the duration of pregnancy as the Arunta tribes now are. This, however, to say the least, seems to be highly improbable in the case of the natives of India, Africa, North America, and other countries who are well accustomed to the long periods of gestation of the higher mammals, and whose totems include the cow, elephant, buffalo and horse. We can scarcely imagine those close observers of Nature being ignorant of the part played by the male when they continually saw the female refusing the attentions of the male when she was conscious that the desired result was accomplished, any more than we can imagine them as attributing the fact of their mares being in foal to the entering into them of a totemic spirit. Then the fact that sexual unions were often sterile would not surprise a native or set him searching for supernatural reasons to account for the fact any more than the fact that his fish-trap was often empty when he expected to find it well filled, or that he himself was not always successful in war or in the chase would necessitate the same course of action. Then, because the Arunta tribes living in a nomad condition in a comparatively barren country are said not to know the simple truth that a seed sowed in the earth will spring up and bear fruit, can we assert that the same ignorance also prevailed among people living in a very different environment? I cannot myself imagine any natives in tropical or sub-tropical countries, people who know the difference between the male and female fruit-bearing trees, who constantly see the palm-seeds or nuts fall to the ground and then sprout and grow, ever having been in such a state of ignorance.

Then it is an almost universal belief among women that certain medicine or other means adopted will prevent conception. Whether these are effective or not is of no importance. What the practice shews is that other primitive peoples clearly understand the part played by the male, and, presumably, have always done so. I write under correction ; but, so far as I know, there are few, if any, other peoples who are ignorant "of the physical process by which men and animals reproduce their kinds" in addition to these few Central Australian tribes ; and it will be well to wait a while longer for more definite information before deciding that in the manners and customs of these peoples we have a definite explanation of the origin of totemism.

Summary.

1. I have endeavoured to show that it is in the belief and practice of magic that we find the origin of totemism ; that it dates back to the time when man first became conscious of a power greater than himself, with which, however, he was intimately connected, and which he could use for his own advantage or for the benefit or injury of others.

2. That in order to make manifest the reality of this connection and the alleged control of supernatural powers, there must be some outward and visible means of communication between them, and that an animal, plant or other object was chosen for that purpose.

3. That in the case of some men their continued assertion of supernatural power and of their means of communication with that powe by the animal or bird chosen, aided often by some lucky apparent confirmations of these assertions and claims, would naturally give them great influence ; that they would also be able to transmit some of their prestige and influence to members of their families who would naturally adopt the same totem, and so it gradually became hereditary.

4. That in other cases the individual totems did not become hereditary, or only continued so for the limited time or period in which the fame and influence of the original proprietor was known and felt ; whilst in others they were adopted as the totems of secret societies, and so became permanent. The Iniat Society in New Britain have stone or wooden images of pigs, iguanas, sharks and other animals. These represent the animals which they are forbidden to eat, and which I think were their totems formerly, if they are not so now. So far as I know these prohibited animals are not now the totems of any individuals or families outside of the Iniat Society. They represent totemism in decay and show how the process of degeneration has been carried on in other years.

5. That the totemic clans and the exogamous classes were of separate and different origin, and that in those cases in which some particular animal or plant became the totem of, or was specially

connected with, one of the exogamous classes, there was always in the native mind a vague and undefinable, but quite definite, idea that the totemic clans and the exogamous classes were not essentially the same. Marriage, for instance, between people of the same totem, though not regarded with favour, was still permissible in some places. This was the case at Dobu (Goulvain Island, S.E. New Guinea), but on that same island marriage between a man and a woman of the same class was absolutely prohibited. Any violation of that law would be unanimously condemned, and the parties thereto would be severely punished. In New Britain, also, where the class distinctions are very strong, the totems of the respective classes are scarcely ever mentioned or considered.

6. That whilst the progress of totemism from individual to hereditary totemism was along a great trunk highway of natural and orderly development, it did not always proceed at the same rate, and that it was sometimes arrested altogether. There are people, such as some of the Central Australian tribes, living in isolated localities far away from the influences which affected the main bodies of peoples, and among such tribes hereditary totemism has not yet been fully developed, and it is probable that some of their strange ideas about conception may be due, in some measure, to this fact. If, for instance, no outstanding prominent men had raised the influence of their totems so much that they became hereditary, the number of individual totems would greatly increase, and some means must be found to secure the continuance of the most popular ones and also to enable those who desired any particular totem for their children to secure the accomplishment of their wishes. The totem centres at which " only the spirits of people of one particular totem are believed to congregate " and where they are waiting to be born again would naturally fulfil all these requirements.

7. That I do not consider that the conceptional theory explains the origin of totemism because it fails to account for precedent beliefs. Dr. Frazer describes " absolutely primitive totemism " as consisting of " nothing more or less than in a belief that women are impregnated without the help of men, by something which enters their womb at the moment when they first feel it quickened ; for such a belief would perfectly explain the essence of totemism—that is, the identification of groups of people with groups of things." This belief that women are impregnated without the help of men may be a development of the totemic idea, but it is not, I think, the origin of totemism. There must have been, for instance, among primitive peoples the antecedent belief that it was possible for individuals or groups of people to be identified with groups of things. There must have been also a belief in some supernatural power which made that identification possible and which enabled the " something " to enter the womb when a woman first found it quickened. The conceptional theory, also, does not show, in my

opinion, any sufficient reason for the existence of totemism—that is, it does not show how or why primitive men would regard their identification with groups of things as being either advantageous or necessary, and yet these are the motives which principally govern their actions. It does not also explain or account for the belief in totemic spirits, their power to enter women, and the power of the women to receive them.

8. That any satisfactory theory of the origin of totemism must be one which can be applied to the case of all totemic peoples and that the conceptional theory fails when it is applied to totemism among peoples living in very different conditions to those in which the Central Australian tribes live.

9. That natives are close observers of nature ; that the fact of a woman's going to a sacred place is capable of quite another, and more satisfactory, explanation ; that the reasons given for the astonishing ignorance of the Arunta natives would not apply to peoples who are accustomed to the long periods of the gestation of the higher mammals ; that, so far as we know, there are few, if any, other peoples who are ignorant of the physical process by which men and animals reproduce their kinds ; and that it is a very general belief among women that certain medicines, or other means, will prevent conception.

10. That I therefore do not regard the conceptional theory of the origin of totemism as accounting in a satisfactory manner for all the facts of the case ; that I believe the beliefs, or rather the ignorance, of the Arunta people to be quite abnormal, and that they are due almost entirely to the state in which they lived, and to the arrested and incomplete development of the people from individual to hereditary totemism.

II.—DOBUAN (PAPUA) BELIEFS AND FOLK-LORE.

By REVD. W. E. BROMILOW, D.D., Sydney.

The difficulties in obtaining a full and complete account of the folk-lore of a people like the Papuans are very great. First of all, prejudice against foreigners has to be overcome. The natives, for instance, are bound by custom not to allow a stranger to live amongst them. Short visits could be made (the shorter the safer the first time), but unless it was decided to adopt the stranger into the tribe, he was never allowed to remain.

Considerable persuasion is needed to overcome this difficulty, and the risk to life is not slight. Then it is a long and tedious task to establish confidence and so not remain a complete outsider, though living amongst the people, and meeting them every day.

Further, as a missionary becomes familiar with the language and habits of those whom he wishes to influence, he finds there is so much to condemn, that unless he is a man of tact and patience he will meet insuperable obstacles when he attempts to penetrate the inner life and thoughts of the tribe amongst whom he lives. It is comparatively easy to think in the language of the natives, but it is almost impossible to get at their innermost thoughts and feelings.

To convince an ignorant and barbarous race that in making inquiries you are simply seeking information is an almost impossible task. They always think you have an ulterior motive. Then, if you put off your researches too long, there is a danger of variations being introduced into the stories and legends to suit the new conditions, which tend to suppress the natural expressions of a primitive people.

After a residence of four years on the island of Dobu, in south-east Papua, I was able to gather some stories and legends from a company of men, who were rewarded for their information by Dr. Loria, of Italy, who was at the time visiting our island for anthropological purposes. These stories had never been told to a foreigner before, for the simple reasons that the natives did not know English, and I was the first outsider to learn their language.

The telling of legends was restricted to the night time, under the penalty of the narrators and hearers becoming fixtures to each other and to the place where they were sitting. It would be disrespectful to listen standing.

At the close of each story the whole company would cry out "Neda bubune kalakea sopile"—having reference to nits in the hair—at the same time drawing the hand quickly over the face, from the forehead down; then all would shout "Me Gilagila kamikeiga kolokolo" (Inhabitants of Gilagila your cocoanutshell is well scraped), and then all would spit. This ceremony performed, no evil effects would follow.

As they had never known me to break a promise, our team of old and middle-aged men accepted my assurance that no evil results would follow the telling of stories and legends in my study in the daytime, and after moving about freely at the close of the first narration, they said: "Of a truth these are different times."

The stories and folklore contain very few references to the Creator or gods. They deal mostly with the doings of men and women. Women appear very prominently in many of the legends.

Eaboaine I.—The Dobuans openly stated that all things were not made, but came into being of themselves. There were two gods in the Milky Way of the same name—Eaboaine. One formed fingers and toes on human beings, also nose, eyes, mouth and ears. He looked down upon the people as they fought their battles, or made canoes, or carried out their feasts. They called up to him on great occasions, but were not at all afraid of him, though when he was angry he caused children to be born deformed. He is said to have looked down upon the earth and to have seen a man walking alone, so he made a woman out of the ground and threw her down to him. To give her breath he poured blood over her head. He causes women to conceive, and is thus the creator of man.

Eaboaine II.—The other Eaboaine is called the god of the thief, whom he watches only, but does not protect, as anyone caught stealing food or property from one who is not a stranger or enemy may be killed by the owner of the food or property without fear of revenge being taken.

Kekewagei.—There was another god called Kekewagei, and it was through disobedience to him that death came into the world. Kekewagei used to walk about the earth, and though he was terrible in appearance, no human being must show fear at his presence. But there was a woman who had two children who by their disobedience brought death into the world after this manner:—The woman went to the spring to fill her water-bottles, leaving her children at home, with the instruction, "You remain here, while I go to get water, and if your ancestor appear you must not be afraid or call out." But Kekewagei appeared before them, and, being afraid, they called out. Whereupon he said, "You were afraid of me, and therefore screamed, so, as a consequence, you must die." When the woman returned she asked her children whether they had seen their ancestor, and they told her how that his appearance was so terrible that they could not refrain from screaming, and that he was angry. So their mother scolded them and said, "Did I not tell you not to call out. You have disobeyed the order, and so death will come upon us and our children." This is the reason why death has come into the world. Had the children only obeyed, we would all live for ever, and there never would be a famine.

Spiritland.—The Dobuan's views about spiritland are very clear. Man consists of body, shadow and spirit. The shadow has a separate existence from the body and the spirit, and remains about the house or place where the body dies. All spirits, except those of men killed and eaten, go to Bwebweso, a hill which is almost bare of trees, about twenty miles from Dobu, on Normanby Island. The spirits of those killed and eaten rise up into the clouds and take up their abode above the place where the tragedy occurred. They come down occasionally to partake of fish, which they cook, ascending again in the smoke of the fire they make. The spirits of those killed but not eaten have to delay their journey to Bwebweso until some days have elapsed, so as to allow corruption of the body. The smell of blood must not enter the land of spirits. The spirits of all who die otherwise than by being slain proceed without delay to a point at the south-east of Dobu, and there, resting on a tree, await the falling of a leaf. When the leaf falls the spirit alights on it and is wafted across the sea to Normanby Island. Arriving safely on the beach the spirits climb a tree and take a last farewell of Dobu, weeping for friends left behind. It then wipes away all tears, and proceeds to Bwebweso, where the spirits of its totem have been warned of its approach by the dropping of a leaf from a particular branch of a tree. The reception of the spirit depends upon the condition of the life spent. The spirits of the rich, the brave, the well-formed, the healthy and wholesome, are welcomed with dancing, and led over the bridge across the chasm into everlasting life with the blest. The spirits of the poor, the emaciated through long sickness, of those who have suffered from scrofulous sores, are led by the dancers on to the bridge, which then turns into a snake, and by its wriggling precipitates the so-called bad spirits into a deep gulch, where they remain for ever and ever. The question of character or conduct does not determine the abode of the spirits, only that sorcerers who have so much power over life and death on the earth are requested to live in a special community of their own.

The following story is given in proof of the fact that Bwebweso is the land of spirits :—

Legend.—There was a man from Budiana whose wife died, leaving one child. This child cried so much after the mother that the man determined to go on a journey to Bwebweso with the child. First of all he went through numerous incantations, and was then able to travel. As he approached Bwebweso he met the spirits who were gathered together on a fishing expedition. The man inquired for his wife, but found her not, so went on and at last entered spirit-land and soon saw his wife, who was occupied in making a mat, for the spirits carry on the same occupations that they were wont to do in this life. When the child saw its mother it began to cry to be taken and nursed. The man said to the woman : " The child was crying so much for you to give it suck that I have brought it to you." " Am I," she answered, " a human being to give milk to a child ? I am a spirit. Take up the child and come with me to see the nature of the water that we drink here."

The woman then went outside and sat in the water, which soaked into her, and showing her husband how the water was bubbling up in her body explained to him that she could no longer nurse the child. She then stood up and the water ran out of her, for she was like a sponge. She then said, " Do not give me the child, I cannot carry it. Let us go into the village."

" Now," said she, " see how we cook our food." In the meantime the fishing party had returned, and the man saw the yams being cooked away till there was nothing but froth left, but they gave him special yams to roast apart. The fish too were boiled into froth. The spirits say they are strong and light and happy because they have no heaviness of solid food in them to keep them down. By this time it was night, and the woman said, " You must see what we do in the night, and in the morning you may go." Mats were brought for the man and child to sleep on, but the spirits flew up into the roofs of the houses and held on like flying foxes. In the morning the spirits came down, and the man, being convinced that he had seen everything, went home.

The man came back and told that the place where he had been was turned upside down to keep people out, as on one occasion some impertinent folk had ventured near and stolen drums from the spirits. There are two mountains at Bwebweso which sleep together at night, but are separate in the daylight.

Those who hear this story say it is true, because the man and the child, being bones and flesh, would indeed sleep on the ground. That is quite right. The spirits would be in the roof. That is quite right. We can also see the mountains apart in the day, and we watch them close together as darkness comes. So this story must be true. Neda, etc., etc. There is no god or chief in spirit-land, but communistic principles prevail.

Sorcery and Witchcraft.—Though the Dobuan does not fear any god, and is not at all agitated concerning the presence of the "shadow" of the departed, his life is made miserable by the powers of the wizards and witches amongst his own people. In fact, the whole life of the Dobuan is full of charms and counter-charms. He is more afraid of wizards and witches than he is of evil spirits of the woods. This is not surprising when it is believed that wizards have the power of causing death in twelve different ways :—

Sorcerers.—A wizard, after fasting from food and drinking sea water performs special incantations in secret and then :—

(1) His touch will cause death.
(2) He can impale his victim with an imaginary stick.
(3) He can pierce the body with an imaginary spear.
(4) He can bewitch food left over after a meal, or a tuft of hair or portion of clothing, and so cause death.
(5) He can bewitch food before it is cooked, and make it poisonous.
(6) His hand placed secretly on the head of a child will cause its death.
(7) He can send poison into the mouth of a person as he is eating.
(8) He can kill by spitting at a person.
(9) He can cause a man to fall when climbing and so cause his death.
(10) He can bewitch a fireplace so that food cooked upon it becomes poisonous.
(11) He can poison the drinking water by putting into it a leaf which he has bewitched.
(12) He can bewitch a sharp-pointed stick and cause a man to walk with his bare feet on the spot where he has hidden it, so that it will pierce his victim's foot and kill him.

These and many other things he can do, but he must do them secretly ; therefore no one must walk about alone. There must always be two or three together.

Counter-charm.—A man must be very wise in counter-charming to walk alone. In fact he must be able by incantations to do one of the following :—

(1) Charm his own body so that it becomes invisible, and he is as a spirit.
(2) Charm a tree so that it will split open and take him in until the wizard has passed.
(3) Change himself into a bird so that he may fly above the wizard's head.
(4) Change himself into a snake so that he may crawl through the bush.

Witches.—Witches can kill by :—

(1) Cutting the heart open.
(2) Drinking the blood in the veins.
(3) Snapping the muscles and veins.
(4) Breaking bones.
(5) Deafening the ears and driving to madness.
(6) Throttling. This is how children are killed.

Witches can also fly about in the night. They go from mountain to mountain on a piece of string, which bursts into flame as they pass along.

They also fly over the sea looking for canoes to capsize. They can also go into the bowels of the earth, and when they rejoice there are good crops, but if they become angry they can bring up an epidemic which causes many deaths.

Tabu.—Besides the wizards and witches, who are supposed to be always ready to attack those who offend them, the poor people live in constant dread of breaking some *tabu* which has been placed across a path, or under trees. To break one of these *tabus* brings on an attack of one of the following complaints :—Rheumatism, polypus, elephantiasis, ulcerated throat, asthma, blood-poisoning.

Charms.—In order to make life at all bearable, and to counteract the evils strewn in their path, charming is resorted to. When preparing for a sea-voyage :—

(1) The body is charmed to prevent the witches from knowing that anyone is coming.
(2) The canoe is charmed to make it strong and so that it will not leak.
(3) The steer-paddle is charmed so that the canoe will not broach to.
(4) The wooden baler is charmed so that it will not sound against the canoe, which would attract the witches.
(5) The mast is charmed that it may not snap.
(6) The conch-shell is charmed so that when blown it will drive away the squalls.
(7) The waves are charmed to keep the sea calm.

When making a garden knives and axes are charmed, and there are special incantations before burning off, before digging, before planting, while the crop is growing, when the harvest is reaped.

Every part of a canoe is charmed as it is being made right up to the launching. Fishing and hunting nets are charmed, spears and implements of warfare, houses and trees.

If a woman becomes the envy of the other women because of her good gardening qualities, and the care she takes of her supplies of yams, thus earning the title of Arawata—the highest title a woman can possess—the jealous will try to get hold of her peeling shell, which they will bewitch so as to cause her to be reckless and careless over the food and to lose her title.

If a young man becomes a hardworking gardener, much to the joy of his friends, the neighbouring families will become jealous and will secretly bewitch his gardening tools, so as to cause him to hate them and become lazy.

If the young folk become too fond of their distant relations and visit them too often, the near relations become jealous and secretly bewitch their food and drink, also their sleeping houses to keep them at home.

If visitors come repeatedly until their hosts are tired of seeing them, the latter will charm the rollers on which the visitors' canoe will be launched, so that they will not return for a long time.

Rain, wind, drought, blessing and calamity are brought about by human agency.

Eclipses of the sun and the moon are caused by women with secret powers who throw spears made out of the small ribs of the cocoanut leaf through the interstices of the houses.

From the above it will be understood how firm a hold sorcery and witchcraft have of this people, in fact they will tell you that in order to escape the evils awaiting them they must ever be on the watch and never over-confident. To scorn or try to throw off the effects of incantations, except through medicine men, will only result in speedy death.

The Origin of Cannibalism.—A giant named Tokedokeketa lived on Fergusson Island, near the sulphur springs. He was of immense size and a great warrior. He had a wife, and his mother lived with them. It was his custom to go out with his net, into which he put all the people he could catch. He and his wife and mother lived on the victims he caught. Human flesh was their only food. The giant was wont to blow a conch-shell and beat a drum when he returned with human prey in his net. At last the people of the land were so exasperated at their losses through Tokedokeketa's depredations that they gathered together and determined to kill their enemy. The giant poled along the coast in his canoe, and as usual hauled it up at the landing-place of the Wariboa tribe. He proceeded inland to the plain, where the host was preparing to meet him. When the warriors saw him coming with his great net on his back they divided into companies and shouted defiance, but he said, "Who are you? Are you big? Why, you are only of small stature!" They answered him, "You'll be killed to-day." He called out, "Your destruction has come to-day; I shall kill you all." Whereupon they hurled their spears at him from all quarters, but as they stuck fast in his flesh he knocked them out, saying "My blood is as the blood of the canoe-wood tree. Your end has come; it is all finished with you." They replied, "Return! Return!" They continued to throw spears, which pierced his body, till at last he began to grow weak, and so could not hurt them, but had to drop his implements of warfare. He stood erect a little longer, and then his head began to shake, and soon after he fell, and his fall was like an earthquake —it opened the ground. The warriors now ran up to the body and belaboured it with their clubs. They also took his net off his back and tore it to pieces, releasing those who were in it. There were also dead bodies and pieces of flesh in the net. These they buried, and allowed the released prisoners to go home. An old woman now cut off one of the giant's fingers and cooked it on the fire; she then gave it to a dog to see would it poison it, but the dog liked the food so much that it said, "Where is some more for me to eat?" They waited till the next day, and the dog did not die. The old woman then tried some, and said "I have eaten and my body is strong." Therefore they all gathered around and began to cut the body into pieces and divide it out. They had a heap the size of a big house to divide. The district of Morima had one hand and arm given to it, Garea the other; Si'irugu a leg, and Taulu a thigh; Warera a leg; Bwaio his feet, and that is why they can run so fast; Kukuiaa thigh. The rest of his body was divided amongst the surrounding tribes, each tribe a portion. The warriors then said, "Oh, we have given nothing to the two tribes Bwakera and Dobu, which are always fighting against each other." So they sent to Bwakera the leaves which are used as lids of cooking pots, and to Dobu the head and the blood, and that is why the Dobuans drink human blood raw. The liver was given to the people of Oiabawe, and that is why they are always fainthearted and run away. The intestines were given to the tribe of Nadi, and so they are expert at catching and breaking spears. The conclusion of the whole matter is that, because of their partaking of the giant's flesh, they are giant's children, and boast of the fact when they are successful in war.

Kasabwaibwaileta and the Origin of Polygamy.—K. was a native of Tewara Island, who went with his friends on an expedition to Boioa (Trobriand's), the Land of Dreams. K's body was well formed, and he was a Gomabwaina, or good-looking man, but he had an outer skin which was very ugly and covered with sores, so that his appearance was a dirty, dingy white. Being ugly, he remained in the canoe whilst his relatives went into the villages in search of Bagi (a highly-prized pendant made of two strings of shell beads). They saw a Bagi, called Goma'Arakedakeda, but did not succeed in procuring it, so went on through other villages. K. in the meantime took off his outer skin and decorated his real body. A female child, daughter of the owner of the pendant, came to the canoe, and, in answer to a question from K., told him that her father and herself owned it. He told her to precede him to the village and he would follow to see the pendant. So he left his outside skin on the canoe, and with his adorned body went to the village, sat on the verandah, and said, " Bring down the pendant that I may see it. I have come for the Bagi Goma'Arakedakeda " They thought he was a great chief, so gave it to him. He returned to the canoe before his friends came back, folded up the pendant, put it on his head, and then put on his outer skin, thus hiding the pendant. His companions came back to the village and asked again for the pendant, but were told that someone had taken it, but they did not believe it. When they arrived at their canoe they asked K. in the usual way as to where he had been, and he said, " What, am I an ordinary human being to walk about ? " They then journeyed to Karuana Island, where there is nothing but stones, and they caught some fish. While they were away fishing, a small boy, who stayed behind with K., dressed K.'s hair for him, removing the nits. In doing so he discovered the pendant, through a crack in K.'s skin. On the return of the rest the boy told his friends secretly what he had seen, whereupon they gave K. the biggest fish they had caught, saying " Let us give to our chief our best fish." They then went to look for water, and having found it, returned and told K. where he could get a drink. While he was away they hoisted sail and left the island. When he came back and found they had gone he wept with rage, and threw big stones at them, which were changed into islands, so that they had to be careful in avoiding them. He then kicked in his rage, and every time he kicked an island or sandbank into the lagoon. So he wept until his body became weak, and he ceased making any more islands. K. then looked up and saw a canoe, which was really a star, and said, " Thumb, I wish to embark," but he was told to wait for " First Finger " ; when that canoe came he was told to wait for " Second Finger." This canoe came, and he was told to wait for 'Third Finger." This canoe came and he was told to wait for " Little Finger." This canoe came, and the owner said, " Wait till the wind moves my flag, and then you may come on board." He embarked, and the owner of the canoe called out, " Oh, my canoe ! my canoe ! My outrigger ! my outrigger !" But K. said, " That's all right ; just put me on to that star over there." So they left him at Wanuwanuine, the land where there are only women. On landing he threw away his ugly skin. He stole some sugarcane and bananas out of a garden. When the woman-owner discovered her loss she said, " Who has stolen my bananas and sugarcane ? " and hid to watch for the thief. In the afternoon K. entered the garden again and the woman caught him, saying, " You have woven your own net." She married him right away, and wrapped him up in her bundle of fire-kindling leaves, and carried him on her head to her house, where she hid him from the other women. The next day she had to go to the garden again, and the man stayed in the house, but necessity came upon him, and he made water, which poured through the floor on to the ground, the house being built on piles. A woman saw this and said, "Let us see how it is that our sister's water-bottle has upset." She accordingly climbed into the house, and found the man there, whereupon she married him right away. The first woman on returning from her garden, and finding another woman in her house, asked in anger what right had she to be there, and they had a fight, but afterwards made it up and arranged that K. should be their husband. So unto this day when a man marries a second wife the first one is very angry, and attacks the second wife, beating her, but afterwards they become quite friendly and call each other sister. And so on with other wives. The first wife became pregnant, and when the child was about to be born the other women wished to cut her open with obsidian, but the husband said "Don't," and took hold of his wife. He ordered one woman to wait in front to receive the child, while he pressed his wife down by the shoulders, whereupon the child was born, and all were greatly rejoiced. The child was taken to the sea to be washed. The woman and child were now put into a house where a fire was lit and kept burning, and after a certain time they came out. As it was a male child the women wished to marry him at once, but the father would not allow them. The second wife became pregnant and gave birth to a child, but they now knew how to attend to the matter. So as time passed a great number of children were born.

Kasabwaibwaileta returns home to Tewara.—One day the children were playing the game of noki (rolling an unripe bread-fruit along, which they tried to spear while in motion), and the noki rolled into a clamshell in the graveyard. Taking up the shell they saw underneath an island, and told K., who saw that it was Tewara, his home. He looked down and saw his mother sweeping the village. She was crying for her son while she was sweeping. K. saw his betelnut tree, and closed up the hole, as he was anxious not to let the women know. He now prepared his pendant, part of which he had given to his children as ornaments, but it was still long enough for his purpose. He let it down to try its length, and saw that it reached his betelnut tree. So he told his children to hold tight to one end, and he then went down, down, till he rested on the tree. He had arranged with his children to pull when he shook the pendant, which they did, and the pendant broke. So the children pulled up their part, and the hole closed up for ever and the children cried. K. was on the betelnut tree, and his mother was sweeping the village. K. threw a nut down, and his mother wanted to know who was interfering with her son's tree. K. had his own lime-gourd with him, for they have the same sort of lime up there as is in use down below. The mother went on crying while she swept the village, thinking she was alone. He spit out some of the nut and lime which he was chewing, and she thought it was bird's dung. When the sun rose high the shadow of

K.'s leaf-flag, which was fastened to his arm, was seen on the ground. So the mother looked up, and saw him, and was much rejoiced, saying, "Who brought my child there?" So K. climbed down. When he was seated on the platform, he saw a pig pass by. "Whose pig is that?" said he; and he knew it was for the mourning-feast in his own memory. So were all the pigs and the dogs and the bush-rats, and the wallaby, and the lizards. The yams also were for the mourning ceremonies.

So he commanded all the people to gather together, and he made them build a very large house with not an interstice in the walls or the roof. It was very dark inside. K. said, "Let us get the wood ready, and to-morrow we will have the feast." He killed all the dogs and the pigs and the other animals, and made a great heap. All the food from the gardens was brought also, and put into the large house with the people who had left him on the island and their friends and relations. His true mother and himself were the only ones outside.

He gave them sufficient food to eat, but shut the door; so those who had treated him so badly could do nothing but bow in shame.

After a time he went round the house and struck it with a stone-axe, saying, "Children! look out for your eyes! I am driving flies away!" He then went to the side, and struck that, and all inside the house were changed into unfledged birds. He then struck the doors and the feathers grew. The birds now tried to get out, and beat against the walls, but could not find an outlet, so they sat on the floor. Suddenly the Bedinegwa (small honeybird) saw a small hole and flew out; the Binama (hornbill) with its big beak now forced its way out, and made a hole big enough for all the rest to get through.

K. saw them, and said: "Children! Come back!" And they came back and lighted on a tree, which was so crowded with them that the branches and leaves could not be seen. K. said: "Who will go up to Heaven and see my place there?" Beginning with the cockatoo they all tried their best, except the manucodia and the brush-turkey. These two were punished for their laziness, and now cannot fly very much. The others tried in turn, but failed. The honeybird then put on a leaf-flag and started. The others laughed at this small bird flying up, but it flew out of sight itself first and then afterwards its flag went out of sight also. They all said, "It is gone."

When the honeybird arrived it saw house-building going on. It took some paint which was being used to adorn the houses, and put it on its forehead, and taking a bit of thatch flew down to its friends. It was so tired that the other birds said: "Let us perform charms over it; it is dying." When it came to itself, they asked it to tell what it had seen. It showed its forehead first, and said that all the houses were so painted. But while it told them all the parts of a house, it said nothing about the door, and the result is the honeybird is the only bird which has a perfect nest.

K. then asked each bird in turn what food it wanted, and each told him. He gave them permission to eat as they chose, even to the flying-fox, which asked to eat at night, and the crow which eats excrement. (The long list of birds is sometimes repeated, with their natural food.)

K. now cut down the tree, and all the birds flew away, except the pigeon and the flying-fox, so that is how it is that those are the only kinds of birds living on the island of Tewara.

(Neda Bubune, etc., etc.)

Distribution of Peoples, Fish, and Languages.—In the days when all people lived together at Sawatupwa an old woman was out gathering firewood and bush vegetables when she came across a strange sight. Fish were falling on the earth from the top of a mango tree. They were wriggling about on the ground, and though she did not know what they were, she took five of them to her village, cooked one and gave it to her dog to see if it were poisonous. The dog, however, wanted more, and so ever since dogs have been excessively fond of fish. The woman then said to her son : "I will try it, and if I do not die, we will get some more." The next morning the son said : "Mother ! are you well ?" "Oh, yes," she said ; and the mother, son and son's wife went to the mango tree and found some of the fish were stinking, but a fresh supply had been vomited out of the tree. They gathered the live fish and returned to the village, where they divided them out amongst the people. They also arranged to sharpen their axes and to cut the tree down next morning, so as to get all the fish at once, and not wait for a small supply every morning. They went accordingly in large numbers, ate the fresh fish, and chopped at the tree all day, but did not succeed in cutting it right through, so returned home. The next day they found that all the chips of the previous day's work had gone back to their places, and the tree was intact. That day a small boy took a chip to the village, and on returning they found that the chips had again gone back, but there was one place not filled up, just the size of the chip taken to the village. They then decided to burn the chips as they chopped at the tree, which was a successful plan. As the tree was swaying, the Boio tribe were plaiting armlets and the Sawatupwans girdles. That is how it is the Boioans make armlets unto this day and the Sawatupwans girdles. As the tree fell it scattered the tribes all over the earth, and their speech was made different. The top of the tree fell right up to Boio (Trobriand's), and vomited out large quantities of fish. That is why there are more fish in that part than anywhere else in the world. The bottom end of the tree gave Sawatupwa a knock into the bush. Three persons were changed into fish—Tobebesa, Tobwaratoni, Tomodawa. They had jumped on to the trunk of the tree to keep it steady, and as they held it tight the whole earth shook with the struggles of the tree and the men. The cause of the struggling of the tree was the absent chip, which it wanted to get at. The motions of the tree were eating the land away, and had they lasted much longer the land would have been cut into two, but the hill of Mwatebu was too strong and thick. At last the tree found its missing chip at the village of Ainowa, and was satisfied. Exhausted, the tree sank to the bottom of the sea which had been made by a great fish called Watuwatuke. When the tree fell at first a big flat fish hammered the earth to the north out flat, but the fish Watuwatuke spoiled this by smiting the earth with its body and cutting it up into islands, so forming the sea. Watuwatuke then made the passage at Dobu, and tried to cut the mountain of Soromonai into two, but was stopped by rattan cane, where it remains caught unto this day.

The person Tobwaritoni, who was turned into a fish, still holds on to the tree as it lies under the sea, and is called The Earth's Salvation, because if he should let go the whole world would be flooded by the sea.

The second individual, Tomodawa, is lying down, and turns occasionally, thus causing earthquakes.

The third, Tobebesa, travels along the trunk of the tree, and when he gets near Dobu and Boio there is a plentiful season at those places, but when he is near Sawatupwa there is famine at the two places named, but plenty where he is near.

The descendants of those who cut down the tree live at Sawatupwa, and have grey hair, and are dwarfs. (I have seen children at Sawatupwa with light grey hair.—W.E.B).

Where the roots of the famous tree were there is a fresh water spring.

It was from Sawatupwa that the original inhabitants of the world came, so when the natives of other parts come near the scene of this story they must always paddle their canoes for fear that in poling they might strike one of their ancestors on the submerged trunk.

The Origin of Fire.—Our ancestors ate food raw. They hunted for pigs, the flesh of which they also ate raw. An old woman was left alone one day in the village while the whole of the inhabitants went on a hunt. She put the yams for the hunters aside in a dish by itself, and then took out of her vagina that which made a fire and boiled her own yams in a pot. Then she put the fire out, threw the ashes away, and gave the hunters raw food when they returned. By mistake she put one cooked piece amongst the rest, which they liked so much on tasting it that they determined to watch the old woman. So the next day one of the hunters returned to the village and saw the fire, whereupon he gathered leaves together to make a torch, and lit it. He then set fire to the grass, though the woman called out, "Kaiagu, kaiagu, 'u da ilenama!" My fire! My fire! Bring it back! She then fell dead. The fire burned much grass and bush, until a big rain fell and put it all out. They looked for the fire, but could find none until they came across a snake coiled round with fire underneath it; therefore the underside of that snake is as if it were scorched until this day.

From this they cooked food, and buried the old woman, saying, "Oe! Oe!" We are happy now! So they kept the fire as long as they could, and then found out how to produce it by rubbing the point of a hard piece of wood on a softer piece.

A Snake Story.—A python called Moata Weiu took up its residence on the top of a tree, and made a roof over itself by joining the leaves of the tree together. It reposed under this roof. The snake swallowed up every person and animal on Dobu, and afterwards at Nekumara. The body never left the tree entirely; the head stretched out and so reached the victims. After Nekumara Bwaio was finished, and then the whole world. But there was one woman on Dobu who hid away by digging a hole in the ground and staying in the hole so that the snake could not see her. She was lying down in the hole with head and feet hidden away and only certain parts exposed to the rain, which poured down the hole, the result being she gave birth to a cockatoo — her male child. The cockatoo grew and came out of the hole, flew up and rested on a branch of the tree, and said "Wakekeka Daidudaidu"—a dancing song. The snake said, "Where do you come from? I have killed everything in the whole world—where do you come from?" And the cockatoo said, "I have come from Nekumara," and then he flew high up and towards Nekumara, but came back quietly to his mother. The snake stretched out to look for him, but could not find him. In the daytime, while the snake was asleep, the cockatoo plucked the snake's house to pieces, and the snake woke up and said, "Where do you come from? I have killed everybody, and here you are again." The cockatoo answered, "I have come from Bwaio"; and so it went on, the cockatoo changing the places whence he was supposed to come, until the world was finished, and yet the snake's house was not properly cleared away. Once the snake's head went to Boio (the land of dreams), searching for the cockatoo, but could not find him. At the last the cockatoo answered to the snake's enquiry, "From Heaven," and he flew so high that the snake could not see him, so he came quietly down to his mother. The snake unrolled itself upwards to follow the cockatoo, who was then with his mother looking up out of the hole. As soon as they saw that the snake had stretched itself up until only the tip of its tail touched the tree the cockatoo came out of hiding, and bit the snake's tail off, and then as the snake dropped down the cockatoo snipped his body off piece by piece, until he was all cut up, and therefore slain. The cockatoo then went down the hole and brought his mother up, and she proceeded to divide the pieces out. She threw some into the sea, and they became jackfish, sea-snakes, etc. She threw some into the bush, and they became snakes and lizards, and eels. The head was thrown into the sea, and it became a shark, and the woman was rejoiced so to finish off their revenge-victim. (Neda Bubune, etc.)

3.—THE ARTISTIC SENSE AS DISPLAYED IN THE ABORIGINES OF AUSTRALIA.

By CHARLES DALEY.

In the later Paleolithic Age in Europe, that continent to which we are indebted for most of the information which we possess concerning the very ancient forefathers of the human race, there is abundant and ever accumulating evidence that the cave-dwellers and workers in flint of those far distant ages very gradually developed an increasing skill in working their chipped stone implements and in improving the weapons of war and of the chase. Between the rude "eolith," whose human origin is questioned, and the polished stone axe of the later Paleolithic Period ages probably elapsed, but the record of progressive skill and constructive ability remains.

The flint arrow and spear-heads, the axes, knives and scrapers of the same or similar material reached a high level of efficiency if the nature of the material be regarded. The long-continued use of flint, so suitable for cutting purposes, gave the skill in forming implements from other materials, such as bones of animals, the antlers of deer, the ivory tusks of the mammoth, which in the later periods of the Paleolithic Age seem to have been wrought into effective weapons or implements. Some of these latter to a great extent replaced the earlier implements of chipped flint, the polished stone weapon also, at the close of the Paleolithic period superseding the chipped axe-head.

With the effective cutting implements the faculty for representation of familiar forms, such as those of animals, grew, and resulted in that skill to carve in bone and ivory which reached such a high standard of excellence, as shown in the Madelainian specimens. With acquired skill in carving naturally followed engraving on stone and wood. In some of the caves in France which those Paleolithic men frequented numerous examples of this work, depicting animals, and also men, occur, as at the famous Mas d'Azil at the Dordogne. Naturally those animals used for food, or with which the cave-dwellers came most in contact, are the subjects of reproduction, such as the reindeer, the mammoth, the urus, the horse, etc. The surfaces of rock were sometimes carved, and as the sense of ornamentation grew the handles of implements made of bone and ivory were often effectively carved. One specimen, in particular, of a reindeer from La Madelaine is specially remarkable for its artistic feeling. In general the forms of animals are better represented than those of human beings, which are usually crude in execution. At several places in Europe, besides the Dordogne, rock-carvings have been discovered, as in the Pyrenean caves, and at Altamira, in Spain. These show in many instances skilful representations of animals, such as the horse, bear, seal, rhinoceros, deer, etc., and also the more or less effective use of colours, such as black, brown, red and yellow. It is extremely probable that, besides artistic skill in carving and drawing, the Paleolithic man was also skilful in ornamentation of the body. From the tangible and visible evidences of the development of the artistic sense we may not unreasonably conclude that there was also advancement in other ways, such as in weaving grasses, fibres, etc., of which, owing to their perishable nature, no record would remain. At a later period in the Neolithic Age, although we find that the stone weapons show an advance in being carefully hafted, in being more varied in form, and also in being ground and polished, instead of being simply chipped as at the earlier age, yet as far as revealed there is not shown any advance in the artistic sense, but rather a falling away. This may have resulted from a change involved in the manufacture of the distinctive weapons, the earlier flaking and chipping away giving greater skill in manipulation of the cutting material, and a more acute sense of form than in the latter period, when grinding and polishing would render skilful shaping less important. In the well-known Danish kitchen-middens some of the finest work in the polished weapons of the Neolithic Age has been found.

Australia, which in so many other respects shows the survival of conditions no longer existent in old world lands, was, at the advent of the white race, really in a stage corresponding in many features to that of the Paleolithic Period above mentioned, whilst New Zealand and New Guinea resembled more that of the Neolithic Age. Professor Sollas, in his interesting series of articles in "Science Progress" on Paleolithic Races and their Modern Representatives, designates the Australian aborigines as the survivals of the Mousterians of the Stone Age, showing, in addition to cranial resemblances, many points of similarity in the nature and the construction of weapons and in the measure of advancement attained.

The Australian aborigines, part of whom in the more remote districts of the continent are still virtually in the stone age, thus afford a practical and instructive study of conditions comparatively similar to those of Paleolithic times, the race itself being, as far as mental endowments and physical qualities, almost on a parallel with the men of that distant age from whom some modern races have descended, and serving to show in a remarkable degree an interesting stage of human development through which mankind has passed in prehistoric days. The old idea that the Australian aborigines were about the lowest in the scale of human progress has been considerably modified in the light of fuller knowledge.

In studying the question of the development of an artistic sense, consideration may first be given to the weapons and implements distinguishing the race. A stone is the natural tool of the savage, as of the civilised man when deprived of the advantages which advancement has given.

The Australian aborigines, like their Mousterian prototypes, had made definite progress in the manufacture of stone weapons. Their stone axes, in many instances, show careful workmanship, the stone being quarried, chipped into the required shape, then the cutting part being ground and polished to the requisite degree. Skill in chipping, attainment of a due balance, and a desirable finish, are exemplified in many fine specimens. In this particular, many of these weapons more resemble the polished axe-heads of Neolithic times. Flint not being so widely distributed as in European countries, stone of hard texture had to be chosen, rocks such as diorite, diabase, quartzite, close-grained basalt, etc., being used. The chipping or flaking of knives and scrapers frequently shows delicate touch and fine workmanship in obtaining the required shape with the crude means at command. The leaf-shaped spearheads of quartzite, quartz, chalcedony, and, later, of glass and porcelain, reveal a wonderful delicacy in treating such fragile materials, and a remarkable skill in their symmetrical construction. The degree of finish in stone weapons varies a good deal in Australia with the district, the quality and the quantity of the stone material, and with the character of the food supply. Some of the finest polished stone axes have come from the Murray River and Riverina district, where suitable stone is almost unknown, the material, usually diorite, being brought from a great distance, its scarcity enhancing the value of the axes, and increasing the attention bestowed on their construction. In South-west Australia, and in many coastal districts, the axes are often roughly chipped or ground, and frequently simply adapted from water-worn stones. The hafted knives of Central and Northern Australia, skilfully flaked, and with accompanying sheaths, show deft workmanship. In other parts the chipping or flaking of flint, chert, quartz, and quartzite into knives and scrapers is effectively carried out.

The general shape of the stone axes throughout the continent is a somewhat oval shape, but every degree, from "eolith" to polished stone axe, is found in the stone age in Australia. The numerous stone quarries from which material was obtained, and which have been noted from every part of Australia, with the multitude of chips and "rejects" in the vicinity of the quarries, give evidence of the patience and labour expended in the manufacture of the stone weapons. The axe-head was sometimes grooved to receive the haft; but the hafting and fastening were designed so as to combine lightness with strength.

In the construction of wooden weapons the aborigines of Australia show great ingenuity and a natural desire for ornamentation. By means of fire and stone implements the rough timber was fashioned as desired into spear, nullah, langeel, throwing-stick, shield, or boomerang. Again, we find the excellence of the weapon in regard to design to vary with the character of the timber used, as well as the environment. Frequently, where there was abundance of food, giving leisure for more careful construction and a higher standard of effort, or where a tribe was unusually warlike in character, the weapons were of better make and superior in design and in ornamentation. Some of the shields, particularly the broader ones, are decorated with colours—white, black, or red—the designs being principally on lines, curves and dots, and of conventional character. The narrower shields, usually of harder wood, are often carved or marked with lines. Some of these have distinctive characters according to district, as in the zig-zag patterns of Western Australia, where the shields are longer and narrower than in the east, often grooved in a neat pattern with alternate lines in red and white pigments. The larger shields were used more frequently for ceremonial purposes, and on this account were painted in appropriate designs. Professor Spencer and Mr. Gillen state in regard to the construction of the shields of some of the Central Australian tribes, "The symmetry is perfect, and with only a flint as a cutting agent the workmanship is astonishing." The ornamentation of shields is never elaborate, being confined to the grooving and colouring in application of the straight or curved line. As far as observed there is no evidence of inlaying.

The boomerang is the most distinctive Australian weapon and the one which shows a remarkable ingenuity in its construction. The curved root or branch of such a tree as the she-oak is used in its manufacture. Some boomerangs are very artistically made, with just the amount of curve, poise, and flexion ; scraped, polished and ornamented on one side, with serpentine or parallel lines and bands carved or grooved with good effect. The return boomerang was, or is, not altogether in general use throughout Australia, the tribes in some districts of Western Queensland and also in some parts of Central Australia only using the heavier non-returning weapon. The Brisbane Museum has a splendid collection of boomerangs illustrating great variation in type, from the return weapon to the beaked boomerang of Northern Queensland, and the fighting boomerang, three or four feet long, probably used like a club. Many of the boomerangs from Queensland have incised patterns, rather geometric in character than representing natural forms.

The nullahs or clubs are of great variety, and although often well shaped, polished, and sometimes carved, are devoid of other ornamentation.

The throwing-stick, or woomera, is in general use throughout Australia, varying in form from narrow to broad and leaf-like, according to district. It is sometimes ornamented. In Northern Queensland a shell is often attached to it. The peg into which the end of the spear is inserted may be of wood or bone, the handle often being enlarged by a piece of gum, into which is inserted a flint or cutting stone. This throwing-stick, or javenlinthrower, is one of the most ancient of weapons. It is interesting to find that javelin-throwers, not differing much in form from the Australian type, have been found well-preserved in the cave-dwellings of pre-historic man at La Madelaine, in France. Some of these, of bone or of reindeer horn, are skilfully carved with figures of animals. The Australian woomeras are seldom ornamented.

In the construction of spears the Australian aborigines have shown great diversity and ingenuity. Some of these weapons exhibit remarkable skill in workmanship. They differ in shape, material, weight, and finish, varying with the district and the constructive skill of different tribes. Some are in one piece, others are made of light reeds tipped with hardwood; they may have one prong or many, and the spear-head may be of wood or of chipped or flaked stone, such as quartz, quartzite, desert sandstone or opal. The leaf-shaped heads are often of beautiful workmanship, especially in North and North-West Australia. Some of the finest examples of spears come from Northern Australia, where several types appear to be used. In Western Australia the lighter spears are pointed with shell or flint, whilst heavy war spears, ten or twelve feet long, have carved barbs with pointed notches.

In regard to domestic utensils there is not much variety. Receptacles for holding water and food were made usually from wood, an excrescence on the trunk, or a suitable piece from the outside of the red gum or some other tree being cut out into a wooden vessel. Some of these vessels were left rough on the outside, but others were symmetrically trimmed. The manufacture of the "pitchis," or wooden troughs, in use among the Central Australian blacks is highly praised in Professor Spencer & Gillen's "Tribes of Central Australia." These are made out of soft wood like the useful bean tree, or of very hardwood, and ornamented with conventional designs in pigments, or grooved with fine parallel lines on the outside, and with coarser ones inside. "Their symmetry of form is perfect," and reference is made to the manipulative skill and the artistic feeling displayed both in shields and pitchis in regard to beauty of form and symmetry of line. Characteristic specimens may be seen at our chief museums.

It has been repeatedly noticed in Australia as elsewhere that there is a natural tendency in native industrial arts to specialisation in certain weapons or utensils—a tribe, probably from the possession of greater facilities, becoming extremely expert in one particular direction, another achieving a reputation in a different department. This also leads to specialisation in families and individuals, and thus to the production of superior work. *Apropos* of this, a friend in Northern Queensland writes:—"The spears, woomeras, boomerangs, firesticks, etc., are all made of gidgee and lancewood, and by different natives, much the same as with our carpenters, blacksmiths, etc.,—that is, one is a spear-maker, another a woomera-maker, etc., each like a different tradesman." The corollary of this distribution of labour is, of course, a wide system of barter, which has always prevailed among the Australian blacks, products of different districts, as well as special weapons and utensils, being freely interchanged.

Plain bone utensils for cutting or grooving, for awls and needles, are in use among some of the Australian tribes. The skins of some animals, as in West Riverina, were sometimes made into water-bags; and in the south and east opossum rugs for covering and warmth were in use. The skins were softened by scraping and rubbing, tanning being unknown. After being stretched and dried the skins (according to Mr. D. Bunce in "Wanderings in Australia") were often curiously marked with figures of animals—kangaroos, emus, and the human figure being scratched on them. Mr. E. M. Curr in the "Australian Race" says that opossum skins are ornamented with patterns scraped on the fleshy side with a mussel shell. In Northern and Central Australia the inner bark of a species of Melaleuca is frequently used for a covering.

In the art of weaving, progress was made among the coastal and river tribes, fibres of plants being woven into strong and serviceable cordage for fishing nets, which were often many yards in length [1] Some fine examples are to be seen in our large museums. String is also made from human hair and from fur, a spindle being used in the manufacture. Some hair girdles have been seen many yards in length. Among the Arunta and Urabinna we are told that bags "as well-formed and skillfully knitted as those in use among highly civilised peoples are often met with." In "dilly-bags" there is a great variety. They are often pretty and neat in design and cleverly executed, being made of reeds, rushes, bark, cane grass, string, or vegetable fibre, according to locality. Near Halifax Bay water-bags are formed from plaiting the Calamus australis and by sewing palm leaves together.

Among some coastal tribes fish hooks are made from tortoise-shell, pearl, and mussel shells, particularly in North-Eastern Queensland. Canoes are of the most primitive character, improving, however, towards the north as a result of the influence of Malaysian contact.

The Australian aborigines, being nomads and living under a favourable sky, require little in the form of dwellings. Their most pretentious gunyahs are of a dome shape, and constructed of boughs, grass, etc. However, in some of the northern parts they are of better construction. The Reverend Mr. Morrison, of Yarrabah, states, "The natives have learnt quickly, under a Torres Strait islander, to build delightful houses of grass and cocoanut leaves, in one of which I live." From Norman River to the north-east the natives show considerable skill in building these huts of grass and sticks. Captain Sturt mentions that on the Darling one native camp contained seventy huts, each capable of holding twelve to fifteen men, and all facing the north-west.

The Australian climate, which has given no creative stimulus in regard to architecture, has also rendered clothing almost unnecessary to the aborigine. In the south and south-east opossum, and other skins, were frequently used, but over the greater part of the continent the native is naked and unashamed, the clothing being more for ornamentation than for covering. A waist covering—often of the scantiest—of hair, feathers, plant-down, or fibres, tail-tips, etc., attached to a girdle of human hair or fur string wound round and round the waist is sometimes worn, but more frequently the body is nude. A head covering or forehead band of somewhat similar construction is about the only other article of attire.

As ornaments, necklaces of yellow cane or grass stems cut in lengths, red berries, seeds, kangaroo or wild dog teeth, bones, shells, feathers, etc., are worn among different tribes. Both forehead

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1 In Captain Sturt's Expedition to the Darling in 1828 there is mention of native fishing-nets beautifully made and ninety yards in length.

bands and girdles are frequently ornamented with pigments, with feathers, and kangaroo teeth, whilst armlets are also sometimes worn. Towards North-West Australia the pearlshell, cut into shape and marked, is sometimes worn suspended from a girdle.

The artistic tatooing for which the Maoris and some other Polynesian races are remarkable is not found among the Australian natives, the initiation and other marks made by incision on the bodies at certain rites and ceremonies are disfigurements rather than otherwise.

The feathers of birds are often used with effect for ornamentation. A Queensland correspondent writes: "Here they show conspicuous taste. In corrobborees they often decorate themselves most artistically, not so much in the painting of their bodies, but in the way they use leaves, flowers, and especially feathers of cockatoos, etc., in their decorations and in their dances."

In ornamenting the bodies with pigments for corrobborees and ceremonials, etc., the Australian aborigines, like most savage races, follow to a great extent the lines of the bony structure in the application of colours; but it is in the representation of tribal rites and totemic displays, such as Professor Spencer and Mr. Gillen had the unusual privilege of closely observing and so graphically describing, that the Australian natives exhibit much ingenuity and a considerable amount of genuine, although primitive, artistic talent and imagination as well as constructive ability. From the meagre materials at hand in the form of stone, twigs, wood, feathers, bone, down, string, etc., they are skilful in preparing the elaborate headpieces and emblematic objects pertaining to their observances.

It is rather surprising that in the ornamentation of weapons and utensils, and in personal adornment, there is almost an entire absence of the representation of natural forms, either animal or vegetable. This has been commented upon by many writers on the subject, the conventional treatment being universal throughout Australia. In accounts of the Central and Northern tribes of Australia a good idea is given of the elaboration in regard to the significant designs connected with tribal ritual, etc., as shown in the Churinga or sacred stones and pieces of wood, in which the concentric circle is a prevailing form, with variations in wavy lines, spirals, etc. These sacred Churinga were held in great veneration, and probably their ancient origin and attributed inherent virtue helped to preserve their conventional character. Occasionally there is a suggestion of imitation of natural forms, as in the serpentine representations, totemic ground drawings, etc., but little direct reproduction. Conservatism, so marked a character of the Australian aboriginal social life, the ingrained subordination to restrictive traditional customs, the absence of stimulating agencies in a country so thinly populated, and probably some prevalent superstitious feeling restraining them from directly reproducing animate nature in adornment, may in part account for the absence of natural forms. Certain districts have their own particular designs, as in the circle, the zig-zag hatching, the parallel lines, etc., but all are conventional in treatment. Also the character of the weapons and utensils to a certain extent is opposed to anything but simple ornamentation as described. In examining the splendid collections of Australian handiwork in the museums at Melbourne, Sydney, Brisbane, Adelaide, etc., illustrating the native arts of war and peace as well as " religious " feeling, one cannot but be convinced that it is not owing to want of skill, but to restraint, that there is so little of the imitative art exhibited.

When we come to the pictorial and carved representations on sheets of bark, trees, smooth rocks, the walls of caves and cliffs, etc., we find more freedom, if less skill, in the character of the forms represented, many of which are zoomorphic. Some, like the Churingas, are evidently sacred and significant in character, and as such are conventional in form and design, and of almost geometrical proportions. Others are evidently drawings, stencils, or carvings of ordinary natural objects, mostly natural objects, chiefly animals. Throughout the whole of Australia we have evidences of such work more or less skilful in execution. Early in the last century Flinders discovered drawings in the hollow of a precipice, where porpoises, turtles, kangaroos and human hands were drawn with burnt stick and charcoal and red pigment. In the account of the English Colony in New South Wales in the 18th century, by David Collins, the aborigines of Port Jackson are described. Mention is made that " on the rocks are frequently to be seen various figures of fish, clubs, swords, animals, and branches of trees, not contemptibly represented." In Lieut., afterwards Sir John, Grey's explorations near the Glenelg River, Western Australia, in 1838, mention is made of cave paintings on the sandstone representing human figures and kangaroos, black, white, red, yellow, and blue pigments being used. On an isolated rock the profile of a man was seen cut in solid stone. Allan Cunningham also found, at Clack's Island, on the north-east coast of Australia, galleries on a sea-cliff, where dogs, turtles, fish, clubs, canoes, kangaroos, etc., were figured on a red ground, white lines and dots being also freely used. On the Swan River rude paintings have been found.

In the north-west, near Broome, at De Puch Island, similar drawings and carvings, representing kangaroos, wallabies, turtles, turkeys, fishes, and gum trees are to be seen. At many other places in Western Australia records of a like nature remain. Professor Spencer and Mr. Gillen describe rock-paintings at Ayer's Rock, Barrow Creek and elsewhere. Although not so numerous or so well-preserved in South-eastern Australia, yet some examples are known, as in the Victorian Valley, where a cavern has old aboriginal paintings on its walls. In New South Wales and Queensland many rock paintings and carvings have been noticed and described. At Melville and Bathurst Islands, North of Australia, the natives of which are Australoid, the carving of wooden memorials to be placed over the remains of the dead shows considerable skill. Mr. R. H. Matthews has described and figured a large number of rock-carvings of various subjects, some of considerable size, principally on the Hawkesbury sandstones and vicinity, and Mr. W. D. Campbell has given an instructive monograph on the rock pictures of Sydney Harbour.

It has been contended that in Western Australia some of the rock drawings have been done by Malaysian or other occasional visitors to the north-west coast ; but the wide distribution of these representations and their similarity in so many respects to those of the other parts of Australia negative the assumption. Throughout Australia this prevalence of rock-paintings and carvings, exhibiting animal and human forms, reveals the presence of the primitive imitative instinct, as disassociated from the conventional treatment in ornamenting weapons and in ceremonial emblems.

Where Australian aborigines have been placed under suitable educative influences it has been found that they display great aptitude for drawing and carving. At Yarrabah the Rev. Mr. Morrison writes : "An aboriginal man and a half-caste boy have done some really beautiful carving on cedar wood for one of our churches ; they only used a pocket knife." "I think I can claim that they do develop in artistic skill under education. I have always found a much keener appreciation of beautiful things amongst the aborigines than amongst the ordinary working classes of the British race."

In other places testimony is given by school inspectors and others as to the skill of aboriginal children in drawing and in representing form.

We may conclude that the Australian aborigines in their natural state possess considerable artistic ability, much greater than they are usually credited with, and skill in the essentials of effective decoration. In these respects they are at least equal to their prototypes of the Palaeolithic Age. Contact with civilisation has a blighting effect upon their industries as upon their health, habits and morals. As Mr. Welsh, of Normanton, states : "The taking up of all the Gulf country for stations, and the consequent dispersion and decimation of the various tribes, has caused the cessation of *all native* industries or art work." This is applicable to every part of the continent.

Despite the erroneous estimate formerly held in regard to the mental capacity of the Australian aborigines, their artistic and constructive faculties are capable of cultivation, direction and improvement to good purpose.

In order to preserve the remnant of this interesting race, and to do even tardy justice, an honest and systematic attempt should be made by the Federal Government to fully protect the interests of the surviving tribes throughout the States. The Australian aborigines are fast passing away, and every available opportunity of noting their habits of life, their customs, traditions, language, industries and art should now be taken, before, like the vanished Tasmanian race, concerning whom our knowledge is very meagre, our native race, a surviving type and almost a living replica of prehistoric races, becomes utterly extinct.

At the present time two scientific expeditions, chiefly with ethnological objects in view, and under British and Swedish direction respectively, are exploring the little known parts of north-western Australia. Their observations will no doubt do much to supplement the invaluable information obtained by the Horn Expedition, and the subsequent labours of Professor Spencer and Mr. Gillen, in those remote regions where the native races still live in their primitive state, as yet comparatively untouched by the inevitable deterioration which contact with civilisation brings to them. It would be a work worthy of our Federal Government, and redounding to the credit of Australia, to effectively equip a scientific party under Australian auspices for an exhaustive and immediate study of a race so intensely interesting as the Australian race is, both from an ethnological as well as from a general standpoint ; and every year will render the work more difficult, the field for observation more limited, as the materials for it disappear with the certain extinction of the tribes consequent upon the breaking down and demoralisation of their social customs and characteristic features before detrimental influences.

4.—ON THE NECESSITY FOR A UNIFORM SYSTEM OF SPELLING AUSTRALIAN PROPER NAMES.

By REVD. GEORGE BROWN, D.D., Sydney.

THE object of this paper is not so much to advocate the adoption of some means by which the proper pronunciation of Australian place names can be obtained, though that also is very important, but to plead for some uniform and intelligible form of expressing the sounds as we at present understand them.

At the present time there is no uniformity and no system whatever in the spelling, and letters are used, without any marks of distinction, to express widely different sounds. We in Australia have, in some measure, got accustomed to this absurd and disgraceful state of affairs, but those who visit us from time to time must often wonder why we allow it to continue. Most of the men who compile vocabularies, or write about the language, beliefs, manners and customs of the people among whom they live, have their own way of spelling, and write the words in characters, which, no doubt, express certain sounds to them, but which would certainly not express the same sounds to a stranger. This is a serious hindrance to any effective study of the relationship of the respective dialects to each other, and of their connection with some original stock.

The difficulty has been met with in other parts of the world, and has, to a very considerable extent, been overcome by the adoption of a uniform system by the Royal Geographical Society of Great Britain and the British Admiralty. This system is, practically, the same as the one used by the missionaries in the Pacific groups, by Threlkeld, and others in Australia, and by the United States Board of Geographic names. It is, undoubtedly, the system which should be adopted by the Commonwealth of Australia, for if it is not a perfect system, it is certainly far in advance of our spell-as-you-please plan, and it has the merit of being a system the rules of which can readily be understood and which are of universal application.

The principal characteristic of the system is that the vowels are used to express the same sounds as they do in the Italian and other allied languages, *e.g.* :—

"a" is pronounced ah as in father, and does not have to do duty, as in English, for such an utterly dissimilar sound of the same letter as in the words "gate," "fate," etc.

"e" has the sound of "a" in the words "gate," "fate," etc.

"i" has the sound of "ee" as in the word "beet," of "i" as in the words "ravine," "machine," etc., and is certainly excused from having at the same time to express the sound given by us to the letter "i" in such words as "final," "gibe," etc.

"o" is sounded as in English.

"u" is sounded as "oo" in the word "boot," or as "u" in "flute." Why this "oo" should be so very dear to us in Australia is a great mystery. It is very difficult, for instance, to understand why we use the letter "u" in such words as "flute," "truth," and many other words to express a particular sound, and think it to be necessary to use "oo" to express the same sound in so many other words. I often wonder if there is any man living who can write the word "Woolloomooloo" without feeling a sense of injury at the strain on his time, temper, and memory by such a system of spelling. That word can easily be written "Wulumulu" with the acute accent on the final letter to mark the emphasis ; Goonoo Goonoo can be written Gunu Gunu ; Boonoo Boonoo as Bunu Bunu, and many other mis-spelt words can be similarly altered with great gain to the beauty, simplicity and usefulness of the words. Threlkeld, who wrote an Australian Grammar, which was published in 1834, adopted the Italian sounds for the vowels, and says "u" is pronounced as "oo" in the words "cuckoo," "cool," etc. The Council of the Royal Geographical Society, the Foreign and Colonial Offices, the Admiralty, the War Office, all say that "oo" "should never be employed" for the sound of long u as in flute, the sound of oo as in boot—that we should, therefore, not write Zooloo but Zulu ; not Soomatra, but Sumatra. The United States Board on Geographic Names, all the learned Societies in the world, and all the Missionary Societies in the Pacific have adopted the system here advocated, but we in Australia still adhere to the old absurd style. One of the most prominent examples of this ridiculous system is that of the way in which the name of a suburb of Brisbane is spelled. I do not know the history of the word, but I venture to think that "Kuaparú" would express the sound much more clearly to a native than "Coorparoo," and would be more easily pronounced by ourselves and visitors.

The other principal features of the system are :—

(*a*) That the consonants are sounded as in English.

(*b*) That every letter is pronounced and no redundant letters are introduced.

(*c*) That one accent only is used, the acute, to mark the syllable on which stress is laid.

(*d*) That all vowels are shortened in sound by doubling the following consonant.

The following examples will shew some of the changes which would have to be made on the adoption of this system :—

Letters.	Pronunciation and Remarks.	Examples.
a	*ah*, as in *father*	Not Capertee but Kepati. This is one prominent example, but in many N.S.W words the proper letters are used, *e.g.*, Narara, Waitara, Killara.
e	*eh*, *a* as in *fate*	
i	English *e i* as in *ravine*; the sound of *ee* in *beet*	Not Bega but Biga. ,, Bena but Bina. ,, Kerrabee but Kerrabi. ,, Meermaul but Miamaul. ,, Pee-Dee but Pidi. ,, Wee-Waa but Wiwaa. ,, Emu but Imiu.
o	*o* as in mote	
u	long *u* as in *flute*; the sound of *oo* in *boot*	Not Caloola but Kalúla. ,, Boolaroo but Bularú. ,, Boonoo-Boonoo but Bunu-Bunu ,, Coogee but Kuji. ,, Coolabah but Kulabá ,, Coolamon but Kulamon ,, Woolloomooloo but Wulumulú or Wullumulú. ,, Woollahra but Wulára.
ai	as *i* in *ice*; as in *eye* (Threlkeld) ..	Not Kiama but Kaiama. ,, Bondi but Bondai. (N.B.—This spelling is properly used in many words *e.g.* Gilgai, Gundagai.)
au	*ow* as in how; as in *cow* (Threlkeld) ..	Not Bowral but Baural. ,, Bowna but Bauna. ,, Cowra but Kaura. ,, Cowlong but Kaulong.
ao	is slightly different from the above.	
ei	both vowels are sounded, but often pronounced as one, like *ey* in *they*	
iu	" as in *pew* " (Threlkeld)	Not Emu but Imiu.
b	as in English.	

Letters.	Pronunciation and Remarks.	Examples.
c	The soft sound of this letter should always be written *s*.	Not Collarina but Kollarina.
	The hard *c* must always be written *k*. The observance of this necessary rule will cause great alterations to be made	,, Cootamundra but Kútamundra. ,, Coolangatta but Kúlangatta. ,, Coonabarabran but Kúnabarabran. ,, Coolamon but Kulamon and many others.
ch	is always soft as in *church*	As in Chindera (not Chinderah).
d	As in English.	
f	As in English. (Not used by the Aborigines of N.S.W.)	
g	Always hard as in *Gilgai*. (The soft of *g* is given by *j*)	Not Gerringong but Jerringong. ,, Gerogery but Jerogeri.
h	Rarely, if ever, necessary. Threlkeld discards the use of *h* at the end of an open syllable, and says that as an initial it occurs only in a very few words, such as *hilaman*, a shield.	Not Kogarah but Kogera. ,, Bulahdelah but Buladila.
j	As in English	Not Girilambone but Jerilamboan. (See under *g*.)
k	As in English. It should always be used for the hard *c*	(See under *c*.)
l, m, n	As in English.	
ng	As in *singer*, and occasionally as in *finger*.	It is very probable that many of the names which are printed with *G* as the initial letter took the sound of *ng* for that letter. This, however, cannot now be determined unless it were practicable to hear the exact pronunciation from a native.
p	As in English.	
q	"should never be employed," *qu* . . (in quiver) is given as *kw* . . . . (These examples of the changes which would have to be made in words beginning with *q* if the system were to be rigidly adhered to are given, but it is probable that, owing to long usage, the complete change involved would not be desirable.)	Not Quambone but Kuamboan or Kwamboan. ,, Quaama but Kwama. ,, Queanbeyan but Kwinbian or Kuinbian. ,, Quinburra but Kwinbura or Kuinburra.
r, s, t, v, w, x	As in English.	
y	is always a consonant, as in *yard*, and therefore should never be used as a terminal, *i* or *e* being substituted . .	Not Adaminaby but Adaminabi. ,, Balderodgery but Baldarodjeri. ,, Bannaby but Bannabi. ,, Barranjoey but Barranjoi. ,, Yarrongobilly but Yarrongobili. ,, Dee Why (!) but Diwai.

The great difficulty with these words ending in "y" or in "i" is to know what sound is to be given to the terminal letter. Is it, for instance, Adaminabee or Adaminabai? Murrurundee or Murrurundai? Quirindee or Quirindai?—for both pronunciations are used. In some words, *e.g.*, Bondi, the "ai" sound is always given, but this is not so in other words. If the proposed system were adopted no such mistakes could possibly be made. The terminal letter in the name of Yarrangobilly is so absurd that one is filled with wonder why it has been retained, or why, if it was thought to be necessary, it should not also have been used in names like Kirribilli. It is sad to feel that, in the not far distant future, someone will be found gravely asserting in the public prints that the name is associated with a very necessary article used in camping and picnic parties, or with some stockman or bullock-driver called Billy ——, who "discovered the caves."

APPENDIX.

The following is the System of Orthography for Native Names of Places adopted by the Council of the Royal Geographical Society, the Foreign and Colonial Offices, Admiralty, and War Office, etc., etc.

1. The true sound of the word as locally pronounced is taken as the basis of the spelling.

2. An approximation, however, to the sound is alone aimed at. A system which would attempt to represent the more delicate inflections of sound and accent would be so complicated as only to defeat itself. Those who desire a more accurate pronunciation of the written name must learn it on the spot by a study of local accent and peculiarities.

3. The broad features of the system are—

(*a*) That vowels are pronounced as in Italian and consonants as in English.

(*b*) Every letter is pronounced, and no redundant letters are introduced. When two vowels come together, each one is sounded, though the result when spoken quickly is sometimes scarcely to be distinguished from a single sound, as in *ai, au, ei*.

(*c*) One accent only is used—the acute, to denote the syllable on which stress is laid. This is very important, as the sounds of many names are entirely altered by the misplacement of this "stress."

The following amplification of these rules explains their application:—

Letters.	Pronunciation and Remarks.	Examples.
a	*ah, a* as in *father*	Java, Banána, Somáli, Bari.
e	*eh, a* as in *fate*	Tel-el-Kebír, Oléleh, Yezo, Medina, Levúka, Peru.
i	English *e*; *i* as in *ravine*; the sound of *ee* in *beet*. Thus, not *Feejee*, but	Fiji, Hindi.
o	*o* as in *mote*	Tokyo.

Letters.	Pronunciation and Remarks.	Examples.
u	long *u* as in *flute* ; the sound of *oo* as in *boot* ; *oo* or *ou* should never be employed for this sound .. Thus, not *Zooloo*, but	Zulu, Sumatra.
	All vowels are shortened in sound by doubling the following consonant	Yarra, Tanna, Mecca, Jidda.
	Doubling of a vowel is only necessary where there is a distinct repetition of the single sound.	Nuulúa, Oosima.
ai	English *i* as in *ice*	Shanghai.
au	*ow* as in *how* .. Thus, not *Foochow* but	Fuchau.
ao	is slightly different from above	Macao.
aw	as in *law*.	
ei	is the sound of the two Italian vowels, but is frequently slurred over, when it is scarcely to be distinguished from *ey* in the English *they*.	Beirút, Beilúl.
b	English *b*.	
c	is always soft, but it is so nearly the sound of *s* that it should be seldom used.	Celébes.
	If *Celebes* were not already recognised it would be written *Selébes*.	
ch	is always soft as in *church*	Chingchin.
d	English *d*.	
f	English *f* ; *ph* should not be used for the sound of *f*. Thus, not *Haiphong*, but	Haifong, Nafa.
g	is always hard. (Soft *g* is given by *j*) ..	Galápagos.
h	is always pronounced when inserted.	
hw	as in *what* ; better rendered by *hw* than by *wh*, or *h* followed by a vowel. Thus, *Hwang ho*, not *Whang ho* or *Hoang ho*	Hwang ho, Ngan hwi
j	English *j*. *Dj* should never be put for this sound	Japan, Jinchuen.
k	English *k*. It should always be put for the hard *c*. .. .. Thus, not *Corea*, but	Korea.
kh	The Oriental guttural	Khan.
gh	is another guttural, as in the Turkish	Dagh, Ghazi.
l, m, n	As in English.	
ng	has two separate sounds, the ane hard as in the English word *finger*, the other as in *singer*. As these two sounds are rarely employed in the same locality, no attempt is made to distinguish between them.	
p	As in English.	
ph	As in *loophole*	Chemulpho, Mokpho.
th	stands both for its sound in *thing*, and as in *this*. The former is most common ..	Bethlehem.
q	should never be employed ; *qu* (in *quiver*) is given as *kw*	Kwangtung.
	When *qu* has the sound of *k* as in *quoit*, it should be given by *k*.	
r, s, sh, t, v, w, x	As in English.	

·.—NOTES ON SOME CUSTOMS AND BELIEFS OF THE NATIVES OF CHOISEUL ISLAND, SOLOMON'S GROUP.

By REVD. S. R. ROONEY.

1. *Class Relationship.*—So far as this island is concerned I have failed to discover more than one class. The people seem to know nothing whatever of class distinctions. Theirs is a common lot. The recognised big chiefs mix up freely with, and stand on the same level as the common folk. And then the son of a chief can marry the daughter of a man holding no rank whatever, and *vice versa*. The boys and girls of the same village are allowed to intermarry. It is not compulsory for a boy of one village to marry a girl belonging to another. Here it seems to be a case of go as you please and do as you like, so far as the question of marriage is concerned. Then it is of little consequence where the newly-married couple decide to live. If a young man has procured a wife from a village other than his own he will sometimes go and live in that village, but more often than not the bride will settle down with her husband in his village. Taking everything into consideration I think it is quite safe to say that there are no class distinctions on Choiseul.

2. *Rites or Observances at Puberty.*—These people have no rites or observances at such time.

3. *Ceremonies on Beginning and Conducting War.*—Before starting away on a head-hunting raid the oldest chief of the party pays a visit to one of their many sacred places—generally the shrine of some of their ancestors—and there makes an offering and invokes the aid of the spirits in their raiding operations. With much ceremony and amid intense excitement they then embark in their beautiful war-canoes, in each of which has been placed a sacred relic or charm, and travel long distances, ranging from fifty to one hundred and fifty miles, in search of human skulls. Their mode of warfare is that usually adopted by natives of almost any country—taking their enemies by surprise, and killing them before they have an opportunity of defending themselves. When the head-hunters return to their own village they are received amid great rejoicing by the male portion of the community. Immediately they land the head chief pays another visit to the little "tambu" house, and on behalf of all who accompanied him on the expedition makes an offering of food, shell armlets and tobacco, by way of returning thanks to the spirits for their assistance in the raid. Immediately after this, men, women and children make preparations for a great feast and dance, which usually take place about a week after the arrival of the victors.

4. *Peace-makings.*—The head chief of one tribe deputes two or three members of his party or tribe to wait upon the head chief of the tribe with whom it is desired to make peace. If the interviewed chief is satisfied with the terms offered by the other tribe he sends a message back, accompanied by a small present, usually

native money, to the chief, at the same time asking him to name a day when all the people of both tribes may meet to feast and dance and exchange presents.

After the great event all hostility between the tribes concerned ceases, and those who were once the worst of enemies become the best of friends.

It sometimes happens that the chief of one tribe will not accept the terms of peace offered by the chief of another tribe. In which case hostilities continue as heretofore.

After a murder, peace is usually made by the chief of the village to which the murderer belongs offering a large sum of money ("kesa") to the chief and people of the murdered man. In the event of the money being refused, the murderer, or some poor, unfortunate innocent being belonging to his village, will lose his life at no distant date. In some parts of the island a tit-for-tat business goes on for years, and in some instances continues until all or nearly all the members of both tribes have been wiped out.

5.—*Marriages.*—The laws regulating this question are very simple. The wife is always acquired by purchase. When a man makes a proposal for the hand of the girl of his choice and is accepted he immediately informs his father, or should the father be deceased, the chief of the village, of his intention to marry. When the parent, guardian, or chief, is satisfied that all is well he hands over to the bride's father or guardian a portion of the purchase money. The balance is paid at the end of the probationary period (which lasts from a month to three of four months) provided that all is satisfactory and the parties are agreed that they can live happily together. But it sometimes happens that the two are agreed that they are not well matched, and accordingly decide to separate. In which case the deposit money is refunded and no further notice taken of the affair. In the event of everything being right a big feast is made to celebrate the happy occasion, after which the newly wed settle down either in the man's village or the girl's.

If a girl's father or guardian asks a certain lad to marry his daughter he (the girl's parent) has to provide the marriage feast, but if the boy asks permission of the girl's father to marry his daughter the boy's father or guardian, or chief, has to provide the feast, in addition to finding the purchase money, which must always be what is known here as "kesa," or big money.

When a widow wishes to marry again she cuts off her hair—which has grown to a great length during the period of mourning—bedecks herself with all her ornaments and finery, moves about from village to village and lets it be known that the first good offer of marriage will not be rejected.

On this island it is not the custom to have more than one wife, though I know of several cases where a chief has more than one. In each instance the man took to himself a second wife only when the first became too old and helpless to work for him—for on this island, as in many other parts of the group, the women are always the drudges of the men. Many years ago some of the big chiefs had as many as fifty wives, but such a thing is not known at the present time.

6. *Childbirth Customs.*—When the time of a woman draws near she is taken away to a little leaf house in the bush, specially built for the occasion by the women themselves—no man being allowed to touch it—there to await the birth of her child. No man is allowed to go near the place for at least ten days after the birth of the child. During this period the woman's female friends attend to her requirements and see that she has plenty to eat. No married woman is allowed to sleep with a woman in her confinement, but it is quite permissible for unmarried girls to sleep in the same house.

7. *Burial Customs.*—Immediately after the death of a man all his relatives and friends are summoned to the house, where great wailing and lamentation goes on for several hours, with the idea of appeasing the wrath of the spirit of the deceased and frightening away any evil spirits that might be lurking about. After that the body is carried away by four of the relatives, placed upon the funeral pile, and cremated.

After the cremation ceremony, all the people of the village gather together, and a time of feasting takes place. Then some of the ashes and all stray bits of bone from the cremation—if such it can be called—are taken by the nearest of kin and placed in the little sacred shrine in the village, out of regard for the dead and by way of remembrance. The period of mourning generally lasts from eighty to two hundred days, and during that time the widow of the deceased will not leave the village. She will not allow a drop of water to touch her body, nor a comb or knife to touch her head. Her hair grows long, and in a few months she is a most miserable and pitiable object to behold. Thus she lives to express her sorrow.

As soon as possible after cremation takes place the relatives of deceased get someone to give a pig and taro to those who chopped the wood and attended to the cremation rites. Then in six months a feast is made for the benefit of the one who gave the pig, and he is at that time paid for the pig. The payment usually consists of shell armlets. Should the one who gives the pig be connected in any way by marriage with the family, he must not under any consideration look for payment.

A "tabu" lasting for six months is placed up on all cocoanuts that belonged to deceased, no one being allowed to go near them, touch them, or trade with them. When the period of mourning is ended another big feast is made to celebrate the occasion, and the widow is released from the customary restraints. No wonder that such an occasion is a time of great rejoicing.

8. *Religious Beliefs.*—These people believe in a Great and Good Spirit, by name "Bangara la'ata." To him they give the credit of making the world and all that is therein. In addition to

the Great First Cause, these people believe there are several minor gods, who with their great chief live on all reefs and outstanding rocks in the water.

They believe also that at death the spirits of all people, whether good or bad, go to a place in the heart of the island known as "Vudu ni Vungini" (the abode of spirits, or the spirit world), and there they dwell for ever and ever.

Money.—This consists of strings of money made from small white shells, but the most valuable money is known as "kesa." It consists of three or more large rings made from the shell of the giant clam. One of the rings often, if not always, has the head of a turtle carved on it. It is supposed to have been made by the Bangara La'ata (Great God) at the creation of the world. It is not made now, and the present generation (including the very old people) has no idea what it was made from nor how it was made. The leading chiefs own a great quantity of it. This money is kept out of sight, and is usually buried in the ground in places which are but little frequented, and the secret place is known only to the owner of the rings. These rings generally go in sets numbering from three to fifteen. Their value varies according to the weight, thickness or breadth of the rings. This money is much used at inter-tribal peacemakings, for settling minor disputes, as a peace-offering after a murder, and in every case inthe purchase of a wife. Shell armlets are also used for the purposes of payment or barter.

6.—SOME MOURNING CUSTOMS OF THE AUSTRALIAN ABORIGINES

By R. H. MATHEWS, L.S.

[PLATE XLI.]

I HAVE before described the so-called "widows' caps," as well as the elongated oval tablets of *kopai* which were placed upon native graves along the Darling River and its hinterland.[1] Other mourning emblems found at aboriginal burying places in that district were made of the same material as the "caps," and resembled them in general outline, but were larger and heavier. The largest example of this kind of article which has yet come under my notice is one in my own private collection, illustrated in the accompanying photographs. Unfortunately, the smaller end was broken off before it was discovered, leaving the specimen open at both extremities, with a funnel-shaped cavity reaching right through it. The thickness of the shell is irregular, being greatest near the base and middle of the shaft, where it is in places about two inches, thinning out to intermediate thickness down to less than half an inch at other portions. The length outside of the wall or shell of the cylinder in its present damaged and weather-worn state is $13\frac{1}{2}$ inches.

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1 *Queensland Geographical Journ.*, vol. 24, pp. 63-69.

At the base, which is only slightly damaged, the longest diameter of the orifice of the funnel is $8\frac{3}{4}$ inches, and the shortest 6 inches. The corresponding internal diameters of the opening at the smaller end are $5\frac{1}{2}$ and $4\frac{3}{4}$ inches respectively. The outside measurement of the circumference at the base is $28\frac{3}{4}$ inches, and a similar outside measurement at the smaller end is 23 inches. The original circumference has evidently been a good deal reduced by the wasting away of the outer surface by the weather and wind-blown sand during many years of exposure.

This specimen was discovered on Tongo station, about three miles eastward from the homestead. It was partially buried in loose sand, near the margin of Tongo Lake, the outfall of which flows into Paroo River. Tongo is in the county of Fitzgerald, in the north-western portion of New South Wales, and is about 80 miles north-north-east from the town of Wilcannia.

Plate XLI, fig. 1 is a photograph of the article standing upon its larger end, and exhibiting the other extremity in its broken condition. There is a thin, irregularly-shaped patch on the outside of the cylinder, consisting of the same material as the rest of the article, but slightly lighter in colour. This patch was evidently put on after the main trunk had been completed, because along portions of the margin it has peeled off, owing to the difficulty of making the new wet mixture properly adhere to the previously dried surface. It was put on either to secure a uniformly rounded contour, or to remedy some defect in the original structure, or partly for both of these reasons. On examining the inner side of the wall opposite to the middle of the patch there is a small flaw, which probably extended through to the outside, where it was perhaps larger, and required mending.

Plate XLI, fig. 2 shows the larger end, with a view right through the hollow interior to the other extremity. Near the distal end of the funnel there is a discoloured streak in the wall or shell, which is shown in the photograph. Such a mark could have arisen from a stoppage of the work for additional material, which was not quite of the same shade along the joining line. This photograph also contains a side view of the patch on the outside, showing places where flakes have peeled off its edges, as stated in describing Fig. 1.

On the inner side of the entrance of the funnel there are about a dozen lines, from one to two inches long, resembling the impressions of stalks of cane-grass or rushes. They are not arranged symmetrically like what a net would have been, but appear to be the marks made by the outside of a bundle of rushes or grass placed inside the funnel for the purpose of keeping the plaster in position while wet. This opinion is supported by the fact that only the ends of some of the stalks have left their impression. They became fast in the plaster, where they remained until they rotted away. No impressions of a net are visible upon any part of the inner wall.

In the making or "building" of the subject of the illustrations, a considerable quantity of sand has been mixed with the gypsum, which has given it a sandy colour, both inside and outside, as well as along the broken part at the upper end. When the specimen was found it was lying in the position shown in Fig. 3, with all the lower part embedded in the sandy bank of Lake Tongo, and had apparently lain in that position for a long time. The upper half, from *a* right back to the other end, was freely exposed to the weather for many years, and is consequently considerably diminished in thickness by disintegration. It is much the thinnest part of the shell, being in places less than half an inch thick. The lower half of the article, as seen in the photograph, is the thickest portion of the shell, from the front to the rear.

I have stated above that the outside height of the specimen, in its present damaged state, is 13½ inches. We can safely assume that before the breakage the height was at least 2½ inches more, which would make the total original height about 16 inches. The depth of the internal hollow space from the front inwards, if restored, would be about 14 inches or more. The present weight of the article is just a little over 15 pounds. At a moderate estimate, the portion broken off would weigh about three pounds, making the weight of the complete article about 18 pounds. Then we must take into consideration that the whole outside surface has suffered by disintegration during many years' exposure to the weather. The same would apply to the inside surface of the cavity, though in a lesser degree. The original weight has also been diminished by the drying of the material in the sun for such a long period. The reduction in the weight due to the two combined causes mentioned is difficult to estimate, but judging by the worn and contracted appearance of many parts of the surface I think that at least two pounds could be allowed for it. This would bring the total weight of the article when it first left the maker up to about 20 pounds.

As regards the purpose of articles such as that now illustrated, it is hard to obtain full particulars, because they are not used by the remnants of the tribes at present living on the Darling River. It is not at all likely that they have been worn on the head, like the widows' caps described by me in 1908, because the opening in some of them is too small to fit any adult skull, whilst others are much too large and heavy. The great depth of the cup-shaped cavity—14 inches in the present specimen—would be quite needless as a receptacle for the head; and there are no impressions of a net on the inner wall similar to those found on widows' caps. An old blackfellow, whom the white people called "Marra Jimmy," a head-man of the Ngunnhalgu tribe, who resided most of his later years at Marra station, on the Darling, and who died about ten years ago, said the articles with the deep cavities were not worn on the head, but were laid upon the graves of old men and women of tribal importance, in the same way that the kopai tablets were deposited.

Mr. J. E. Suttor writes me as follows :—

"In 1880, while mustering cattle on the back part of Curranyalpa run, I came across two old black men and a woman camped at a waterhole. They had shifted out from the Darling River to hunt opossums for the skins. The old woman was lying in the camp very sick. A few days later the two black fellows passed my camp, which was about five miles from their own, and told me the old woman had died. Going that way a couple of days afterwards I found the woman's grave on a pine ridge close by the camp I had previously seen, and upon it were lying two hollowed kopai articles somewhat resembling widows' caps. At the place where the camp fire had been was a piece of bark, with the remains of kopai plaster upon it, together with some lumps of kopai, burnt and ready to break up, if more had been required. The woman's husband and the other man, who was probably a relative, had each left a token of their sorrow upon the grave before they went away."

Although a widow's head-dress consisted of a cap similar in shape to those depicted at pages 67 and 68 of volume 24 of the Queensland Geog. Journ., they were also worn by a woman for an adult son or daughter, or for a favourite brother or sister. Their use was not restricted to the women only. Old "Marra Jimmy," already quoted, said that men sometimes wore such a cap in mourning for their mothers, mothers' sisters, their own elder sisters, their wives and other blood relations of mature years. Generally speaking, however, the men used the kind of articles described in the present paper, which were never worn on the head, but were deposited at the grave.

The facts just narrated would account for the comparatively large numbers of so-called "caps" which have been found at individual graves. Mr. T. Worsnop mentions four found on a grave, one of which weighed 14 pounds, but he does not state whether any of them had marks of the meshes of a net on the inner surface.[1] A friend writes me that he has seen five caps similarly used, but cannot remember details. A station owner on the Darling River informed me that many years ago there was an aboriginal grave not far from his homestead which had from half-a-dozen to a dozen articles lying upon it, which then appeared to him to be "caps." They were not all of one size, but comprised some very large ones, others medium size, whilst others were small. In the cases just mentioned it is likely that some were widows' caps, some had possibly been worn by men, whilst others had been manufactured as tributes of mourning. The latter kind could be placed upon the grave as soon as the body was buried, whereas a "cap" could not be deposited till the wearer's term of mourning had expired.

The widow's cap illustrated in the Queensland Geog. Journ., already quoted, is made from kopai, with only a small mixture of sand or ashes, because kopai is abundant over a large portion of the Darling Valley. But on some of the tributaries of the Darling, such as the Macquarie, Mara, Bogan, etc., where gypsum is found only in small quantities, the mourning caps were made out of a

1 "Aborigines of Australia" (Adelaide, 1897), p. 63.

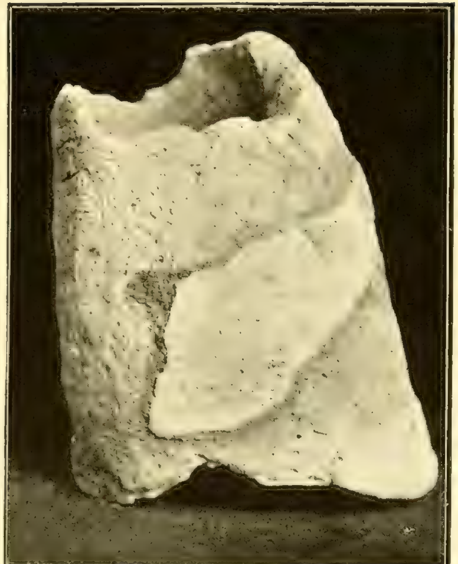

FIG. 1.

FIG. 2.

FIG. 3.

WIDOWS' CAPS.

Aboriginal Paintings, Finke River.

brown-coloured tenacious mud, obtained from the bottoms of waterholes and streams, with little or no admixture of gypsum. Yellow or reddish clay, sometimes seen cropping out on the slopes of ridges, or on the banks of watercourses, was utilised for the same purpose. The shape of the cap was the same, no matter what the material consisted of. Clay caps, when removed from the head, and exposed to the weather on a grave, soon became disintegrated and fell to pieces ; hence none of the caps of this material have been preserved by the white people. White is the favourite colour for mourning among the Australian aborigines, but when it cannot be obtained other colours must be substituted for it.

It is well known that human skulls were used as water-vessels by the aborigines in several parts of Australia. Mr. E. J. Eyre saw some drinking cups of this sort, and gives an illustration of one.[1] The tribes referred to by Mr. Eyre adjoined the Darling River people on the west. When surveying on the Darling and Paroo Rivers in 1884-5 I met an old blackfellow who had a skull among his paraphernalia, which he used for drinking purposes on ceremonial occasions. Old "Marra Jimmy," already mentioned, told me that, in addition to their use as mourning emblems, the kopai articles were imitation skulls which the spirits of the dead were supposed to use for their water supply in that arid district.

EXPLANATION OF PLATE XLI.

Figs. 1, 2, 3, Widows Caps.

Addendum.—For the purpose of enabling the reader to compare the photographs in Figs. 1 and 2 with the "caps" known to have been worn by widows, I have supplied a block (Fig. 2) illustrating the inside of a widow's cap, made of kopai, showing the marks of the meshes of the net which was on the woman's head. This is a reduction from the larger plate given in the Queensland Geog. Jour. above quoted, and is now repeated in order to bring the whole subject under the reader's eye in one article.

7.—NOTES ON SOME PUBLISHED STATEMENTS WITH REGARD TO THE AUSTRALIAN ABORIGINES.

By R. H. MATHEWS, L.S.

[PLATE XLII.]

AT the meeting of this Association held at Brisbane in 1895 the late Mr. T. Worsnop read a paper in which he described, *inter alia*, certain aboriginal paintings in South Australia and Queensland, which appeared to me to call for further inquiry.[2] In 1905 I wrote

1 *Journs. Expeds. Cent. Aust.*" (London, 1845), vol. 2,pp. 310, 316, and 511, plate iv., fig. 20.
2 *Rep. A.A.A.S.*, Brisbane, vol. 6, pp. 141-2-4, plates 12 and 19.

to Mr. T. A. Bradshaw, the officer in charge of the telegraph station at Alice Springs, sending him a copy of Mr. Worsnop's report and a reproduction of his plate xii., asking Mr. Bradshaw to send me a photograph of the paintings at Ooraminna rock-hole. He acknowledged my letter, and after a long interval he got a chance to comply with my request. In August, 1907, he wrote to me from Alice Springs as follows :—

" I availed myself of an opportunity occurring last week to visit the Ooraminna (or Uraminna) range and waterhole, 30 miles southerly from here, taking my camera with me. I had to exercise great patience to secure a photograph of the drawings you refer to, as they are on the sloping roof of the cave. I had to watch until the sun shone between two boulders on to the floor of the cave, and then take the picture with reflected light. I forward you a copy of the result, hoping it will be of interest ; anyhow it will dispose of Mr. Worsnop's elaborately uniform and fanciful design. (Plate 12).

" The cave is situated at the north-west end of the waterhole, and is about 15 feet long, going back about 10 feet into the rock. The height of the roof from the floor at the outside or front would be about 7 feet, rapidly decreasing downwards, until at the back, some 10 or 12 feet distant, the roof and floor join together. The roof, like the rest of the cave, consists of desert sandstone, and has not been painted white, as stated by Mr. Worsnop, but is in its natural state. The greater part of the roof or ceiling is covered with sketches, of which my photograph represents about a fourth, and is a fair sample. (See fig. 3). They are drawn in white, yellow, and red ochre, and there is no trace of a regular design of any kind. There are a few similar markings on some sheltered rocks outside the cave, but no human hands or feet, either inside or outside, unless they are so faint as to be unrecognisable as such."

I also asked Mr. Bradshaw to try and obtain a photograph of the " sculptured rocks " described by Mr. Worsnop at the junction of Sullivan's Creek with the Finke River (p. 144 and Plate 19). He replies :—

" I have not seen them, and am not likely to be in that neighbourhood to inspect them. I am of opinion, however, that Mr. Worsnop's Plate 19 is too regular to be reliable, and would advise inspection by some capable person."

At p. 142, Vol. 6, Mr. Worsnop further states :—

" At Buckland's tableland, in Central Queensland, on the banks of Nardoo Creek, is a high cliff, and on its face is a magnificently executed picture, representing a lake of fire, out of which are stretched dusky brown arms in hundreds . . . The hands are elevated as in the agonies of death, as though a host were engulfed in a seething lake of fire . . . Every joint can be seen, and each looks alive . . . The whole picture is about 70 feet across . . . The groundwork of this grand picture is painted in pigments of red, white, blue and yellow, giving the general effect of a mass of sulphurous fire."

I sent a copy of the above to a resident of the district indicated, and asked him to make inquiries. He reported that Nardoo Creek is about 60 miles southerly from Springsure, in the county of Denison, Queensland. On the smooth natural face of an overhanging rock, sheltered from the rain, a large number of hands are stencilled in the way commonly adopted by the natives, as well as a few other devices. He says there is nothing remarkable about the work, and that to call it a " magnificent picture," or that it represents " a seething lake of fire," is a ludicrous misdescription.

While I am endeavouring to correct some inaccuracies which have appeared in our own Proceedings in the description of rock pictures it may be well to also invite attention to erroneous accounts of other doings of the aborigines published elsewhere. It has truly been said that "no man has been more misrepresented than the Australian blackfellow."

The following is a detailed and very early account of hunting a kangaroo in Western Australia, according to Captain (afterwards Sir George) Grey :—

"The mode of tracking a kangaroo until it is wearied out is the one which beyond all others excites the admiration of the natives ; this calls out every qualification prized by savages : skill in tracking, endurance of hunger and thirst, unwearied bodily exertion, and lasting perseverance. To perform this feat a native starts on the tracks of a kangaroo, which he follows until he sights it, when it flies timidly before him ; again he pursues the track, and again the ainmal bounds from him ; and this is repeated until nightfall, when the native lights his fire and sleeps upon the track. With the first light of day the hunt is resumed, and towards the close of the second day, or in the course of the third, the kangaroo falls a victim to its pursuer. None but a skilful huntsman, in the pride of youth and strength, can perform this feat, and one who has frequently practised it always enjoys great renown amongst his fellows."[1]

G. S. Lang, in describing the native fishing weir at Brewarrina, says :—

"The great weir for catching fish on the upper Darling at Brewarrina is, both for conception and execution, one of the most extraordinary works recorded of any savage tribe. . . . It forms an immense labyrinth of stone walls about three to four feet high. . . . The lower parts of the walls are so solidly and skilfully built with large heavy stones, which must have been brought from a considerable distance and with great combined labour, that they have stood every flood from time immemorial."[2]

If the reader refers to my article on the aboriginal fisheries at Brewarrina[3] it will be seen that the walls of the fishing pens were formed of boulders of various sizes washed out of the bar of desert sandstone which crosses the bed of the Darling River immediately above them, and were consequently lying on the spot ready for the native builders, instead of having been "brought a considerable distance with great combined labour."

The ludicrous and impossible method of hunting a kangaroo given by Sir George Grey would merely amuse a man accustomed to Australian bush life, but the account has been accepted and handed on by an English author, N. W. Thomas, in his "Natives of Australia," pp. 103-104. G. S. Lang's fabulous conclusion respecting the building of the fishing weir at Brewarrina has also been incorporated in the same work at p. 94.

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1 "Journs. Two Expeds. Discov. in N-West and W. Australia in 1837 to 1839" (London, 1841), vol. 2, pp. 275-274.

2 "The Aborigines of Australia" (Melbourne, 1865), pp. 19-20.

3 *Journ. Roy. Soc., N.S.W.*, XXXVII., 147-9.

Another marvellous account of the above fishing weir is given by Mrs. K. L. Parker in her book on "The Euahlayi Tribe." At pages 102 and 109 she says :—

"The greatest of local landmarks is at Brewarrina. It is said to have been made by Byamee, the god and culture hero of this tribe, and his giant sons—the stone fisheries made in the bed of the Barwon [Darling]."

In 1884 the late Dr. A. W. Howitt reported that in the Kaiabara tribe, Queensland, descent was in the male line.[1] In 1889 he repeated that statement.[2] For the third time he repeated it, in 1904.[3] He arrived at this erroneous conclusion owing to a correspondent having written him that the phratry Kubatine comprised the sub-classes Balkoin and Bunda, and that the phratry Dilebi was made up of the sub-classes Barang and Derwain. As I have made several personal journeys among the remnants of the Kaiabara and neighbouring tribes during the past 15 years I am able to report their law of descent with certainty. A table will be useful for illustration :—

Phratry.	Husband.	Wife.	Offspring.
Kubatine or Kappaian	Balkoin	Derwain	Bunda
	Barang	Bunda	Derwain
Dilebi or Diawai	Bunda	Barang	Balkoin
	Derwain	Balkoin	Barang

This table shows that the phratry Kubatine (my Kappaian) is composed of Balkoin and Barang, instead of Balkoin and Bunda. It also shows that Dilebi (my Diawai) consists of Bunda and Derwain, instead of Barang and Derwain, as stated by Mr. Howitt.

If we take Balkoin, the first name in the "husband" column of the table, his normal wife is Derwain, or it is quite lawful for him to espouse a Bunda woman. If he marries Derwain his child is Bunda ; but if he weds Bunda his child is Derwain. The phratry, and the sub-class (or section), and the totem, of the man Balkoin's children would depend altogether upon their mother, quite irrespective of their father.

Dr. Howitt's statement that descent is counted through the father in the tribe referred to has been accepted and repeated by such able anthropologists as N. W. Thomas,[4] J. G. Fraser,[5] and Andrew Lang.[6] On the other hand, Rev. J. Mathew[7] and myself, who have both been among the blacks in question, have reported that descent is reckoned through the mother in all cases.

1 *Journ. Anthrop. Inst.*, 13, p. 336.
2 *Op. cit.*, 18, p.
3 "Native Tribes of S.E. Australia," pp. 116 and 229.
4 "Kinship and Marriage," p. 43.
5 "Totemism," vol. I, p. 447.
6 *Man*, 1910, No. 80.
7 "Eaglehawk and Crow," p. 100.

C. Lumholz says :—" On Herbert River, Queensland, expeditions are sometimes undertaken for the special purpose of securing *talgora*, that is, human flesh. The very thought of *talgora* makes a man's eyes sparkle."[1]

G. F. Angas states that the aborigines of the Tatiara district of Western Victoria used to travel to Lake Alexandrina to catch black children for the purpose of devouring them.[2]

It is well known that the Australian blacks have cannibalistic practices ; but that they go specially and deliberately hunting for human flesh as an article of diet among their neighbours is altogether improbable. No such custom has been reported to me by any of the old blackfellows among whom I have made inquiries in the different States of the Commonwealth.

EXPLANATION OF PLATE XLII.

Aboriginal Painting, Finke River

8.—THE FUTURE OF THE AUSTRALIAN ABORIGINES.

By VEN. ARCHDEACON LEFROY, Sydney.

(ABSTRACT.)

THE aborigines seem to be a fairly distinct race, mainly of Caucasian origin. In many respects they are one of the most interesting races on the earth. Popular opinion has dreadfully misrepresented them, as though they were degraded in character and most feeble in intellect. On the contrary, in character they compared most favourably with the islanders of the South Pacific as the two were known to Captain Cook. Relatively they were gentle and moral beings. Their tribal and family laws and customs are of considerable ethical value. As for intellectual power, they certainly can acquire European ways of thinking and living with marvellous rapidity. Their non-progression, or retrogression, in the past thousands of years is due to unfavourable environment. Australia in its natural condition is an inhospitable land. Its glorious climate encourages a day to day existence, and supplies no stimulus to its native inhabitants. Had a band of European settlers been thus isolated, even for a century, they also would have terribly degenerated. In recent times the coming of the white man has made matters worse for the aborigines. In the first place it has demoralised them, in the second place it has three parts exterminated them. Little positive good, by missionary and other effort, has been done to counteract this evil effect.

1 " Among Cannibals," p. 27.
2 " Savage Life in Australia and N. Zealand," vol. I., p. 123.

Far more effort and devotion has been employed in uplifting the South Sea Islanders. With regard to the ill consequences of the European occupation, there is reason to think that by cruelty, negligence and the communication of disease and moral corruption, it has reduced the native population by three-fourths. Calculations made by Mr. Westgarth, in 1846, seemed to show that the density of population in the so-called settled parts was about 1 in 20, though the population in those parts had certainly been reduced by one-half since the beginning of the English invasion. In other words, the average density of population 120 years ago may be taken as about 1 in 10 square miles, which would allow 300,000 as the population of the whole continent. As bearing out this calculation, there are at the present time about 75,000 aborigines in the far north, in an area which is about one-fourth of the Commonwealth.

Late in the day though it be, some remedy must be sought. It will be found to lie in making the whole of the remnant a national responsibility under national control. Ample reserves should be set apart for them, stocked with cattle and otherwise industrially developed, and on these reserves humane and statesmanlike efforts should be made for the uplifting of a race which was Australian long before we were.

9.—AN ETHNOLOGIST IN GERMAN NEW GUINEA.

By A. B. LEWIS, Ph. D.

(ABSTRACT.)

The writer was in German New Guinea from August, 1909, to November, 1910. During that time he visited many native villages from the Dutch boundary on the west to the British boundary on the east, and also ascended the Kaiserin Augusta River in the German New Guinea Company's steamer "Siar" for about 200 miles, reaching a higher point than any before reached since the river was first explored in 1885. He also visited a number of places in New Britain. Comparatively little is known of the interior of German New Guinea. This is due chiefly to the mountainous character of the coastal area. Except at the mouth of the large rivers there is everywhere a coastal range of mountains, which in some places ascends directly from the sea shore, but in other places leaves a narrow coastal plain. Back of this range are the valleys of the Markham, Ramu and Kaiserin Augusta Rivers, forming together an almost continuous depression from the Huon Gulf to the Dutch boundary.

Physically the natives along the coast vary considerably, both as regards colour and stature. These differences are often found in the same or in a neighbouring group, and there seems to be no very definite distinction between the eastern and western natives in this respect. The inland people, however, are considerably smaller than the coast people on the average.

Linguistically both Melanesian and non-Melanesian (Papuan) languages alternate irregularly along the coast. It was noticed that the natives of all the islands, even those of the smaller islands lying closer inshore, speak Melanesian, even when their neighbours on the mainland speak Papuan.

In manufactured articles the coast people are much richer than the inland tribes, but many of the articles are made in certain villages only.

Pottery is made only in a few places on the coast, and then usually by beating out the pot from a single mass of clay with a wooden "paddle" worked against a stone held by the other hand inside the pot. In the interior the art seems to be much more widely spread, and where the method could be observed the pot was always made by coiling. Of the eight sections or villages composing the large settlement of Sissano (Melanesian) only one makes pottery, but that particular village had very close relations with an interior (Papuan) village where pottery is made, and by coiling, in both places. As the making of pottery is almost always the work of women, a few wives brought down from the Papuan village would easily account for this. The widespread distribution and excellence of Papuan pottery make it extremely probable that it was an original Papuan art before the Melanesian invasion, and that the Melanesians took up the art after their arrival. This would account for the pre-historic pottery found near Finschhafen, which is now inhabited by non-pottery making Melanesians. The pre-historic pottery found on the island of Watam, in New Britain, may thus also be credited to a pre-Melanesian people driven out or exterminated by the later arrivals. Though the ornamentation is different from any modern pottery known at present, yet in view of the great variety shown by the still very slightly known Papuan pottery, this presents no very serious difficulty.

Section G1

SOCIAL AND STATISTICAL SCIENCE

ADDRESS BY THE PRESIDENT:

E. W. H. FOWLES, M.A., LL.B.,

Barrister-at-Law, Brisbane.

ON UNEMPLOYMENT.

Our section, Social and Statistical Science, embraces a wide range of subjects that not only attract the attention of scientists, but awake interest in citizens of all classes. Social science takes the academic principles of political economy and invests them with living human interest, bringing armchair theories to the fierce test of daily life, and touching closely both the pockets, the bodies and the ethics of an increasing number of the world's workers. I purpose dealing in this address with a new-born department in the realm of political economy—a department presenting problems as inescapable as they are perplexing—problems whose solution is equally essential to the welfare as to the stability of society itself.

A New Science.—Within the last five years quite a new department has been born in the realm of political economy—the Department of Unemployment. Ten years ago unemployment was regarded as a good subject for kind-hearted benevolent societies and pious millionaire philanthropists, but not worth the serious attention of statesmen. The unemployed were an annual winter spectacle in England—harrowing, it is true, but temporary, and their troubles were usually mitigated by soup-kitchens and a respectable subscription list headed by the Queen. In year-books or statistical returns the subject of unemployment, if noticed at all, was relegated to an appendix or foot-note where uncertain figures were bolstered up by vague references to what was done in Germany, Switzerland, and other places on the Continent. But that stage of empirical treatment has swiftly passed away. Unemployment has compelled the attention of writers, economists, and statesmen. In 1908 alone New Zealand passed over 15 Acts dealing with industrial legislation. The questions of adjusting the margins of industry and raising the economic standard have become too pressing to be any longer neglected. Unemployment has become a special study, and its vital bearing on kindred questions of pauperism, race survival, moral fitness and emigration is everywhere acknowledged. Labour statistics everywhere are inserting new columns with new headings.

the workless are being classified, the inescapable residuum is being analysed, the industrial census records the details of those idle in the market place, theorists produce books on the subject, and experiment after experiment is made to find or make work for superfluous labour.

From the mass of theories and discussions, more or less academic, on the problem of unemployment, there are several principles which seem to rest on solid ground. They are these :—

Every man should be given a chance of employment, but not necessarily continual chances.

Sentimental treatment of the unemployed is futile ; the time has come for a sceintific handling of the problem.

The problem is more than local. It is national.

Different conditions obtain in different countries, and these require different remedies.

There is no one cure-all. The theorists who imagine a land tax or any other one reform will automatically eliminate the unemployed have been completely discredited.

Although there are special conditions in different localities, the same causes produce the same results the world over.

The propositions which are still debatable are :—

That every workman has a claim on the State to be provided with work.

That the unemployed is a necessary and permanent factor in our present industrial system. The poor we may have always with us. It does not necessarily follow that we should always have the unemployed.

The Problem stated.—For the purpose of scientific treatment, the unemployed may be classed thus :—

I. Those temporarily without regular employment
- (*a*) with a prospect of tiding over ;
- (*b*) without any prospects.

II. Those permanently without regular employment
- (*a*) Casuals
- (*b*) Unemployable

Statistics show a marked tendency in each of these classes to deteriorate. I (*a*) is the most hopeful class, but some of the hopes are doomed to disappointment, and a percentage of I (*a*) inevitably fall to the rank of chronics in I (*b*). Similarly, from moral reasons within them, as well as from economic causes without them, some of the unemployed in I (*b*) invariably gravitate to II (*a*). And when II (*a*) is reached—*facilis descensus Averni*—the "Casual"—unless he is made of rare material, insensibly drifts from bad to worse, until at last no man wants his unreliable services, and he enters the rank of the unemployable. The law of the survival of the unfittest puts him in his appropriate class, and makes him ultimately the despair of the humanitarian.

Casual employment deteriorates both physique and character, producing unsteadiness, intemperance and drift—effects which are intensified in the next generation. "It takes a very high order of intellect to be self-supporting on an intermittent income."

The obvious reason for the unemployment of those in Class I is the temporary superfluity of labour in one or more industries. This on being traced further back is caused by one or other of these :—

Fluctuation in markets.
Failure of harvests.
Slack seasons.
Changes in fashion.
New processes of production.
Substitution of machinery for hand labour.
Temporary depression.
Strikes either for wages or hours.
Insecurity of investments causing withdrawal of capital.

In Class II we meet with the great straggling host of the unskilled. The casuals are, on the whole, inferior workmen, and as such can command only inferior wages. Trade unions try to find employment for II (*a*) by forcing up wages ; but as usual the minimum becomes the maximum, and the ultimate result is not the employment of a greater number, but a smaller wage paid to the same original workmen.

Class II (*b*) are the despair of the humanitarian. They include all those who either won't work or whose work is not worth having at any price. Drink, laziness, heredity, surroundings—all contribute to the physical and moral condition of this hopeless class. Many of them have learned no trade and can do nothing. The misery of worklessness leads to drink ; intemperance leads to dishonesty and criminality ; and so the unemployable sink daily. In the district of the East End the public house is said to be at the root of the whole problem of unemployment. But without laying too much emphasis on any one cause, the explanation is found rather in the cumulative action of the causes which produce unemployment in the first instance.

Old Age Pensions.—There is one great cause of unemployment which merits a passing notice. It is dominant in every period and nation, namely the infirmities which come from old age. With few exceptions, after a certain period of life, earnings and opportunities for earnings diminish, until there is not sufficient income even for material necessaries. Now for this particular kind of poverty there is one remedy which has been tried almost universally, a remedy to which no objection can be raised, except that it is not always sufficient. This remedy is the fourth commandment, "Honour thy father and mother that thy days may be long in the land which the Lord thy God giveth thee." It may well be that, if children were taught bed-rock ethics in State schools many of the economic troubles of society would gradually disappear.

However, old age pensions are accepted as a fixed policy now in many countries. It is premature yet to state whether their cost is not too high, or whether they are wholly a benefit to those for whom they are intended. In the United Kingdom the cost has exceeded anticipations. In September 30th, 1909, 682,768 old age pensions were being dispensed at an annual cost of £6,063,058. In Denmark, for the financial year 1906-7, 70,445 persons were receiving pensions which amounted in the aggregate to £451,000 for the financial year. There, about a quarter of the population over 60 years of age are in receipt of pensions. In France, the Old Pensions Law of April 6th, 1910, provides for all wage-earners old-age pensions, towards which both employers and workers contribute. The amount of the pension is calculated on the basis of the sum of the contributions paid up to the 65th year of the worker's life. To this the State adds an annuity of 60 francs, and this sum will increase the pension of subscribers for the longest term contemplated to 414 francs, or about £16 11s. The cost to the nation is expected to be £4,000,000 annually.

The Commonwealth figures for old age pensions are as follows: Pensions current at 30th June, 1910, numbered 65,492, viz., 31,781 for men and 33,711 for women; at 30th June, 1911, the numbers were: men 34,811, women 40,691, total 75,502. Claims granted during the year 1910-11 numbered 16,465, viz., 10,311 for women and 6,154 for men, but deductions due to deaths (5,671) and cancellations (784) reduced the net increase for the year in the number of the pensioners to 10,010 persons.

In a total of 4,455,005 persons at the census date (3rd April, 1911) the pensioners represent approximately 1·7 per cent. of the population. Relating the male pensioners to the male population over age 65, 35 per cent. were in receipt of old age pensions; of women, only 30 per cent. of those over age 60 were so pensioned.

In the Statistician's Year Book one finds the heading "Pauperism" under almost every country, and the percentage of paupers ranges from ·52 to 3·6 of the population—or in Spain and Portugal, where, out of sympathy doubtless for the feeling of a large portion of the alert mendicants, no figures are given. In civilised countries poverty is decreasing and the standard of comfort is being raised. This is apparent if the condition of the working classes to-day is compared, say, with Plantagenet days, when working classes lived in chimneyless hovels, and had (in Norfolk) but a single garment, when loathsome diseases, such as leprosy, were common, and a third of the population was carried off at once by the "Black Death;" when local famines were frequent and insurrections were the only voice of the people. Of the increased wealth of England and other industrial countries the largest share has gone in wages, and the remuneration of manual labour, as compared with that of intellectual work, has steadily risen.

How Many are Unemployed?—What proportion of the population suffers directly from unemployment?

In Australia it is a question whether there is at the present time any unemployment. At the present moment Queensland could find work for double its population. As might be expected, in this large, thinly-populated island continent, the need is employees, not employment. The high wages demanded in some trades may lead to temporary disturbances—to strikes, lock-outs, or the withdrawal of capital from certain centres—but that is an artificial unemployment, and the distress is mitigated by strike pay. Australia, in common with the older countries of Great Britain, Germany, and the United States, has already had acute industrial differences between employer and employed. Such differences the world over have given birth to a set of men who subsist by industrial war. "In the journals and speeches of these men," says Goldwin Smith in "Questions of the Day," nothing is said about the improvement which the artisan might make in his own condition by thrift, temperance and husbanding of his means ; he is told only of the advantage he might gain by industrial revolution."

From 1906 to 1909 in Great Britain an average of 1·5 per cent. of the population applied for assistance to the relief committees. During that time the unemployed in trade unions varied from 4 to 10 per cent. If to these members have to be added those who though out of work are maintained in part or wholly by relatives, those who though indigent are too sensitive to apply for public relief, and those who being unemployed in legitimate work prefer a life of dishonesty and crime to an honest occupation, the estimate of 10 per cent. of the population being unemployed will be found to be not far from the mark. Of these, at least 3 per cent. may be classed as chronics. From the year 1893 to 1908 the rate of pauperism (exclusive of casuals and insane) per 1,000 of estimated population (in England and Wales) varied from 23·5 (in 1893) to 21·1 (in 1900). In the same period the percentage of members of trade union members unemployed (in the United Kingdom) varied from 2·4 (in 1899) to 8·0 in 1908, and in 1909 the percentage of unemployed had risen to 10 in every 1,000. Since 1860 there have been in Great Britain seven periods of trade depression, culminating in the years 1862, 1868, 1879, 1886, 1893-4, 1904 and 1908. The years 1870-6 and 1895-1902 were of fat kind, and the ranks of unemployed were comparatively very small.

The Industrial Residuum.—It is this industrial residuum of approximately 10 per cent. that sociologists most handle. With the true industrials there need be but little trouble. Trades unions point the way. Classification, and labour bureaux, registration and insurance against unemployment, give a plain and fairly easy road out of the difficulty. But what of the helpless residuum—those who have no foresight and no self-control ; who live for the present only ; who are merely the footballs of circumstance ; whose lives are one incoherent jumble from beginning to end ; who are the merest children in economics ; who know no law but self-indulgence and have bred in them an insuperable aversion to steady work ;

who are untrained in any trade, and are only fit for factitious or superfluous employments, and are unreliable even in those; who have no adaptability, and know no policy but drift—what is to be done with these? One clergyman, after five years' experience in the East End, says: "There is no general rule. One by one those poor brothers must be taken by the hand; it is only thus that real progress can be made." Another expert says: "There is no solution but death. Let them die out, and rather work towards a remedy in the next generation." The true reformer adopts both views—ameliorating the conditions of the present unemployed, and setting causes to work to prevent the unemployed question ever arising again.

The Way Out.—Numberless indirect reforms are possible, aiming at improving the outward conditions of the life of the poor, and at the same time elevating their character. Healthier conditions in factories and workshops, and in private dwelling-houses; increased sanitation in town life; State education of all boys to the age of 16, and the compulsory teaching of a trade or livelihood to all youths; stricter control of the drink traffic; inculcation of moral responsibility and the principles of self-help; thrift and temperance and the teaching of the ten commandments; medical inspection of all school children so as to conduce to the highest hygienic conditions in school life; legislation against the influx of undesirable aliens and goods; legislation on the science of Eugenics, *e.g.*, as in Minnesota, Wisconsin, and Georgia, where it is proposed to forbid the marriage of confirmed drunkards, consumptives, imbeciles, and all who are affected with incurable disease, and to compel all those desiring to enter the marriage state to produce a medical certificate testifying to their physical and mental fitness; these are indirect, but none the less salutary means towards race improvement, and a gradual but sure elimination of the feeble and unfit from life's strenuous competition. This part of the problem is national, not local. It is for to-day and for all time. It cures by preventing.

But as the practical reformer must deal with things as they are, and not as they should be, what are the best remedies for present unemployment? There are three classes of agencies that can materially help:—

1. Agencies which find work and deal with the unemployed before they have time to sink to the ranks of the unemployable, *e.g.*, trades unions, friendly societies, labour exchanges, private registries, and newspapers.

2. Agencies which make work, and, if necessary, provide industries to equalise the periodic fluctuations of the labour market, *e.g.*, municipalities and the Government (working through labour colonies or other related methods) and voluntary agencies, such as the Salvation Army and the Church Army, and

3. Agencies which insure against unemployment or which grant pensions to the unemployed on certain conditions.

Before outlining in detail the present campaign against unemployment, it will be of value to notice some of the incidents attaching to two special methods which are everywhere winning rapid acceptance, namely, labour exchanges and State insurance against unemployment.

Labour Exchanges.—It is vain to expect too much of Labour Bureaux. They adjust supply and demand; they do not pretend to remove an absolute superfluity of labour. But with this limitation in mind high praise may well be given to the expeditious work of these exchanges.

France established her first in 1848. Her Free Municipal Labour Agencies began in 1886, and in 1891, out of a total of 2,496,079 applicants, 459,459 were placed in permanent work and 361,991 in temporary situations.

In England, Labour Bureaux have passed through 20 years of experiment. Her first Bureau was floated at Egham in 1885 under voluntary management, and in 14 months out of 382 applicants, 289 (or 75 per cent.) were found work. The Ipswich Bureau, opened in 1885, found it had to leave severely alone the old, the incapable, and the vicious. The Wolverhampton Bureau failed because all applicants (even the submerged tenth) were admitted to registration, and employers refused to use it. Private registries, good and bad, went on exploiting the field of the unemployed in all parts of Great Britain. In spite of Mr. John Burns' plea to use the 18,000 post offices in England as Labour Bureaux, English statesmen refused to be awakened to the true office and potentialities of well-conducted Labour Exchanges. In 1909, however, a new era began.

The Asquith Government has just passed a Labour Exchanges Bill proposing to establish a uniform national system of exchanges, spread over ten divisions, all working in harmony, and with a central clearing-house in London. The control of the whole scheme is in the hands of the Board of Trade. "The Labour Exchange," said Mr. Churchill, "is a gateway to industrial security; it is an essential piece of social mechanism; it is necessary to almost every approach to the unemployed question—it opens the way to every approach; it bars the way to none." Well managed, the Labour Exchanges can bring men and work together; they should be able not only to tell workmen where to go, but where not to go; they should act as a guide to discover to the new generation what trades are not overworked; they should prevent the exploitation of boy labour, and should be able to dovetail one seasonal trade with another.

In New Zealand the Department of Labour, instituted in June, 1891, has more than justified its existence.

The figures for the four past years are :—

Date.				Men.	Dependents.
April 1906 to March 1907			..	7,393	4,187
1907	,,	1908	..	6,305	4,408
1908	,,	1909	..	10,391	7,510
1909	,,	1910	..	8,506	10,164
June 1891	,,	1910	..	77,679	110,900

In the U.S.A. the Free Public Employment Offices in most of the States have wrestled with unemployment with success. Taking this as an average State, the figures for the period 1890 (the date of organisation of the five free public employment offices) there has been a total of 487,883 applications for situations wanted, 455,368 applications for help wanted, and 309,242 positions secured. Of applications for situations, 61·3 per cent. were filled; and of applications for help, 67·9 per cent. were filled.

In Oklahoma for the 12 months ending June 30th, 1909, the Bureau received applications for employment from 3,452 persons, for 3,250 of whom positions were secured. During the same period requests were received from employers for the help of 4,089 persons.

Labour Bureaux have been established in New Zealand (1891), Melbourne (June, 1892; abolished in May, 1893), New South Wales (1892), and Queensland (1886)—in every instance by the Government. In each case the bureau has been of exceptional value in directing workless men to work, and the past four years of prosperity has resulted in almost all applicants finding permanent work.

Insurance Against Unemployment.—This has passed the experimental stage. Successful cover can be assured to unemployment arising from—

Displacement by new invention.
Temporary depression, as a result of war or other calamity, affecting a whole industry.
Temporary depression, resulting from bad times in trade.
Seasonal unemployment in certain trades.
Permanent under-employment of casual labourers.

But the crux lies in "bad risks." Good workers object to pay for the bad. At St. Gall in Switzerland human nature broke into the whole scheme of compulsory insurance, and it was abandoned after two years' trial. Why should the industrious man carry the loafer on his back? And if premiums are on a rising scale, according to the wages received, the more a man deserved by his own labour, the more he would be called on to pay towards keeping his indolent brother in contented idleness.

So that general and unconditioned insurance against unemployment would break down morally as well as financially unless by a huge system of benevolent socialism every nation provided for its own wreckage. It is only when the area of beneficiaries is carefully chosen and the actuarial basis is made perfectly sound that insurance against unemployment emerges in triumph.

In Germany, Denmark, Switzerland and Norway voluntary systems of insurance have met with success. Denmark passed its first bill against unemployment in 1907, and it came into force that year. The minimum is $6\frac{3}{4}$d a day, the maximum 2s 3d. Beneficiaries must have been subscribing members of the "unemployment fund" for 12 months. The State contributes up to half the amount of subscriptions paid by members; the Communes contribute up to one-third of the subscriptions.

In Germany the principle of insurance seems to be welcomed against most of the ills that flesh is heir to. There are Imperial laws introducing compulsory insurance of workmen against sickness (the cost of sickness in 1908 amounted to £14,868,840, of which each member's share amounted to about 24s 2d), insurance against accidents by employers, and insurance of workmen against old age and infirmity. The National Bill in 1906 under those insurance laws was :—

Compensation under Sick Insurance Law ..	£13,317,374
Accident	7,158,063
Invalidity and Old Age Pensions	8,301,957
	£28,777,394

Following the report of the English Poor Law Commissioners, Great Britain has at last made a definite move towards the form of insurance. It is to be compulsory, and will work in close association with the proposed system of labour exchanges. The first trades on which the experiment is made are :—

Housebuilding and works of construction
Engineering
Machine and tool making
Ship and boat building
Vehicles, and
Sawyers.

These trades contain about 2,500,000 adult males, or one-third of the total industrial population. Moreover, they cover the worst half of the field of unemployment in England. Workmen, employers, and the State each contribute $2\frac{1}{2}$d weekly, making a total of $7\frac{1}{2}$d a week for each worker. The best features of the Basle system have been embodied, and, according to Mr. Asquith, "the scheme will go a long way towards solving one of the most urgent social problems in this country" on behalf of the members resident in this district. There are 40 funds and 75,000 members. In Basle the worker pays 5d a month to the State Insurance Department, and may receive a benefit from 10d to 2s 1d a day during unemployment, but if he is out of work by reason of a strike, illness, disablement, or bad conduct his benefit ceases. Nor is he entitled to any payments if he refuses work offered to him by the State Labour Exchange, which works in close harmony with the Insurance Department.

The Campaign Outlined.—To deal effectively with the great problem of the unemployed it must be attacked on three sides with a view—

(1) To assist the temporarily unemployed

(2) To dispose of the permanent surplus

(3) To so improve the organisation of industry as to prevent unemployment.

The first problem—to assist the temporarily unemployed—is the one that is most insistent, and evokes immediate sympathy. Benevolent persons rush in here where economists fear to tread. Charitable organisations of all sorts compete with each other in helping the wife and children of some worthless beer-soaked husband. Relief societies, managed often with more kindness than judgment, crowd each other in their efforts to "do good." The money subscribed by the public and spent in direct relief would probably, if spent on scientific lines, cope twice over with the whole problem. Almost every civilised country has its imposing array of relief statistics. Even in happy Japan the public purse is open to relieve distress. Here are the figures of expenditure for 1907 (in yen, exclusive of Formosa) :—

Shelter	6,044
Food	364,677
Clothing	24,069
Medicine	1,449
Provisional dwellings	46,923
Expenditure for providing work ..	92,947
Miscellaneous	490
	536,599

In the United Kingdom two million paupers are relieved in the year. 20·8 per 1000 of the population of the United Kingdom may be regarded as permanent paupers ; and 26·3 per 1000 are given temporary relief for a shorter or longer period, but for less than six months. The total expenditure on poor relief for 1906-7 was £16,428,064. In 1856 to 1857 the cost of pauperism in poor law institutes was £16 12s. per head ; in 1906-7 it had increased to £29 5s, or 76 per cent. To meet special distress a grant of £200,000 and a supplementary grant of £100,000 were voted by the British Parliament during the financial year ending on March 31st, 1909.

But such forms of charity, however sufficient for the moment, leave the whole problem still unsolved.

Schemes to assist the temporarily unemployed have been many and varied. Those with some pretence to an economic basis are :—

(*a*) State or socialistic schemes. The municipal schemes are as old as Rome. They may succeed or not. The Paris National Works of 1848 were a gigantic failure and nearly ended in industrial chaos. The relief works during the Lancashire cotton famine were a pronounced success. In the winter months in England attempts have been made to find work in the way of road-making, street sweeping, snow cleaning, excavating and levelling ground for new parks, but the experiments show only negative results.

The constant danger in temporary relief works is that they tend to become permanent, and the cure is worse than the disease. Here are the bare totals of Berlin's experience—a city where no experience has been left untried, and where the bill is mounting every year :—

Year.	Person on Permanent List.	Year.	Poor Relief Cost.	Population (1889).
1889	18,668	1885	£405,000	1,315,412
1904	34,370	1903–4	£939,875	1,917,609

Perhaps it is a similar twist in human nature that leads to the amazing yearly increase in old age pensions in the Commonwealth, in Great Britain, and wherever this relief remedy is being tried.

To ensure success of municipal schemes, there should be :—

An inquiry into the *bona fides* of applicants.
A careful selection and grading of applicants.
Works that will pay the municipality.
Absence of political interference.
Work for half-time only. And
Less than current wages.

But these very essentials scare the loafer away and leave the ranks of the unemployed—good, bad and indifferent—almost as crowded as ever. Nor have municipalities been particularly happy in the experience of finding or making work. The municipal workshop has become too often the receptacle of the worthless, and the General Purposes Committee of the Corporation of Birmingham found it necessary at last to "fall back on the sound principle that municipalities exist for certain limited public functions, and not to find relief for everyone out of work."

Trade unions are more successful in their methods, and the reasons are obvious. They have knowledge of their own trade, and the state of the labour market within it. They can regulate trade, restrict overtime, spread and equalise work, restrict apprentices, collect dues, dispense unemployed and travelling benefits, manage relief that it is to every member's interest to see that no member is unemployed. But trade unions of to-day are particularly careful in having nothing to do with the unskilled labourer, or the nomadic unemployable. If legitimate trades unionism could be extended to include these, it would be found a useful agent in reducing the numbers of unemployed. As far back as in 1887, it was suggested that a large percentage of the present unemployed could be attached to different trade unions as associates enrolled on a different financial footing to full members, paying a smaller subscription when in work, and receiving a smaller allowance when disabled or out of work, but enjoying the full use of the house of call and all registry offices in connection with trades unions. An industrial map of the country could be prepared, and by means of a central clearing house the local adjustment of supply and demand could be accomplished. "Even the wider problem of the dove-tailing of different industries might be successfully attacked, and a central committee forecasting annually from reliable statistics the probable supply and demand for particular industries for the coming year could largely minimise both surpluses and deficits." It is interesting to note that this 20 year-old suggestion is at last being definitely tried in Great Britain. Nor is the experiment without hope of signal success. Temporary depressions are inevitable and fluctuations in industry carrying a temporary superfluity of labour are scarcely preventable, but the remedy here is a scientific forecast from reliable statistics, and a minimising of the gambling spirit in trade, so as to avoid the slump that surely follows.

Disposing of the Permanent Surplus.—I. Here the theorist vies with the practical man both in number and variety of schemes. A better poor law, a sweeping land tax, State labour colonies, assisted immigration—these are a few of the panaceas proposed. Agencies to make work are multiplied, but it must always be borne in mind that there is a limit to manufactured work. The minority report of the Poor Law Commission proposed that the Government should find £40,000,000 of work in ten years, spreading the work over the leanest periods, the work to include afforestation, coast protection and land reclamation by suitable labour taken on in the ordinary way at local rates.

This is in effect a socialistic extension of the principle of labour colonies. English communities have been slow to adopt these. In Germany the first Labour Colony was at Wilhelmsdorf in 1882. In 1894 there were 26. The colonies were established as "institutions of Christian charity for those who have suffered inward and outward shipwreck." The great bulk of the material with which they have to deal is not the efficient workman, but rather the tramp, the ex-prisoner, and others whose distress is caused by personal defects. They became places of temporary resort for single and often undesirable men. The objections to these were the frequency with which inmates returned (46 per cent. is an average taken from eleven years at one institution), the large percentage of ex-prisoners and ex-convicts (76 per cent. in one institution), the lowered wages, the fact that the colonies are shunned by the respectable workers, and the fact that after all they are an artificial remedy and effect no actual or permanent increase in work. Hamburg has lately undertaken an experiment—a combination of town with farm colony—with excellent results. It is part of the "back to the land" movement under such physical and moral influences as contribute materially to success.

On the other hand, the "beggar colonies" in Holland were filled with the fibreless and irresponsible to an extreme degree.

In Belgium, the distinction is made between free and penal labour colonies. It was found that a colony open to all tends to be occupied by the lower classes. The classes will not mix, and to admit one is to exclude the other. But although the Belgium labour colonies are classified into free and penal, the tendency is for all to become penal. Dr. Woeste regards the colonies as being, ultimately, only for the inferior and the shiftless. "If workmen are out of work," is his dictum, "when they search well they will find it." Labour colonies were founded in France in 1892. In Austria, "relief stations" take the place of the colonies; in the penal colonies soldiers have to be kept on the premises to maintain order. In Switzerland the colonies provide a temporary home for those in search of work, as well as for unemployed persons discharged from the prisons of Berne—board, lodgings and wages being provided in return for agricultural labour till permanent work is secured elsewhere. The Witzel Colony in the canton of Berne affords the most distinct object-lesson. The colonists are never more than 250 in number, and with each one the Director keeps in close touch so that the personal element in the reformation of the vagrant, the work-shy, or the drunkard, has full play. The colony covers 4,500 acres; the time is filled in with agricultural and drainage work, repairing roads, fencing, building, and various artisan work. The colony (described by Miss Sellers in the "Nineteenth Century and After," Jan., 1910) is self supporting and reclaims 33 per cent. of its inmates.

They are financially successful, and on the whole it may be said that labour colonies justify themselves as a means of dealing with vagrants, beggars and discharged prisoners.

Labour colonies have not yet had a full trial in England. The Salvation Army Farm Colony of Hadleigh, in Essex, has proved the reformatory value of the principle on a small scale. The Church Army Labour Homes have been an interesting experiment though here the benign administration has militated against financial success.

In the voluminous Poor Law Report, detention in penal colonies is proposed for those who wilfully neglect to maintain themselves or families, or give way to drink, gambling, or idleness, and is to extend from six months to three years. But the free farm colony is not yet acclimatised to Great Britain—perhaps because of the limited acreage left for such experiments.

In Victoria an attempt to found a labour colony was made years ago, but unless for the training of farmers, it is difficult to see either the necessity or the use of farm colonies in so vast and prosperous and thinly inhabited a country as Australia.

Reorganising Industry.—II. There are some who despair of solving the question of unemployment until Society is reorganised and all industries come under a form of socialism. That day is far off yet. It is not certain that it will ever come. It is far less certain that any form of socialism would absorb, on a remunerative basis, all the industrial wrecks, the tramps, the wasters, the feeble-minded, the criminals, and all the host of hopeless unemployables. State remedies may go far to reduce the undesirable classes, and indeed, as we will show later, there are many indirect means by which the class of the unemployed can be brought within comparatively easy handling, but neither in commonism, nor in collectivism, or in any plan, however skilfully devised of socialism, will unemployment automatically cease. At one time compulsory and universal profit-sharing was loudly lauded as a bulwark against the evils of unemployment, but profit-sharing, as such, as Professor Nicholson points out, furnishes no guarantee against instability of earnings and fluctuations of employment. "No system of division of proceeds can be a guarantee that the proceeds will be forthcoming. The greatest perseverance would be no remedy against over-production, or the loss of a foreign market, or the popular adoption of some substitute for an old staple. In any event the opinion may be hazarded that unemployed margins can be effectively and economically handled without socialising all industries.

A Threefold Problem.—The whole problem is partly moral, partly physical, partly economic. There is the morally inefficient surplus, the great horde of those whose conduct, life and morals unfit them for employment. They are the empty bags that cannot stand upright ; the class who do not want work and could not work if they had the opportunity ; they are the hopeless and irresponsible ; the hand-to-mouth classes who neither know nor care where to-morrow's breakfast is to come from. Drink, dishonesty, crime, and sheer laziness breed this class daily, and the process of deterioration is intensified generation after generation.

There is also the physical side. Bad surroundings, scanty food, insanitary dwellings, and want of exercise all contribute to swell the sickly class. The mentally deficient or the feeble-minded are estimated in older countries to be only two per thousand of the population, but it is unfortunately from this class that the ranks in penetentiaries, asylums, reformatories, workhouses, inebriate retreats, maternity hospitals and women's refuges are mostly recruited. Often enough relief is wasted in making parenthood easy among the conspicuously unfit, and in offering inducements to the spread of future misery. There is, thirdly, the economic side. Even if economic conditions do not wholly account for the magnitude and complexity of the later stages of unemployment, they most certainly lie at the root of the problem. Mr. Booth remarks in his work on "Labour and Life of the People in London" that "the modern system of industry will not work without some unemployed margin, some reserve of labour, but the margin in London to-day seems to be exaggerated in every department and enormously so in the lowest class of labour." The eternal question of wages—the same question that Jacob bargained over and that vexed those who stood idle in the market place in the parable of our Lord—governs unemployment to a large extent. On the one hand the employer always likes ten men to be offering for nine jobs ; the employee prefers nine jobs ready for eight men, and the scale of wages differs accordingly. Whether wages boards will solve this part of the question remains to be seen. The crux seems to lie in the difficulty of comparing the worth of different pieces of work or the value of one industry as against another. And as long as wages are based not on a definite principle but on an arbitrary agreement grounded solely on the conditions obtaining in one industry without reference to the great field comprising all related industries, so long will unrest and dissatisfaction survive every Wages Board determination.

Great Britain's Experiment.—We pass from a study of principles and data to consider, in conclusion, the most important document ever issued on the question of unemployment, namely the recent report of the English Poor Law Commission issued in 1909. There were two reports—a majority and a minority report. But both agree on these points :—

To abolish general workhouses ;

To abolish the Boards of Guardians ;

To give separate treatment to the aged, the weak, the able-bodied unemployed, and the loafer ;

To detain the vagrants in colonies ;

To initiate labour exchanges ;

To discourage or prevent boy labour.

With regard to unemployment the majority report states :—

There should be national labour exchanges, giving workmen cheap fares to get to work.

Institutional workshops should be created to train and maintain applicants with a good record and a decent home.

Education in elementary schools should be less literary and more practical, boys being kept till the age of 15.

There should be more physical drill.

Parents should be guided by a special organisation to find other than casual work for boys.

Unemployment insurance should be established in conjunction with trades unions, friendly societies, etc., and helped by contributions from public funds.

Government and public authorities should regulise work and give out their irregular work at slack times.

Unemployment requiring temporary or longer assistance should be helped by the Public Assistance Authority (composed of members of the County Council and an equal number of outside experts, women being eligible) and the exchanges ; but those needing discipline should be sent to detention colonies.

Industrial and agricultural institutions should be set up in the outskirts of towns ; separate ones for women. There should be labour colonies, with good conduct pay.

Emigration is recommended at public cost.

The minority report advocated a Minister for Labour to organise the national labour market and prevent or minimise unemployment. Use of the National Labour Exchange by employees should be made compulsory. No one should be employed under 15 ; those from 15 to 18 should work not more than 30 hours a week, and have to attend trades schools for 30 hours. The Government should arrange £4,000,000 of departmental work a year for ten years—the work to include afforestation, coast protection and land reclamation. Such expenditure to be used specially against lean periods. The Government should pay each trade union half the sum it gives in out-of-work benefit. All left unemployed after the above schemes are in force should be assigned to day training depôts or residential farm colonies, their families receiving home aliment. Vagrants and the like should be kept in detention colonies.

Had the Commission set out to consider the best of the Continental schemes and apply them to English conditions, the report would almost have been identical. If Great Britain adopts the recommendation, poverty and distress in the United Kingdom would be revolutionised. The confirmed loafer would find his lot by no means so easy as at present, and the class who really need help would get it. Running right through the report is the suggestion that the well-to-do should co-operate with the proposed new authorities, by personal service, with the object of improving the physical and moral standard of their humbler brethren. Increasing extravagance in dress, the craving for amusements, and the subordination to frivolity of the serious side of life are stated to be habits responsible for much pauperism and distress. " If reform in these directions is to be effective, the lead and example should come from above."

This report marks a new era in Great Britain's treatment of pauperism and unemployment ; and with the passing o the workhouse and the inauguration of the new methods, it may be safe to prophesy that the new conditions will differ from the old almost as much as order and principle differ from chaos itself. The world of economists will watch with the keenest interest Great Britain's first colossal experiment to deal with poverty on scientific lines.

In some matters, *e.g.*, the ballot box, old age pensions, woman suffrage, and a land tax, Australia has pioneered the way for Great Britain. If ever Australia comes to have as part of her heritage the incubus of the unfit she will be able to learn much from the present gigantic object lesson in the Homeland.

PAPERS READ IN SECTION G1.

1.—SOME STATISTICAL SIDELIGHTS ON AUSTRALIAN MORALITY.

By J. STONHAM, M.A., Commonwealth Bureau of Census and Statistics, Melbourne.

(*Rede wenig, aber wahr, vieles Reden bringt Gefahr*—GOETHE)

1. *Introductory.—Necessity for Statistical Illumination of the Subject.*—The truth and wisdom of Goethe's advice were perhaps never more apparent than during these latter days, especially in connection with problems of such complexity as the various aspects of the moral condition of the community. A widespread tendency is increasingly evident to "Vieles Reden" on all sorts of subjects, a tendency from which even the leaders in Australian public affairs cannot plead complete immunity. Moreover, the hosts of arguments and opinions, sometimes expressed with great charm of diction, prove on analysis to be in many cases pure *ex cathedra* statements, or else have their foundation in invalid assumption, or a limited personal experience. That the last-mentioned basis is a very unsafe one on which to build up a superstructure of fixed opinion has been proved times without number, even in the law courts. It has been proved, too, in regard to persons, such as renowned legal luminaries, whom one might naturally class as skilled observers. Failure to recognise the limitations of argument from personal experience leads very easily to the common fallacy of arguing from the particular to the general, where such experience does not consist of a sufficiency of carefully garnered and rigidly correlated facts. (Mr. Foster Fraser fell into some curious errors of this nature in his recent book on Australia.)

In dealing with the question of the advance or retrogression in the moral conditions of the community, arguments or opinions of the nature hereinbefore alluded to are found to be exasperatingly common. How frequently, for example, one finds disparaging statements in regard to various aspects of morality nowadays, as compared with the "good old days," or in respect of social conditions here and in the "old country." But when the matters in question come to be examined scientifically it is found that the "good old days" were, to a large extent, comparatively bad old days, and that the particular conditions in the old country are no whit better than in Australia.

What, then, does this scientific examination of social or moral conditions connote? It connotes, primarily, an analysis based on accurately compiled and carefully considered statistical data, and, secondarily, a due discrimination and allowance for those factors bearing on the question which cannot be reduced to statistical form. If it is held that the last-mentioned factors overshadow in importance those that can be expressed statistically, the question resolves itself into a *solvitur ambulando*.

In regard to the plea for a sufficiency of statistical data, it is of course quite common to meet the trite rejoinder that "statistics can be made to prove anything," or perhaps the old saw about "lies, awful lies and statistics" will be trumpeted forth with much gusto. Strangely enough, these peculiar ideas on the subject of statistics find such comparatively wide acceptance that it is necessary to emphasise that they are based, consciously or unconsciously, on one of two assumptions. These are, first, that the statistics are built up from unreliable data, or, second, that granted the accuracy of the data, actual figures can be advanced from the same set of tabulations to support either the *pro* or the *contra* of an argument. The latter ingenious misuse of statistics was fairly common in the old Freetrade *v.* Protection days in New South Wales, when each side "selected" figures which seemed quite admirably to bolster up its arguments. In many cases the disputants were unaware that this was an illegitimate use of statistics; but if they were aware, they managed to conceal the fact very well from their hearers. Legitimate and intelligent use of statistics implies not only familiarity with the methods of collection, compilation and presentation of the units, but presupposes also the faculty of recognising and making due allowance for those elements bearing on the investigation which cannot be directly embodied in the tabulations. It implies, also, a recognition of the principle that results for single years cannot fairly be taken to prove or disprove a tendency which may require *at least* five years for its proper manifestation. One might at this juncture allude also to a pitfall which frequently entraps persons who might naturally claim to possess some statistical facility. This is the fallacy of mistaking cases of parallelism for cause and effect. For example, some years ago, in connection with an investigation into the decline of the birth-rate in New South Wales, one observer produced a set of statistical tabulations shewing that the decline in the birth-rate was accompanied by an increase in the insanity rate, thereby suggesting a causal relation, which analysis proves to be quite unwarranted.

Sufficient has perhaps been advanced to shew that in dealing with the question of the improvement or otherwise in the moral condition of Australia there is urgent necessity for the dispersal, by the clear, cold light of statistics, of the mists of obscurity in which the problem has been enveloped through hasty generalisation and *ex cathedra* assertion.

Space will permit of the detailed examination of two only of the possible elements which bear on the problem. These are the statistics of crime and the statistics of natality, and they have been chosen because they apparently lead to quite dissimilar conclusions.

2. *Crime and Morality.*—At the outset it must be pointed out that in dealing with statistics of crime, one has to be careful to observe the advice given in a preceding paragraph, in regard to making due allowance for factors which are not or cannot be embodied in the tabulations. In the first place, the spread of civilisation is naturally attended by an increase in the number of laws, or the scope of legislation, necessary to safeguard the ever-widening circle of human interests. The corollary to this is of course obvious. Again, the improvement and extension of means of communication, and the spread of education and technical training amongst the police, render the detection and identification of criminals much easier than was the case in former years. These influences will naturally be reflected in various ways in the criminal returns. Further, the attitude of the judiciary and the police towards certain offences, such as drunkenness, gambling, and the several forms of vagrancy, is subject to considerable fluctuation. The question is complicated also by the circumstance that accurate returns are not available for the Commonwealth as a whole in respect of the prevalence of undetected crime. Moreover, the methods of compilation of the returns are not identical in all the States, nor have they been identical during the period for which figures are available.

Happily, however, after making allowance for all these factors, investigation shews clearly enough that during the last half century —*i.e.*, up to the end of the year 1908 (the latest year for which complete figures were available at the time of writing) there has been a very considerable decrease in crime throughout the Commonwealth. This decrease is manifested in the returns from the higher as well as from the lower courts. In view of the circumstance that the returns of discharges and withdrawals have purely a negative interest, figures relating to actual convictions only will be quoted. For the lower, or magistrates' courts these are as follow, the comparison necessarily starting with the year 1881 owing to the difficulty of obtaining accurate results for earlier years :—

CONVICTIONS AT LOWER COURTS IN THE COMMONWEALTH, 1881-1908.

Convictions.	1881.	1891.	1901.	1908.*
Total	105,057	127,050	125,924	141,307
Rate per 1000 of the population..	47·3	39·9	32·3	33·4

The above figures refer to all convictions at the lower courts, and include many offences which can hardly be classed as criminal, the number of which has a tendency to increase with the increase of local enactments. For example, in addition to the graver offences

* There has been a considerable decrease in 1909—figures not quite complete.

against person and property, the figures include such minor matters as breaches of municipal by-laws, non-compliance with various orders of the court, and technical breaches of various Land Acts, Fisheries Acts, Masters and Servants Acts, etc., many of which were unwittingly committed. Convictions for drunkenness also are responsible for a large proportion of the total. Logically, it can hardly be claimed that simple intemperance in drinking is any more criminal than intemperance in eating, although the effects of the former are as a rule more clearly apparent. At all events the old-fashioned idea of sentencing the dipsomaniac to imprisonment, or mulcting him or her in a fine, has proved to be quite worthless as a deterrent, the same faces constantly reappearing before the magistrates. Moreover, the practice of sending the drunkard to gaol to herd with real criminals is not only foolish, but dangerous, as the drink-soddened brain appears to be remarkably susceptible to evil suggestion. In an investigation by the writer some years ago it was found that over 40 per cent. of the prisoners in New South Wales gaols had commenced their criminal career with a short sentence for drunkenness. Fortunately, it is becoming more widely recognised that dipsomania is rather a disease than a crime, and the tendency nowadays is to segregate the drunkards in special institutions. It is pleasing, however, to be able to record a great improvement in the sobriety of the people, as judged by the records of the convictions on this charge. This will be seen from the following table shewing the convictions for drunkenness together with the rate per 1000 of the population at various intervals since 1861 :—

CONVICTIONS FOR DRUNKENNESS IN THE COMMONWEALTH, 1861-1908.

Convictions.	1861.	1871.	1881.	1891.	1901.	1908.
Total	8,866	16,375	37,166	40,372	50,375	50,590
Rate per 1000 of the population ..	17·46	10·60	16·72	12·67	11·96	11·95

Complete returns for all the States are not available prior to 1891, and the rates for 1861 and 1871 have, therefore, been computed on the populations for those States for which figures could be obtained.

It is frequently claimed that the statistics of drunkenness do not of themselves offer a sufficiently reliable test of the relative sobriety or otherwise of a community, and that they should be supplemented by a statement of the amount of intoxicants consumed per head of the population. Against this, however, it may be urged that the larger portion of the alcohol which enters into consumption is consumed by persons who are not drunkards, and a very slight increase in the amount per head consumed by the "moderates" could easily account for a considerable increase in the total consumption. Such a statement would, moreover, be valueless, unless account were taken of the consumption of non-intoxicating beverages, like tea and coffee, as well as of the general habits of the people. For example, the amount of beer consumed per head in some of the German States appears at first sight extremely high, while in France the consumption of wine is relatively large, although drunkenness is not common. The explanation, of course, lies in the circumstance that light beer is habitually consumed as an ordinary beverage in parts of Germany, while claret and other light wines are commonly drunk by all classes in France, the use of tea and coffee in both cases being comparatively insignificant.

Before leaving the returns from magistrates' courts it will perhaps prove of interest to ascertain what proportion of the persons appearing there were charged with offences sufficiently serious to warrant their committal to a higher court. The rate per 1000 of the population is given hereunder at various intervals since 1861.

Committals to Higher Courts per 1000 of the Population 1861-1908.

Year.	Committals per 1000 of the population
1861	2·2
1871	1·4
1881	1·2
1891	1·1
1901	0·8
1908	0·6

The above figures, which perhaps afford a fairer test than the total convictions at the lower courts, give evidence of a persistent and regular improvement in the moral condition of the Commonwealth.

Turning now to the record of convictions in the Superior Courts, it will be found that there has been a great decrease during the last half century. Figures shewing the total convictions, together with the rate per 1000 of the population, are given in the table hereunder :—

Convictions at Commonwealth Superior Courts, 1861-1908.

Year.	Convictions.	Rate per 1000.
1861	1531	1·32
1871	1460	0·87
1881	1815	0·80
1891	2122	0·66
1901	1743	0·46
1908	1446	0·34

A consideration of the above figures, together with those quoted in previous tables, will make it abundantly clear that, judged by the records of crime, there has been a substantial improvement in the moral condition of Australia. The limits of this paper preclude any attempt at an estimation as to how far this improvement has been due to such factors as the spread of education, more extensive knowledge of penology, or the general amelioration of social conditions during the last fifty years.

III. *The Birth Rate and Morality.*—A review of Australian natality statistics will shew that since 1861 the birth-rate in all the States has considerably declined. The following table sets out the crude birth rate in each State and in the Commonwealth at decennial intervals from 1861 to 1901, and for each year of the quinquennium 1905 to 1909, single years being given for the last mentioned period in order to shew that the limit of decline has apparently not yet been reached.

CRUDE BIRTH RATE IN THE COMMONWEALTH, 1861-1909.

State.	Births per 1000 of Mean Population in the years									
	1861.	1871.	1881.	1891.	1901.	1905.	1906.	1907.	1908.	1909.
New South Wales ..	41·6	39·7	38·2	34·8	27·8	26·8	27·1	27·2	26·9	27·3
Victoria	43·5	37·2	31·3	33·6	25·8	24·8	25·2	25·3	24·7	24·6
Queensland	45·6	43·9	38·0	37·1	28·5	28·9	26·3	27·0	27·0	27·5
South Australia ..	43·3	38·0	38·1	33·4	25·1	23·7	23·6	24·0	24·6	24·6
Western Australia ..	37·4	30·1	34·2	35·1	30·3	30·3	30·0	29·4	29·3	28·1
Tasmania	35·7	30·1	33·7	33·6	28·6	29·3	29·8	29·5	30·9	29·9
Commonwealth ..	42·3	38·0	35·3	34·5	27·1	26·1	26·4	26·6	26·3	26·4

Before attempting any explanation of the causes and the moral aspect of the decline in the birth rate of Australia, it will perhaps be advisable to examine the natality statistics of other countries. The rates for the more important countries of the world for which records are available will be found in the appended table. The figures refer to the period 1897-1907.

BIRTH RATES PER 1000 OF THE POPULATION OF VARIOUS COUNTRIES.

Country.	1897.	1901.	1903.	1904.	1905.	1906.	1907.
United Kingdom ..	28·9	28·0	27·9	27.6	26·9	26·8	26·0
France	22·3	22·0	21·2	21·0	20·6	20·6	19·7
German Empire ..	36·0	35·7	33·9	34·1	33·0	33·1	32·2
Holland	32·5	32·3	31·6	31·4	30·8	30·4	30·0
Belgium	28·9	29·4	27·5	27·1	26·1	25·7	25·3
Denmark	29·9	29·8	28·7	28·5	28·4	28·5	28·3
Sweden	26·7	27·0	25·7	25·8	25·7	25·7	25·5
Switzerland	28·3	29·1	27·7	27·7	27·4	27·4	26·8
Spain	34·1	34·9	36·1	33·9	34·7	33·4	32·9
Italy	34 7	32·5	31·7	32·8	32·5	31·9	31·5
Hungary	40·3	37·8	36·7	37·0	35·7	36·0	36·0
Japan	30·9	32·7	32·0	30·6	30·6	29·1	32·6

A scrutiny of the figures just given will shew that Australia is sharing in what appears to be practically a world-wide tendency to a restriction in the birth-rate.

To what cause or causes is this world wide decline in the birth rate due, and what causes, if any, are operative in Australia, that are not operative in other countries ? It must at once be confessed that the problem is one on which statistics can at present throw but a feeble light. Of *ex cathedra* statement, and arguments based on a more or less limited personal experience, there is a superfluity, but of definitely correlated statistics bearing on the subject there is very little of real value. And this is especially a matter in which —as G. B. Longstaff well says—" without statistics you can prove nothing." Under the circumstances, therefore, one must perforce make the best use of the materials available, taking special care to avoid the pitfalls alluded to in the introductory paragraphs of this paper. In the first place, records shew that the average number of children per married mother in the Commonwealth is between 3 and 4. This is the actual average, but the question naturally presents itself as to what is the possible average. Excluding those married very early and very late in life, statistics show that the period of potential fertility of the married woman in the Commonwealth averages about 22 years. By period of potential fertility is meant the number of years elapsing between date of marriage and age 45, which may be taken as the ordinary limit of productiveness. What then is the potential average family ? Here we enter at once into the realms of guesswork. I have obtained opinions from various medical men, and their estimates range from 5 to 7, the estimates, of course, being based on the assumption that artificial checks were not resorted to, and due allowance being made for various factors, such as the ages of the husbands and wives, etc.

At this stage, it seems to me that all that can be said is that marriages in the Commonwealth are not productive of as many children as they might be. But without further inquiry one cannot from these premises raise the cry of " race suicide," nor is one justified in immediately joining the ranks of those who, knowing little or nothing about the subject, wisely nod their heads and preach about the weakening of Australia's moral foundations. Brushing aside for a time the litter of empirical assertion and inconclusive argument about the widespread existence of deliberate limitation, let us examine some other factors which may or may not bear on the question of the decline in the birth rate.

We have seen that the tendency is practically a world-wide one. Is it not just possible that this decline is *in some measure* due to the operation of natural law, and if so, how much of the deliberate limitation of the family is due to the promptings of this law, and how much to what the clergy and the medical profession at all events stigmatise as hideous immorality. We are accustomed nowadays to hearing that women do not care for children as they did in the good old days, that they have become too selfish and pleasure-loving to endure the annual or biennial pangs of child-birth, and that with Australian fathers and mothers the comfort and worldy advancement of themselves and their few children is the primary consideration, and the welfare of the nation at large a matter of small moment.

To what extent is this true ? If, excluding the genus *homo*, we turn to the other members of the animal kingdom, we find that " Nature red in tooth and claw " by a merciful dispensation, according to some, or through callous brutality, according to others, has provided that animals shall kill each other, either for food or from sheer lust of slaughter. One shudders, for example, at the possible condition of the sea, if the countless millions of young fish were allowed to reach maturity, or of the land, if the lower animals and insects were allowed to breed unchecked. Fortunately for man, too, some of the more powerful and dangerous animals are, comparatively speaking, unprolific. The sow once reproached the lioness with having only two whelps at a birth, whereas she had over a dozen. " True," rejoined the lioness, " but then, you see, my offspring will be lions while yours will be only swine." The lower animals prey on each other ; but man has to fear chiefly war, pestilence and famine. With the increase in power and devilishness of engines of destruction, war will eventually become such an inferno of horror that increasing common sense will put a stop to it. Pestilence has lost much of its terrors, for man is acquiring the mastery of disease, and the time is perhaps not very far distant when human beings will die principally of old age, or by accident, or suicide. The death rate is rapidly decreasing, so that the problem of the world's food supply, at the present rate of natural increase in the population, must sooner or later become an acute one. While, for many reasons, which the limits of space forbid entering on here, the problem is not so grave as Sir William Crookes would have us believe, sooner or later it will have to be faced. Can we in any sense, therefore, say that Nature herself is providing against too rapid an increase in population by limitation of productiveness.

Another factor which has an intimate bearing on the decline in the birth rate is the great change which has come about in social conditions during the last fifty years. With the spread of education and the all round improvement in the lot of the people, the tastes and desires of the nation have altered considerably. With the growth of democracy, intellectual and social eminence are more widely hungered for, and there appears to be an increasing desire amongst parents to give their children a " good start in life." To manage this on a comparatively small income means, in the case of a large number of people, that they must necessarily restrict the number of their children. Is this ambition a laudable one, or is it vile and immoral ? And can anyone prove to what extent this ambition is accomplished by abstention, or by mechanical interference with the course of nature ? Moreover, will a family of three or four well-clothed, well-fed, and well-educated children prove to be better or worse citizens than a dozen ill-clothed, ill-fed and ill-educated ones, and will they and their parents be healthier and happier ? Medical men and the clergy, however, tell us that the "laxity in morals" which leads people to restrict the number of their families must inevitably have a baneful influence on the future of the race. It is, of course, more or less generally believed that there are a certain number of people who deliberately restrict the number of their children, or who refuse to have children, either from sheer hedonism or through hatred of "brats," but there is no very definite information as to the number of such people. Besides, evidence can be adduced to show that the doctors and the clergy-to some extent, at all events, advocate a vicarious morality in regard to the size of the family. In vol. 39 of the Journal of the Institute of Actuaries will be found an article which throws a sinister side-light on the question. During his investigation into a certain Clergy Widows' and Orphans' Fund in England, the consulting actuary found that from 1881 to 1905 the average number of children per family of the contributing clergy had fallen from 2.67 to 1.63. After careful examination of all possible reasons for this decline, the actuary gave it as his conviction that it was due to deliberate limitation. He stated also that the result was the more surprising in that poverty could not be pleaded as an excuse, since the average salaries had risen in the meantime. The actuary certainly disregarded the increased cost of living during the period, but the increased salaries form a legitimate set-off against this, and probably the clergy of that particular denomination are no worse off now than they ever were.

In 1901 a Royal Commission was appointed to inquire into the decline in the birth rate in New South Wales. This Commission gave it as its opinion that the decline was largely due to deliberate restriction, and amongst other things advocated the enforcement of the provision of the Customs Act of 1901 with reference to the prohibition of the importation of certain appliances. It is very debatable whether any practical value accrued from the long deliberation of this Commission, and many people argued that it had a positively harmful effect in that it dragged into prominence several things that were best left alone. It has, moreover, been openly stated that one of the baneful results achieved by it was the concentrating of an unpleasant amount of public attention on the various methods of limitation. It is also stated that the prohibition of importation of various drugs and appliances gave a distinct fillip to the local manufacture of such articles, and that these articles are more easily obtainable and have a larger sale than the imported goods. This, of course, is purely *on dit* evidence, and is not, and in the nature of the case, could not, be supported by statistics. At all events the birth rate in New South Wales has persistently declined since the Royal Commission sat, nor is there as yet any evidence of improvement. Speaking of the work of the Commission one of the members remarked that it "made the man in the street stare." He omitted to mention that it also made him jeer. For the "man in the street" knew well enough that any reproaches in regard to the falling birth rate could not be fairly hurled at him, and he scornfully resented invitations to vicarious morality by inviting the Commissioners to "take the beam out of their own eyes." As far as this goes, I am only repeating what I have heard openly stated. In any case, there is plenty of statistical evidence to prove that the faults, if any, in regard to the limitation of the family, are to be laid to the charge of the wealthier members of the community, who, the man in the street remarks, ought to know better. Dealing with the question of the decline of the birth rate in Western Australia, Dr. Hope, the principal Medical Officer in that State, remarks as follows in his report for the year 1909 :—"The lack of appreciation among the better-favoured classes of their moral duty to themselves and the State causes a retrograde movement in the quality of the increase of the population, leaving those less prosperous and less morally, mentally and physically fit to bear the greater burden of procuration." As regards the decline of the birth rate in the United Kingdom, Dr. Tredgold writes as follows in the June, 1910, issue of the "Contemporary Review" :—"This decline is not general, it is selective, and, unfortunately, the selection is in the wrong direction. There is not the slightest doubt that the decline is chiefly incident in, indeed, one may say, practically confined to, the best and most fit elements of the community." Hosts of other medical men all over the world, including many in Australia, have publicly stated that the "lower" classes are increasing out of all proportion to the wealthier classes in the community.

It is stated also that the relatively prolific reproduction among the weak-minded and the criminal classes constitutes a serious menace to the wellbeing of the British nation. To what extent are these statements true and disinterested ? Again, we are told that the physique of the British nation is deteriorating. When one visits even the best of the Australian State Schools one wonders that the children look as healthy as they do. At four o'clock in the afternoon of a summer day the air in most schoolrooms is "enough to knock you down," while in winter the combined odours arising from hundreds of damp and dirty boots, coupled with that from more or less wet clothes, must be somewhat stupefying to both teachers and scholars. Some day, perhaps, we will learn that it will pay us in the health and happiness of the race to spend a little more money on our school buildings, to have larger classrooms and smaller classes, and to have more teaching in the open air.

It seems to me that there is a good deal of the "parrot cry" in much of the talk regarding our physical and moral deterioration. The statistics of mortality show that the death rate is steadily improving. If we look at the world of sport we find that our representatives can run faster, row faster, fight better, and shoot straighter than was the case in the "good old days." Some of the finest productions in the world of art, literature and science distinguish these latter days. Nor are men any less brave in war, nor any less hardy and courageous in exploration.

Judging by the records of crime there has been a distinct moral advancement during the last fifty years, and in spite of many mistakes, social and economic conditions have wonderfully improved. The birth rate has undoubtedly declined, but how much of that decline is due to moral wickedness, how much to a decline in fertility or the operation of a natural law cannot be determined. If it is due to moral wickedness, at all events it is not reflected in the criminal returns. On general considerations I am inclined to think that the problem is largely eugenic, and it needs the genius of a Karl Pearson to accurately state it, let alone propound the solution.

2.—OBSERVATIONS ON THE FEDERAL SYSTEM OF GOVERNMENT.

By T. R. BAVIN, B.A., LL.B.

In these days it is a little difficult to write on the subject I have chosen without straying into the forbidden region of party politics. I should like to say at the outset, however, that nothing is further from my intention than to enter upon any such adventure. I propose to do nothing more than to offer some humble criticisms, illustrated, so far as may be, by reference to our own experience of the federal system as a system of government—to discuss it solely from the point of view of its efficiency as a piece of governmental machinery.

One cannot, of course, discuss the merits or demerits of any given form of government without formulating some sort of criterion by which it is to be judged. If any form of government is good, it is because it serves, better than other forms, certain purposes which are accepted at any rate for the purposes of the discussion as necessary and appropriate purposes of all forms of government; if it is bad it is because it fails to serve those purposes. It is quite outside the modest purposes of this essay to discuss with any attempt at completeness what are the proper objects of government. I shall content myself with selecting one or two objects which it will be generally admitted that any form of government, if it is to be reasonably efficient, must serve with some degree of success. And in making the selection, I do not propose to venture on any novel or original lines. I shall merely accept, and ask you to accept, the criterion of a good form of government formulated generally by John Stuart Mill in his book on "Representative Government"—a work which, making every allowance for the rapid movement of political speculation since its appearance, still remains a mine of wealth to the political student. I know of no better general statement of the test of a good form of government for practical purposes than the one which appears in the second chapter of the book mentioned. He says:—"We have now, therefore, obtained a foundation for a twofold division of the merit which any set of political institutions can possess. It consists partly of the degree in which they promote the general mental advancement of the community, including under that phrase advancement in intellect, in virtue and in practical activity and efficiency, and partly of the degree of perfection with which they organise the moral, intellectual and active worth already existing, so as to operate with the greatest effect on public affairs. A government is to be judged by its action upon men, and by its action upon things; by what it makes of the citizens, and what it does with them. . . . Government is at once a great influence acting on the human mind, and a set of organised arrangements for public business."

If I may venture to paraphrase the passage I have quoted, for my own purposes, I would suggest that any good form of government must serve two purposes. First, it must be such as to induce in individual citizens a high degree of active interest in the conduct of public affairs and a keen sense of public responsibility. Second, it must allow of a clear expression of the will of the community, and the ready and effective translation of that will into action. These two things are, of course, intimately connected, but it will be convenient for my purposes to consider them separately. It must be borne in mind, of course, that in formulating this test, I am speaking only of the form or structure of the governmental machine. The character of the interest or of the will referred to, is a matter which has to do rather with the policy than with the form of a government.

Historically, the Federal system, as every student of political history knows, has always been adopted as a device to meet a particular set of political conditions. It is not, nor does it claim to be, an ideally perfect system of government. There is probably no Federal Constitution for which the authors would claim any higher merit than that of being the best obtainable in the particular time and place for which they were legislating. The case to which it has been applied has always been the case of a collection of neighbouring states, incapable of, or unprepared for, complete union which nevertheless desire common action for certain limited purposes.

"It must be remembered," says Freeman in his "History of Federal Government in Greece and Italy," "that of all political systems in the world, the Federal Republic is the last which it would be prudent in its admirers to preach up as the one political system to be adopted in all times and places." The passage affords such an admirable exposition of the historical conditions under which the Federal system may be appropriately adopted that I cannot do better than quote the whole of it.

"It is a system eminently suited for some circumstances, eminently unsuited for others. Federalism is in its place whenever it appears in the form of closer union. Europeans accustomed to a system of large consolidated States are apt to look upon a Federal system as a system of disunion, and therefore a system of weakness. To a Greek of the third century B.C. to an American in 1787 it presented itself as a system of union, and therefore of strength. The alternative was not closer union but wider separation. A kingdom of Peloponnisos or of America was an absurdity too great to be thought of. A single consolidated republic was almost equally out of the question. The real question was—Shall these cities, these States, remain utterly isolated, perhaps hostile to one another, at most united by an inefficient and precarious alliance ; or shall they, while retaining full internal independence, be fused into one nation as regards all dealings with other Powers ? Looked at in this light, the Federal system is emphatically a system of union, and of that strength which follows upon union. The Federal connection is in its place wherever the several members to be united are fitted for that species of union and for no other. It requires a sufficient degree of community in origin or feeling or interest to allow the several members to work together up to a certain point. It requires that there should not be that perfect degree of community, or rather industry, which allows the several members to be fused together for all purposes. Where there is no community at all, Federalism is inappropriate ; the Cities or States had better remain wholly independent and take their chance of the advantages and disadvantages of the system of small Commonwealths. Where community rises into identity, Federalism is equally inappropriate ; the Cities or States had better sink into mere counties of a kingdom or consolidated republic, and take their chance of the advantages and disadvantages of the system of large States. But in the intermediate set of circumstances—the circumstances Peloponnisos struggling against Macedonia, of Switzerland struggling against Austria, of the Netherlands struggling against Spain, of the American colonies struggling against England—Federalism is the true solvent. It gives as much of union as the members need, and not more than they need.

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Wherever either closer union or more entire separation is desirable, Federalism is out of place. It is out of place if it attempts either to break asunder what is more closely united or to unite what is wholly incapable of union. Its mission is to unite to a certain extent what is capable of a certain amount of union, and no more. It is an intermediate point between two extremes, capable either of being despised as a compromise or of being extolled as the golden mean."

This being the case, it would obviously be absurd to criticise the federal system as if it were a mere alternative to the unitary system of government, and to complain of limitations which are of its essence, and defects which are inherent in it.

No student of history or politics would deny its extreme ingenuity as a device to meet the particular conditions to which it is adapted, or its great usefulness at certain points in the world's history. The recognition of these, however, need not blind us to the fact that the federal system, in its more highly developed forms —in other words, in the form in which we know it in the United States and Australia—has certain weaknesses and dangers, which will always tend to prevent it from being a satisfactory form of government. It is these weaknesses and dangers which will form the subject of the observations which follow. These may possibly have some practical interest, for it must not be forgotten that, though the germ of the federal idea is as old as the fourth century B.C., the first instance of a developed form of federal government, in any shape comparable to that which exists in Australia to-day was the Constitution of the United States. All earlier unions, of which there were several, came into existence primarily for the purposes of mutual defence, and the powers of the general government were mainly limited to those incidental to this purpose. It is not until we come to the Constitution of the United States, in 1788, that we find a federation that takes for its province, not merely matters of defence, and external relations, but a large number of matters relating to the internal concerns of the federating States. Since that time we have the examples of the Swiss Confederation, which replaced an earlier and loose form of union in 1848, and assumed its present form in 1874; and the Canadian Constitution, which was adopted in 1867. The Swiss system diverges in at least one essential point from what we are coming to regard as the federal type, and for that reason, I doubt whether we can draw many practical illustrations of the working of the Federal system from the experience of that country. The German Confederation diverges still more widely, so that, for practical purposes, it is true to say that before the adoption of the Australian Constitution the world's experience of the developed form of Federal government was limited to that afforded by the United States and Canada. Certainly, precedents drawn from any of the other sources mentioned must be applied with a great deal of caution. Our experience, therefore, when it comes to be adequately written, must prove of great value to the political student, for, as Mr. Bryce has pointed out in his exceedingly interesting criticism of the Australian Constitution, every creation of a new scheme of government is a precious addition to the political resources of mankind, if only because it embodies an experiment full of instruction for the future. We are contributing to the materials which will be available for all who come hereafter to the work of building up a State.

It may be useful if I begin by explaining what are the essentials of the federal system, as we know it. These are familiar, of course, to all students of constitutional law and history, but it may conduce to clearness if at the outset I explain, as precisely as may be, the sense in which I propose to use the phrase in this essay.

Before a Federal State can come into existence there must exist, as Professor Dicey has pointed out, a body of countries so closely connected by locality, by history, by race, or, one may add, by recognition of common interests or dangers, that their inhabitants are capable of bearing, and desire to bear, the impress of common nationality. This desire, however, must stop short of a desire to attain complete unity. Otherwise, of course, there is no place for the Federal system. In Mr. Dicey's useful phrase, they must desire union, and must not desire unity. Along with the desire and capacity for union in matters which are deemed to be of common interest, there must be a determination to retain independence of action in matters which are deemed to be local.

Given these conditions, we have the soil in which the Federal tree may be planted. These are the historical or political circumstances which make the adoption of the Federal system possible. Let us now examine the legal aspect of the system, and determine what are the marks which may properly be regarded as essential to it.

First of all, there must be a classification of the different powers of government, according to their nature. Those which the authors of the Constitution deem to be of a national or general character are vested in the federal government. Those which are regarded as local or sectional are left to the constituent States.

Second, this distribution must be unalterable by the ordinary processes of legislation. In other words, it must be embedded in a written Constitution, which is alterable only in a special way, different from the methods of ordinary law making.

Thus we get the co-existence of two co-ordinate and independent sets of authorities, both being limited in their powers, both deriving those powers from the same ultimate source—the Constitution; the general, or federal, or national government being invested with all powers of a national or general character, the local or State authorities retaining those which are supposed to be essentially local in their nature.

In the third place, this distribution of governmental powers between central and local bodies, if it is to be maintained, implies the existence of some authority, independent of either, in which shall be vested the power and duty of restraining any attempt on the part of one of these authorities to exceed its constitutional rights, and trespass on the sphere of the other. This authority, both in the United States Constitution and our own, is a judicial tribunal. It cannot be said, with accuracy, that this is an essential element in every federation, for at least two comparatively recent federal constitutions, those of Germany (1866 and 1871) and Switzerland (1874) are without it. In both these cases the federal legislature is the judge of its own powers, and no Court has the power of disallowing, or treating as null and void, any Federal legislation. In this respect, however, both these Constitutions diverge from the true federal type. For the purposes of this discussion it may be assumed that in every true federation there must be some authority of the kind referred to above, which has the power, in effect, to disallow and to treat as null and void, any exercise of power on the part of either federal or State authorities, which in its opinion does not fall within the grant made by the Constitution.

These, then, are the essential principles of the federal system —the distribution of the powers of government between independent and co-ordinate authorities, and the existence of an authority outside these to see to the maintenance of the distribution.

A word must be added as to the method by which this distribution is effected. It may be, as in the United States and our own constitutions, by the enumeration of certain specific matters in respect of which the federal parliament is to have legislative power, all matters not so enumerated being reserved to the local authorities. It may be, as in the Canadian Constitution, by the assignment of certain named matters to the general government and of certain others to the local governments, all the residuary powers being given to the general government. In both cases, however, the principle is for the present purpose, the same. Certain subject matters of legislation must be defined as clearly as possible and assigned either to the general or the local governments.

The method by which this is done is, for the purposes of these observations, immaterial.

Passing now to a criticism of the federal system, as explained above, it will be evident, from what has been said, that it involves a somewhat precise definition and classification of the various subject matters with which governments are called upon to deal; and further, that it depends largely for its efficiency upon the precision with which this definition and classification are effected. A unitary government, it need hardly be said, involves no such necessity. There every governmental power, assuming the government to be sovereign, belongs to a single authority. Certain subject matters may for purposes of convenience be delegated to subordinate bodies, but all such delegations may be revoked at will. Under the federal system, however, the necessity for definition and classification is fundamental.

This necessity obtrudes itself at two points. First in the framing of the Constitution. The crucial question, at this stage, is the question which subjects shall be assigned to the central government, and which reserved to the local authorities. This must be answered on some definite principle. You cannot have a merely arbitrary distribution. Powers, which in their nature are national, must be vested in the national authority; those which in their nature are local must be left to the local authorities. So that on the threshold of federation one is faced with the necessity of classifying the subject matters of governmental control, according to their national or local character.

It is not difficult to give illustrations showing that it is a matter of considerable difficulty to make such a classification with any approach to precision. There are some subjects, it is true, which clearly fall within the category of national matters. Defence and the maintenance of relations with external countries and peoples,for example, are matters which clearly belong to the province of the general government. And so long as a federation is limited to matters of this kind, as were the earlier federations, the difficulty now adverted to is not apparent. But when the purposes of the union are desired to extend far beyond these obviously national matters, and to cover a considerable area of the internal concerns of the federating States, it cannot be escaped. Matters such as trade and commerce, immigration, education, regulation of industrial conditions, do not fall readily and obviously into one category or the other. For some purposes, and from some points of view, such matters may be appropriately subjected to national control. For other purposes, and from other points of view, local regulation may be more efficient and desirable. The federal system, however, makes it necessary to assign the ultimate control over these subjects to one authority or the other—in other words, to classify them as either national or local. If it be said that this difficulty can be avoided by dividing up these subjects, and assigning the control over one part to the central, and over other parts to local authorities, the answer is that this merely accentuates the necessity for precise definition and classification, and involves difficulties of another kind, which will be shortly referred to. Nor does the device of giving concurrent control to both central and local governments afford any permanent and complete solution of the problem, for the ultimate power over every subject must be reposed in one authority or the other.

But apart from this inherent difficulty in the way of a satisfactory classification of the subjects of governmental control, as national or local (which arises out of the nature of the subject matter), there are other obstacles which are none the less serious because they are of a factitious and unessential kind. At whatever period of history a federal constitution is formed, the distribution of powers between central and local governments must of necessity be influenced to a very large extent by the special temporary conditions, social, industrial, political, religious, of the epoch in which it takes shape. This is particularly true where the acceptance of the Constitutional instrument depends, as it did in Australia, and in the United States, on a popular vote. The question of the distribution of powers is the one, of all others, which excites popular interest, and arouses popular passion, in the federating States. Consequently, the ultimate form of the distribution almost invariably represents a compromise between the idealism of those who want to make it logically sound, and the political wisdom of those who are determined that their work shall receive popular endorsement. The result of this is that subjects which really belong to the category of national matters are for temporary or local reasons reserved, in whole or in part, to the States: or less commonly, that the converse mistake is made. In either case, a distribution of powers, which must be relatively stable and permanent, and should be based solely upon a distinction in the nature of the powers themselves, is influenced to a very large extent by circumstances of a local and temporary character.

This is the first point at which the necessity for the definition and classification of governmental powers presents itself, and tends to render the planning of a Federal Constitution a somewhat difficult form of constitutional architecture. It appears again, with its attendant difficulties, when, the constitution having been brought into operation, the necessity arises for giving a precise and definite interpretation of the powers which have been conferred by enumeration on either the central or the local authorities. This necessity, it need hardly be said, makes its appearance at a very early stage in the history of every federation. Nor does it seem to diminish as time goes on. Our own federation is ten years old. We already have a by no means inconsiderable body of judicial decisions, explaining and defining the nature and extent of the enumerated powers of the Commonwealth. The United States Constitution is 120 years old. Its Supreme Court is still busily occupied in explaining and defining the nature and extent of the enumerated powers of Congress. A century of carefully considered judicial exposition of these powers has created a little island of certainty amid a limitless ocean of doubt, over which generations of lawyers have floated, and generations more will float, to affluence. And still it is roughly true to say that nearly every new departure in legislation by Congress of any importance is challenged in the courts.

These facts prove a good deal more than the fallibility of constitutional lawyers. They are attributable to some extent, no doubt, to the infirmity of human language. They are attributable far more, however, to the fundamental difficulty of defining and classifying the various subject matters of legislative activity. Our social and industrial conditions to-day are so interwoven with one another, so interdependent, that it is almost impossible beforehand to assign any precise and definite limits to a power of legislating with regard to a given subject matter. Legislation which in one aspect deals with one subject, in another aspect deals with another subject. Legislation, which in its direct effects relates to this branch of social affairs, may have almost equally direct effects on that. To say that a Legislature shall have power to pass laws with respect to trade and commerce, or industrial conditions, or taxation, is not to end, but only to begin a discussion. The reports of our High Court and of the Supreme Court of the United States abound with illustrations of this. Our Constitution and also that of the United States provides that the Federal Parliament may make laws with respect to trade and commerce among the States. How far does this enable the Parliament to control the wages and conditions of the persons employed in inter-State commerce ? Our central legislature has authority to legislate with regard to taxation. Does this authorise it to impose penal taxes on a course of conduct otherwise outside its jurisdiction, of which it disapproves ? It can pass laws relating to trade marks. Does this power include the right to authorise the so-called " Union Label " ? These are some of the questions that have been already raised and discussed in our own court. The number of similar questions which may arise, under a Federal Constitution such as that of Australia or the United States, is limited only by the ingenuity of lawyers. It may safely be said that there is hardly any important and novel exercise of legislative power by the central parliament in either case which is safe from challenge on legal grounds. Similar questions arise, or may arise, though not to the same extent, with respect to the exercise of legislative powers by the States.

These questions can only be determined by recourse to the Courts—the authority ordained by the Constitution for restricting the competing legislative and executive bodies of the Federation to their prescribed sphere. Fortunately we have Courts in this country to which we can resort with the highest confidence. We know that these questions will be settled with all that authority and success which the ability, high character, complete impartiality and long experience of our Judges secure. Moreover, their discussion in the course of argument and their penetrating and careful elucidation in the judgments of the High Court have undoubtedly contributed to raise greatly the standards of constitutional and political education in this country. It is not by any means an empty boast to say that we have in the judgments of the High Court of Australia a body of legal and constitutional literature which is already recognised far beyond the borders of this continent as being of great and permanent value. These are solid and substantial advantages, which no critic of the federal system could overlook. But they must not be allowed to blind us to the political dangers and disadvantages which that system involves. It is those dangers and disadvantages to which I propose now shortly to refer.

In an earlier part of this paper I endeavoured to explain that the distribution of governmental powers between independent authorities was an essential part of the Federal system. I then went on to show that in the nature of the case it was very difficult to make the distribution either logically satisfactory or reasonably clear, and that to resolve the doubts which so frequently arose continuous recourse to the Courts was necessary.

These conditions involve a twofold disadvantage. First, the actual distribution of the powers of government between different authorities tends to weaken the effectiveness and promptness of governmental action. Secondly, the uncertainty as to the limits of the powers of the Legislatures, and the frequent intrusion of legal questions into the work of legislation, tends to diminish the sense of responsibility both on the part of legislators and citizens, and to divert their minds from what should be the fundamental question about all legislation—the question whether it is good or bad for the community.

As to the first of these observations, it is almost a truism that where the powers of government are divided up among a number of co-ordinate and independent authorities they can hardly be so effectively exercised as when they are concentrated in a single all-powerful hand. New problems, new and unforeseen situations, arise day by day. The legislative requirements of Society cannot be compressed within the rigid lines of constitutional definitions. Situations arise from time to time which can only be adequately dealt with by an exercise of general sovereign power: which require something more than the exercise of a legislative power over a defined subject matter. The industrial, social, and economic interests of the community cannot be divided into watertight compartments, with legislative powers in the parliament to correspond. Lord Acton, in his recently published "Lectures on the French Revolution," speaks of the federal system as being the true natural check on democracy. One does not willingly quarrel with the opinions of so profound a scholar as Lord Acton, but it is not quite easy to see how the federal system can be correctly described merely as a check on democracy. That it is a check is obvious. But it may often be much more. It may, and often has, rendered impossible or exceedingly difficult the attainment of an object which is strongly desired by the considered judgment of the community. American history furnishes not a few examples of reforms which, desired by all parties, supported by all enlightened public opinion, could not be secured because there was no single authority with power to carry them into effect. A system which can produce these results is something more than a mere check upon democracy. It may sometimes amount to a clog upon the wheels of government. Applying the test which was suggested at the beginning of this paper, it may prevent the concentration of the force of the community upon the attainment of an object which the community deliberately desires. This defect of the federal system is the more serious because the number of objects which are now deemed to be within the legitimate sphere of government is rapidly increasing. We have passed the days in which the functions of the State were supposed to be limited to the protection of life and property. We recognise that as the State represents the organised will and force of the community its business extends to the removal of every obstacle from. and the provision of every facility for, the fullest self-realisation of its constituent members.

The wider our conception of the functions of the State, the more we shall realise the difficulties involved in a system which prevents the concentration of its powers in a single sovereign authority.

Our first criticism on the federal system, therefore, is that it tends to be inefficient, by reason of the division of governmental powers.

The second is that it tends to diminish the interest of citizens in the business of government, and to weaken that sense of responsibility, both in the legislator and the voter, which is the salt of our whole political system. It also tends to divert attention from the really important aspect of all legislation, the simple question whether any proposed enactment is good or bad for the community. In other words, it does not altogether satisfy the second of the requirements previously referred to as essential to a good form of government. Nothing weakens the interest of citizens in public affairs more quickly than the feeling that they cannot effectively and with reasonable promptitude translate their political ideals into fact. Constitutional obstacles to legislative action, which the average man is apt to mistake for mere technicalities, breed impatience, and impatience may end in political indifference—the one disease which democracy cannot survive. This, of course, is not an argument against reasonable checks on hasty or impulsive legislation. The federal system, as I mentioned a moment ago, is more than a check. It may involve. so far as the ordinary working of the governmental machine is concerned, an absolute inability on the part of any single organ of government to carry out any desired change. Any artificial barrier between the considered will of the community, and its realisation in fact, is an unquestionable evil. It may, from historical or other causes, referred to in the earlier portion of this paper, be unavoidable. But none the less it is an evil. It may, I think, be laid down as an axiom that the more direct the relation between the determination of the voter on political questions and its realisation in actual fact, the keener will be his interest in politics and the more forcibly will his personal responsibility be brought home to him.

This diminution in the sense of responsibility is increased, I think, by another element in the federal system. I refer to the power of the Courts to declare laws passed by the Parliament to be unconstitutional. This is a somewhat untechnical way of putting it, but it will serve my purpose. I mentioned in an earlier part of this paper that this power was an essential element of the true federal system. It is true that it does not exist in the Swiss and German Confederations, but to that extent they may, I think, be considered to diverge from the true federal type. It seems impossible if the distribution of powers, which is so essential to the federal system, is to be maintained, that the Legislature should be allowed to be the judge of its own authority. On the other hand, to establish an authority behind the Legislature, with power to declare that what the representatives of the people have solemnly enacted as law is not law, tends to obscure the relation between cause and effect, to weaken the connection between the decisions of the electorate, or its representatives, and the consequences of those decisions, in a way that must diminish their sense of personal responsibility. The best way to educate a democracy is to make it pay, as quickly and as directly as may be, for its mistakes. This element in the federal system tends to defer the payment and obscure its causal relation with the mistakes.

The uncertainty as to the limits of the different organs of government in the Federal system also tends to divert attention, as I mentioned above, from the substance of legislation to the question of the power to enact it. This is not by any means an original observation. One of the keenest critics of the American Constitution, Professor J. B. Thayer, himself an American, in a lecture on the "Origin and Scope of the American Doctrine of Constitutional Law," delivered before a Congress on Jurisprudence and Law Reform, in 1893, used the following words :—

"No doubt our doctrine of Constitutional Law has had a tendency to drive out questions of justice and right and to fill the mind of legislators with thoughts of mere legality, of what the Constitution allows. And moreover, even in the matter of legality, they have felt little responsibility : if we are wrong, they say, the courts will correct it. If what I have been saying is true (he has been speaking of the power of the courts to declare statutes unconstitutional) the safe and permanent road to reform is that of impressing upon our people a far stronger sense than they have of the great range of possible harm and evil that our system leaves open, and must leave open to the legislatures, and of the clear limits of judicial power ; so that responsibility may be brought sharply home where it belongs. The checking and cutting down of legislative power, by numerous detailed prohibitions in the Constitution cannot be accomplished without making the Government petty and incompetent."

Mr. Bryce, in his well-known work on the American Constitution, makes a similar comment :—

"A singular result," he says, "of the importance of Constitutional interpretation in the American Government is this, that the United States Legislature has been largely occupied in purely legal discussions. Legal issues are apt to dwarf and obscure the more substantially important issues of principle and policy, distracting from these latter the attention of the nation as well as the skill of Congressional debaters."

And Mr. Bryce cites Judge Hare, the author of one of the leading commentaries on the American constitution, as saying :—

"The English legislature is free to follow any course that will promote the welfare of the State, and the inquiry is not, 'Has Parliament power to pass the Act?' but, 'Is it consistent with principle, and such as circumstances demand?' These are the material points, and if the public mind is satisfied as to them, there is no further controversy. In the refined and subtle discussion which ensues right is too often lost sight of or treated as if it were synonymous with might. It is taken for granted that what the Constitution permits, it also approves, and that measures which are legal cannot be contrary to morals."

These criticisms are all made with reference to the Constitution of the United States. But it applies with equal force to our own Constitution. *Mutato nomine, de te fabula narratur.* The federal system has made two questions grow where only one grew before: and the new one, the constitutional question, is often, and tends more and more to become, the one that receives the most attention.

I have been so long in dwelling on the imperfections of the federal system that the only appropriate ending to this paper would seem to be the conclusion that the sooner it is got rid of the better. Nothing, however is further from the purpose of these rather discursive observations than such a conclusion. The demerits of which I have been speaking are relative; they exhibit the inferiority of the federal system to the unitary system of government. But the unitary system may be impossible of attainment, or may be unsuitable to the special conditions of any given epoch, or place. In that case, the alternative to Federation is not Unification, but Separation. And Federation, with all its weaknesses, is infinitely to be preferred to the separation and independence of States which are capable of some degree of union. The conclusion of the whole matter is that the federal system has certain inherent defects which render it inferior, as a governmental machine, to the unitary system. Therefore, where the unitary system is possible, it is to be preferred. Whether it is possible or desirable under the conditions existing in Australia to-day is a question which lies outside the scope of this paper. All I have endeavoured to do is to emphasise certain features of our existing system, which make a strong call for unremitting vigilance and public spirit on the part of every Australian citizen.

3.—THE COMPULSORY PRINCIPLE IN THE SETTLEMENT OF INDUSTRIAL DISPUTES.

By H. Y. BRADDON.

After experiences of the compulsory principle extending over about 16 years in New Zealand, 14 in Victoria, and 9 in New South Wales, it should now be possible to make some definite statement as to its utility as a solvent of industrial strife.

Human nature does not change rapidly. In point of fact there are many who would contend that, essentially, it does not change at all within so brief a span as, say, a hundred years. Manners change, but these are the veneer; the substance below retains its characteristics. Whether this be absolutely so need not here be discussed, for it will be generally admitted that human nature does not change sufficiently in, say, twenty years to count as a determining factor in altered industrial conditions.

If, then, the relations between employers and employed are distinctly less happy than they were twenty years ago, we must search for the reasons in directions other than a change of the human nature on either side. Neither employers nor employed enjoy a monopoly of virtue or sweet reasonableness, and neither side can accuse the other of being distinctly less moral than they were twenty years ago. Something artificial has intervened, and the point is to define that "something."

The compulsory arbitration Acts have been passed, and, as we will see presently, have had a material effect in altering industrial relations for the worse. The transition from freetrade New South Wales to the Federal Customs duties in 1901 has added very greatly in this State to the cost of living; and this, in turn, has, naturally enough, led to repeated demands for increased wages. Higher prices for many commodities are no doubt world-wide; but for this State the change has been sharper than for instance in Victoria, where heavy duties prevailed prior to Federation. Under the spread of education, mostly compulsory and free, many of the children of the manual worker are acquiring ideas which render them uneasy in the humbler *roles* of life, and the spread of socialistic doctrine is adding to the general feeling of discontent. The idea grows among the employees that their share of wealth produced in the industries is disproportionately small. The political successes of the Labour Party have encouraged more insistent demands from employees, and if these demands have been sometimes overdone, it is only because, as von Bunsen put it, "there is an inherent tendency in man to drive his pretensions to inordinate lengths."

On the other side stands the employer, aghast at the increasing momentum of the workers' claims. Frightened to make any concession, because experience shows that such will be construed as weakness, leading to still further demands, he resents the one-sided action of the statutes—in that *he* must obey, while the men, if their numbers are considerable, frequently decline to accept an award which they deem insufficiently advantageous. To the argument that the employer, if the conditions do not suit, can give up his business, it may be replied that, in the average industrial concern, such is not practicable. There are current contracts for raw materials and for output, andthe employers' capital is sunk in his buildings, plant an l stock. He cannot suddenly determine to close down, without facing ruin; whereas the men, in an under supplied labour market, can usually find employment elsewhere, or, at the worst, subsist on "strike pay" until the difference is settled. The reputable employer also feels some injustice in the consciousness that "compulsory" arbitration legislation was brought in mainly in order to check the "sweating" practices of a few employers—practices he always condemned, and never himself permitted. Ready to deal directly and reasonably with his own particular employees, he now finds it difficult to accommodate himself to negotiation with the foreign union secretary, whom, rightly or wrongly, he regards as a paid agitator.

I will now review, in outline only, the arbitration machinery of the Commonwealth, New South Wales, Victoria, and New Zealand, taking them, that is, not in the chronological order in which they respectively legislated, but rather in the order of importance of the areas concerned. Also, I propose to give briefly ths results as actually experienced, and the outlook.

The Commonwealth.—The Conciliation and Arbitration Act of 1904 applies only to industrial disputes affecting two or more States; that is to say, it gives the Federal Arbitration Court no jurisdiction as regards a dispute confined within the limits of any one State. Incidentally, it may be mentioned that, if the referenda pass in April next, the Federal Court will be able to deal with the settlement of any Australian dispute, and with the conditions of any employ. Its jurisdiction will extend to railway servants, agriculture, and domestic service.

The President must be a Judge of the High Court, and from his decision there is no appeal. Preference to unionists may be granted. No legal man to be employed at the hearings, except by consent of both parties. A recent High Court decision laid it down that the Federal Arbitration Court has no power to make a "common rule," and its awards can only apply therefore to the parties directly cited. This robs the Court awards of any general application, and therefore of any general value. The power to make a common rule should be vested in the High Court in respect of disputes affecting two or more States; otherwise industries carried on in several of the States might tend, in cases where transition was easy, to gravitate to the one State where wages were lowest and hours longest.

To date there have been six Federal awards, three agreements under the ægis of the Court, and one *ex parte* award. Out of the nine awards and agreements no less than four relate to inter-State shipping. The second case heard was that of the shearers, and the award by Judge O'Connor was so extremely and unexpectedly favourable to the employees that other employee unions have been encouraged to seek Federal rather than State adjudication. To effect this they had to extend the area of the dispute into two or more States, with the consequence of some manufacturing of technical disputes. The High Court, however, last year made a pronouncement which precludes the purely artificial cases.

The immediate point only turned upon such a dispute as affected two or more States, and was therefore susceptible of Federal adjudication; but incidentally the Court defined an "industrial dispute," and the following quotation should therefore be of interest:—

"The term industrial dispute connotes a real and substantial difference having some element of persistency, and likely, if not adjusted, to endanger the industrial peace of the community. . . . Such a dispute is not created by a mere formal demand and formal refusal, without more."

(Note.—A mere claim, having for its real object the transfer of the hearing from the State to the Federal jurisdiction, cannot lead to a genuine industrial dispute.)

"The dispute must be single, in the sense that there must be a substantial community of interest amongst the demandants and amongst those who refuse the demand. . . . . There must be a substantial identity of subject matter. . . . The difference in one State may be as to hours of labour, in the other as to terms of remuneration in the same industry. In this case there would not be a 'single' dispute. . . . The varying conditions of climate and other physical conditions found in the Commonwealth may make a demand couched in particular language in respect of one State quite different in its essence from a demand couched in the same words in respect of another. . . . There must be real community of action on the part of the demandants, and some community of action on the part of parties on whom the demand is made. . . . If it is found that large bodies of men in two or more States are in fact acting with one accord, then, if the other elements of an industrial dispute are present, an occasion arises for the exercise of the Federal power in question. . . . The dispute must be actually existing and actually extending beyond the limits of one State before such an occasion can arise. Mere mischief makers cannot, therefore, by the expenditure of a few shillings in paper, ink, and postage stamps, create such an occasion."

If the April referenda pass, the men will no longer need to create artificial disputes in order to secure a Federal Court hearing.

So far, the decisions, recorded during a period of increasing prosperity, have been in favour of the employee, in the sense of increased wages. The question therefore arises whether the Act has under the circumstances been really tested. Probably not. Experience in other directions leads to the inevitable conclusion that the penal provisions of the Act will not deter men from striking—as, for instance, the shearers—if an award should prove adverse to their claims. No Act or penalty will hold any considerable number of employees to their Court-defined task—if they quarrel with the terms. The authorities cannot incarcerate them all; nor indeed is it really desirable they should attempt to do so. As long as the authorities preserve law and order, and see to it that, if other men can be found who are willing to work at the prescribed conditions, such should not be molested ; that is all the community can reasonably ask.

New South Wales.—The earlier "Conciliation" Acts of 1892 and 1899 served little other purpose than to prove the complete futility of the purely voluntary principle. The machinery was rarely used, and proved quite inefficacious in the prevention of strikes.

In 1901 this State had the opportunity of choosing between the Arbitration Court methods of New Zealand (1894) and the Wages Board system of Victoria (1896). The New Zealand experience up to that point had been fairly successful in preventing strikes, chiefly because an era of increasing prosperity was in progress, and awards were as a rule favourable to the men. Unfortunately, Mr. B. R. Wise chose the New Zealand model, and proclaimed far and wide the abolition of strikes in New South Wales as the necessary outcome of his Act. Rarely have predictions been more completely falsified by the event.

Under the N.S.W. Arbitration Act of December, 1901, the Court President was to be a Supreme Court Judge, assisted by two lay members—one representing all employers, the other all employees. These three non-experts were to hear all the cases, affecting a multitude of trades, some highly technical and intricate, and they were to determine the conditions, hours, wages, apprentices, lower scales of pay for slow and infirm workers, and the rest. Breaches were enforceable by fine and, if necessary, imprisonment. Preference to unionists, as between unionists and non-unionists offering together, might be granted, "other things being equal." Also, the Court had power to make a common rule.

In practice the Act broke down hopelessly. The one non-expert Court was unable to keep up with the pressure of cases waiting adjudication. It laboured at its accumulating duties with the futile doggedness of a child trying to push the advancing tide out of its sand castle on the beach. The employer obeyed the awards, and had no choice, because his assets were attachable. Not so the men wherever an adverse decision affected considerable numbers. They "struck" if it suited them, and snapped their fingers at the law. In the Teralba strike the Attorney-General admitted the men had "made a laughing-stock of the Act." As a measure designed for the satisfactory settlement of disputes it was a peculiarly complete failure. Delays were interminable and the hearings costly. The presentation of each side's "case" by legal men, in the form of addresses and of evidence extracted from witnesses on oath (often exaggerated in order to impress the non-expert Court), not only tended to lengthen the proceedings, but also engendered a needless amount of bitterness between the parties. The Act created rather than settled industrial disputes, for the men in many cases invoked the Court on the chance of what they might get, rather than to seek redress of legitimate grievances. There were no doubt many perfectly legitimate claims from the men, but these would in all probability have been more easily and satisfactorily settled by the Wages Board method.

Before the Arbitration Act of 1901 expired—(it was to run to 1909)—Mr. Wade passed the Industrial Disputes Act of 1908, a measure based largely upon the Victorian Wages Board. For a time the two Acts had concurrent existence, but shortly afterwards the Arbitration Act expired, leaving the Wages Board in possession of the industrial field.

The Act of 1908 provides for an Industrial *Court*, to adjudicate on appeals, on applications for the constitution of Boards, and the like—such Court being presided over by a Supreme or District Court Judge. The *Boards* representing the various trades consist of an elected chairman, usually quite disinterested, with not less than two or more than four other members—half representing the employers and half the employees. All but the chairman must be men who have been, or still are, engaged in the particular trade concerned. Awards are enforceable by fine and, if necessary, imprisonment. Appeals to the Industrial Court are only allowed where the chairman is not a Judge. The Boards may grant preference to unionists (other things being equal), and can make a common rule.

The practical distinction between these Boards and the older Arbitration Court may be briefly summarised as follows : A Board for each trade, friendly discussion by experts directly interested, expert witnesses on oath rarely required, rapid and inexpensive settlement by the parties themselves. As against : One non-expert Court attempting to deal with all trades, hostile hearings conducted by legal men, with " expert " witnesses on oath representing each side, delayed and costly settlement by external authority.

In practice the difference between a decision arrived at by the parties themselves and one superimposed by a Court is far greater than might have been expected. The Board decisions appear to command the respect of the parties ; the Court decisions always leave one side sore, and sometimes both. It is all the difference between a friendly adjustment of some grievance with a neighbour across the mutual fence, and a settlement of the same trifle in a court of law.

The following has been the actual experience to date (December, 1910) under the Act of 1908 :—

Boards appointed to date	165
Unions now registered under the Act ..	112
Original Board determinations	119
Variations of old awards	77
Awards re-enacting awards of Arbitration Court	20
Largest number of Boards sitting at one time	28

Twenty-eight disputes in course of settlement at the same time, as against the one Court wearily attempting the impossible, with congestion hopelessly clogging its efforts.

While the Board decisions have been generally well accepted, these can not yet be said to constitute a real test. Times have on the whole been good, and the awards have as a rule been favourable to the employees. No machinery of this kind can be finally classed as efficient until it stands the strain of depressed times and of awards adverse to the employees' claims. It can, however, be confidently said that the Act has proved itself an immense improvement upon the Arbitration Act of 1901.

It would be idle to affirm that relations between masters and men are in any degree happy. The 1901 Act sowed much dissension, and the full harvest has not yet been reaped. The men on the whole (there are some exceptions) are not as industrially efficient at the higher rates of pay current to-day as they were 15 years ago. The old direct relations with the reputable employer are gone; and to-day the men more readily obey the hints of the union secretary than the behests of the employer. To some extent this may be due to the gradual displacement of the small individual employer by the joint stock company; but this only applies in comparatively small degree. Labour is not as plentiful as it used to be, yet the unions discourage immigration and the apprentice. The unions have as a rule no test of efficiency in connection with membership, and they object to any grading of unionists according to skill and merit. The really skilled worker gets no encouragement from the union, and his employer dare not specially recognise him. Therefore all employees tend to sink to one level of pay and regulated output.

On the other hand the employer is harassed by the incumbency to obey a dozen or more awards in his one industry, each bristling with instructions upon many minor points, and sometimes one award overlapping another. The "handy man" is doomed to extinction, for a master dare not ask an employee to leave his ordinary work for an hour in order to paint a door, or mend woodwork, or execute any other trifling maintenance job, without risking the breach of some award which insists upon specialists for every type of work, however minute.

Before passing on to the Victorian system it may be well to say a word in explanation of the Amendment Act of December, 1909—more widely known amongst the Labour party as "Wade's Coercion Act." It provides 12 months' imprisonment for *instigating* a strike or lockout. It renders illegal any meetings to those ends, also meetings for *continuing* a strike or lockout; and it empowers the police to forcibly enter premises where they have reason to believe such meetings are in progress. All this in connection with public necessities, such as coal or water, or the transport services. Passed at the time of the recent disastrous Newcastle coal strike, precipitated by the men without much warrant in point of real grievance, the Act was probably justified by the surroundings—though this is a statement the Labour representative in Parliament would indignantly deny.

Victoria.—The crisis of 1893 left behind it an aftermath of industrial depression, which, in turn, led to a considerable amount of "sweating" by the less humane employers. To check this, six Wages Boards were appointed in 1896 for those industries where sweating had been most prevalent, and additional Boards to the number of 21 were appointed in 1900. Then inter-State freedom of trade, set up by the Federation, in October, 1901, backed by a number of good seasons, greatly improved trade in all its ramifications. Victoria was in the depths in 1893, but the period since then has been one of almost unbroken ascent.

The Victorian Wages Board system is based upon the idea of settlement by the parties, rather than by external authority. The chairman has a casting vote, and the discussion is by experts in the particular business concerned. Witnesses on oath can be summoned, but this is rarely necessary. In effect the decision on any given point lies in the hands of the chairman; but it is, to say the least, remarkable how often such points are settled without necessitating resort to his casting vote. Appeals lie to an Industrial Court, presided over by a Supreme Court Judge, whose decision is final, but the Court is rarely invoked. There are statutory penalties for breaches of awards, and there is no provision for preference to Unionists.

To-day there are 88 Boards. With the exception of the bakers' strike, in 1907, there has been no strike in a trade for which a determination of a special Board was in operation. Trouble has occurred in one or two cases which were taken to the Industrial Court of Appeal. There is nothing to compel employees to work at the rates fixed; but, with the exception quoted (the bakers), there has been no refusal so to work.

Generally it is conceded that the Act has greatly improved the conditions of the employee, and strikes have been so far conspicuous by their absence.

On the whole it would be premature to affirm that the Victorian Wages Board principle has completely justified itself, in the sense of abolishing strikes, for it has not yet stood the test of declining prosperity and awards adverse to the men. Probably, as elsewhere, it would, under those circumstances, break down. Meantime there is no doubt the mutually made Board award receives a far wider acceptance by the men than was the case, for instance, with the Court award of New South Wales. Possibly industrial heat is not as easily generated in Victoria as in New South Wales, for in New South Wales are two centres—Newcastle and Broken Hill—where the employees are in such preponderating numbers that local public opinion is practically unleavened by any conservative or employer point of view. However, as a solvent to date of industrial differences, it can be safely said the Board is greatly superior to the Court.

New Zealand.—The Act of 1894 provides a preliminary Conciliation Court, somewhat on the Wages Board principle as to personnel, backed up by the Arbitration Court. There seems, however, to be some fatal canker in any Conciliation Court. For practical purposes that of New Zealand has been a failure, as its recommendations have been rarely adopted. These findings and recommendations, unbacked by penalties, received about as much attention as is given to the unsought advice of candid friends. As Addison sagely put it: "There is nothing which we receive with so much reluctance as advice."

The Arbitration Court, the substantial Court, of decision, has the usual features. It can make common rules for industrial districts, and it often grants preference to unionists, provided the relative unions are open to all who wish to enter. Also there are penal provisions for non-acceptance of awards.

The earlier experience of the Court was successful, in so far as the mere absence of strikes was concerned. The Dominion was enjoying an era of continuous expansion, and the awards were almost invariably in favour of the men. On the other hand the Court's work was marred by the inevitable features of delay and congestion. Meantime relations between employers and employees grew steadily worse. The Court, as in New South Wales, had the effect in many cases of creating disputes, and the machinery of the Act gave ample scope for the activity of the agitator. Premier Seddon, who could not be accused of any special leaning towards the employers, said in 1901 that "the unions were riding the Act to death—industry was hampered, and employers kept in perpetual turmoil. People were getting sick of the Act."

The first shock, from the point of view of those who hoped that the Act would at any rate prevent industrial stoppages, came with the slaughtermen's strike, when the penal provisions proved unable to clear the trouble. The dispute was finally settled *by conference outside the Court!* Since then some awards have not been as favourable as the men expected, and the Act is said to be breaking down hopelessly.

Summarising results not already mentioned:

(1) It was too easy for the men to bring about a legal dispute. They were encouraged to invoke the Court on the off chance of a favourable decision, rather than to seek rectification of genuine grievances.

(2) It substituted a hard, mechanical relationship, dictated by a Court, for the older and pleasanter direct relationship. In a few cases, where the direct relations still exist, all is pleasant as before.

(3) It has not made for better work or fostered trade. It has greatly increased the cost of production.

(4) The wage increases have been mainly for the average or poor workers; there is little encouragement for the skilled hand to rise above the average level.

The outlook is distinctly gloomy, and on the industrial horizon of the Dominion looms a cloud large as a man's hand. It looks as if the period of expansion is ended, and it is said the industries cannot stand added burdens. Meantime the unions, led by socialistic agitators, continue to insistently make demands. Nothing is more likely in the early future than an open defiance of the Act and a general resort to strikes. Already many unions are cancelling their registrations under the Act—in itself an ominous sign. On their side the employers will almost welcome an upheaval, in the hope that some unknown good may outcome. They are tired of the restrictive conditions, the multiplied awards, the reduced output per man, and the continuous surveillance by Government inspectors and union secretaries. Both sides seem to be girding for a fight on a large scale.

General.—It is certain that in Australia the Arbitration Acts have resulted in repressing "sweating," and in materially bettering conditions for the employees. It is to say the least unfortunate that the Acts have also tended to embitter relations between employers and employees. As a means for preventing strikes, Wages Boards are greatly preferable to the Arbitration Court ; but not even the Wages Boards are likely to be of much use, in that particular direction, in a period of declining prosperity and of awards averse to the men. At such a time any system of award, backed by penal provisions, is likely to be one-sided ; to compel the employer, but to be flouted by the employee in any industry involving large numbers.

The Board or Court should have value for the men, in the sense of a safety valve — or a referee ; something better than the blind, unwieldy, uncertain method of the strike. But it is not right that these tribunals should be used by the men when decisions are favourable, and defied when such do not come up to expectation.

For the employer the award has a certain value, because he knows that, during its currency, his competitors have to observe like conditions. The fair-minded employer would not demur to reasonable wage increases, commensurate for instance with the higher cost of living, especially in those cases where he is able to pass on the cost to the public in his sale prices. It is the dozen or so awards, with multiplied and detailed regulations, the constant pin-pricks and harassments, which tire and discourage him. It is not desirable for the community that the employer should be disheartened, for that means frightening away capital, and without capital the very sources of wealth run dry.

The awkward feature about the present position is the attitude of the unions. In order to preserve the spirit of unionism they discourage the preferment of the individual worker, and they desire that employees should negotiate through the union rather than direct with the masters. While coal-miners, shearers, type-setters, and some others are satisfied with the piece-work basis, in other directions unionism works hard to set it aside, probably because of the latent fear that it may lead to pace-setting. Although both the primary and secondary industries are at this moment very short of men, the unions are against immigration of labour, skilled or unskilled. They discourage any system of profit-sharing, as likely to divert the sympathies of the men from the unions to the concerns in which they have a monetary interest.

Any reversion to the older basis of freetrade in labour is unlikely. The unions are here, many of them created under the Arbitration Acts, and they are here to stay with their collective bargaining. To-day the unions have political power behind them, but even if they had not it is doubtful whether the old basis could be restored. In an over-supplied labour market a proportion of the masters would be certain to resume something in the nature of "sweating"—taking advantage of the men's necessity. In an under-supplied labour market a proportion of the men are bound to press their claims unreasonably far. The situation to-day is one of under-supply. The unions know this, and while they retain political power they are unlikely to allow anything to greatly change matters.

The old basis meant the strike as the eventual Court of Appeal, and the community is likely to suffer several more experiments in the hope of some better mode of settlement than the strike as the only alternative to the private and voluntary agreement. The strike is like a frenzied Asiatic running amok, he may hit an enemy, but is just as likely to injure a friend. It is impossible to confine the area of a strike to the particular employers sought to be coerced. So inter-dependent is commerce that a dozen other sections of the community, not interested in the dispute, become involved in its economic losses.

In the existing situation of affairs it is difficult to see the solution. The unions discourage profit sharing in any form, as, for instance, in the Furness case not long ago in England ; otherwise something might be done in that direction. The handing of a percentage of profits to employees, as has been done here, I believe in one or two retail establishments, is one method. The acquirement by the men of an actual interest, say in the form of shares, with representatives on the managing body, is probably the sounder method.

An experiment of this kind was tried a few years ago at one of the Newcastle collieries. Contributing shares were issued to the miners, and were gradually paid up by percentage deductions from their earnings. After a time the men collectively held a very material interest in the mine, and, by invitation of the proprietors, two of their number sat on the board. Relations between the management and the men were satisfactory. Negotiations were conducted through these two representatives, in whom the men had implicit confidence, and any possible troubles were thus averted. The system successfully stood the test of two district strikes, the men in this particular mine declining to join the movement.

Eventually the shares became fully paid up, and the men got their scrip. This proved to have been the initial error. Some provision should have been made to do away with the issue of such easily negotiable instruments. In a comparatively short time some 60 to 70 per cent. of the men's shares were sold or pledged—mostly to the publicans. To-day very few remain in the men's hands. The system broke down, the management retired the miners' representatives from the board, and the men joined in the next strike.

There would be hope if something could be done to amend the attitude of unionists in one or two directions. If, for instance, the rapid worker were encouraged, and all workers were taught to do their best. If the restrained output system were abolished, as a thing discreditable to the men and injurious to the community. If the doctrine were generally accepted that any form of honest work, well done, is essentially noble. If happier relations with employers, on the basis of the board fixed wage, were sought as something desirable in itself, then a distinctly happier era would ensue. The worker under the existing Acts need not fear, as concerns wages, the "sweater" on one side, or the non-unionist on the other, for the boards fix the scale. Something should be done to satisfactorily regulate the apprentice question, so that a steady supply of trained recruits may pass into the labour ranks; while, on the other hand, provision should be made to prevent the undue employment of boy labour by the less scrupulous employer. The men should recognise that something is due to the employer who supplies the capital and the supervisory intelligence, and who incidentally bears the risk of the trading loss. Broadly, nowhere in the world is the employee better off at this moment than in Australia.

On his side the employer should be ready to consider any reasonable pleas put forward by the men, and he should be prepared to regard them more as co-workers than as cogs in an industrial wheel. He must be ready to admit that wages should enable the worker to secure some relaxation as well as the bare necessaries of life. Where practicable he should encourage the men to acquire, if they so desire, an interest in the business for which they toil. On this basis both sides would have a mutual stake in the success of the particular venture; instead of the condition of veiled hostility which exists to-day, accentuated at times by open hostility.

Profit sharing and arbitration are probably only phases, and the next step may be the "economic wage." Will it ever be practicable to arrange a sliding scale wage basis for the ever-shifting cost of necessaries? Will such a system make allowance for the varying capacities of the workers? Will a family of five remain the accepted standard; and, while the worker may be satisfied with the provision for bread, will he not, with his growing idea of the importance of labour in production, demand an ever increasing provision for the circus? And what beyond the "economic wage?"

Society awaits the genius who can suggest a feasible method for bringing about industrial peace. Meantime we can only say with Meredith: "Ah, what a dusty answer gets the soul when hot for certainties in this our life."

4.—NOTES ON THE INCREASED COST OF LIVING.

By A. DUCKWORTH.

THE increase in the cost of living is a world-wide feature, perhaps most noticeable at present in the United States. In Australia the increase in recent years has been estimated variously at from 10 to 25 per cent. In New Zealand the rise has been equally pronounced.

The increase in prices of food, clothing, buildings and rents probably arises, at least partly, perhaps mainly, from the largely increased production of gold in the world. After the discovery of gold in California and Australia the total output of gold was trebled, and the world's prices were disturbed thereby. At that time, however, the effect of the increased production was to neutralise largely what would otherwise have been a sudden and pronounced fall of prices owing to the great expansion of British industry upon the recent adoption of Freetrade. As regards the present condition of things, the obvious universal facts cannot be gainsaid: (1) that there is an advance in prices generally, and (2) an increase in the yearly output of gold. Now, Australian main exports of raw materials are, of course, sold on the basis of world-market values; and, as gold is at once the measure for accounts, contracts and commerce, the importance of variations in the amount annually produced becomes evident, allowing, of course, for the increased consumption of the metal in arts and manufactures. Although "credit" as a commercial factor is of supreme importance, yet at its root lies the gold base on which the system rests, and Australian producers benefit by increased prices on a gold basis.

It has to be recognised at the outset that certain world factors are constantly in operation which should have the effect of reducing prices, *e.g.*, cheaper production of commodities by machinery and appliances, greater output—and quicker turnover of stocks—without increased labour cost, coupled with reduced costs of transit by land and sea, are factors which should have a permanent tendency to bring prices down. On the other hand, there are factors making for increased prices; the greater power of the producers (with increased banking facilities, and by trade unions) to so regulate the time at which the supply both of produce and labour is placed on the market as to secure favourable prices; the heavy cost of advertising and canvassing for orders for goods sold on a competitive basis; and the growth of city populations, as compared with primary producers, affecting the demand for farm products etc.

In Australia there are certain other special features. The "wages fund" at the disposal of the working classes has been largely augmented by the adoption of wages boards and levelling up of industrial conditions. Tariff adjustments have to some extent contributed to this end also. The prices of necessaries such as meat, agricultural products, etc., have risen owing to increased demand for such commodities ; whilst those of imported manufactures, as woven goods, etc., have not increased owing to greater facility for largely increasing the output. Our great gold exports have reacted on our trade, and necessitated paying increased gold prices for goods imported, whilst, on the other hand, Australia, as a whole, has earned increased prices for its wool, wheat, etc.

The increased prices of land in Australia have also affected the problem, and it is a question whether much land is not being speculatively pushed up to too high a price, since if any general over-production of food-stuffs, etc., now results, a glut may follow, and world prices would at least be temporarily depressed, and growers will have to face diminished returns from land for which high prices have been paid. Commodities may obviously temporarily rise in price in harmony with the enhanced amount of the gold production, or else fall from extraneous causes, such as a temporary collapse of credit, etc. Interest rates, too, and prices of stocks and securities are affected by the profits now being made in agriculture and commerce ; and even where business continues brisk, interest may not rise although the gold supply increases. The natural tendency would be for interest to rise in consequence, and for prices of first-class stocks to fall—as witness consols. Further, the natural improvement in the standard of living, of education, etc., has probably become a permanent feature of our day, and in view of this fact, coupled with the influence of rising gold prices due to the several factors indicated, some increase in fixed salaries as incomes of a section of the community seems reasonable. Of course, with increasing gold prices, debtors in general will find it easier to pay off their obligations over a term, as the margin of profit on their exported productions will increase, but to those with fixed incomes this does not carry compensation.

The fact that all Australasian Governments are requiring larger revenues is another factor in the increased stress of modern social conditions and environment. The needs of the State are greater than before, as in the case of individuals, and taxation reduces the purchasing power of the individual, which greater State expenditure on government does not recoup to him.

Should the increased production of gold continue at profitable prices as at present, it has been estimated that the annual production will reach £200,000,000 by 1920 ; and, if so, prices of commodities must go up as the exchange value of the money unit declines. There is, of course, the possibility of a cycle of bad seasons occurring in some parts of the world, or a period of wide over-speculation, the effects of which might be felt in the world's business and profits causing an increase in the unemployed above the normal standard, and a reduction of the purchasing power of the masses. In such circumstances the depression in trade resulting, which would tend to lower prices of luxuries first and of necessaries subsequently, would be aggravated at first by the high prices resulting from the depreciation of gold ; but such prices would tend to sharply and heavily fall owing to lack of effective demand. The depression would, however, be lessened in duration because of the gold production, as prices must eventually rise again in sympathy with the maintained increase of the gold supply. This contingency, however, does not affect the position as a whole, being of a transitory nature, acting as a temporary check to the general trend of events. There will, on the whole, probably be a demand for a considerable readjustment of fixed incomes, including therein the fixed wages of the working classes ; and, as political power is now so largely in the hands of the masses, an era of political and economic changes seems to be imminent, the probable effects of which cannot yet be forecasted.

It must not be overlooked in this connection that a very serious responsibility rests upon Australian public finance in connection with the early and rapid increment in the amounts maturing out of the total sums now outstanding as public debts. The Commonwealth Statistician, in his Official Year Book, has pointed out tha during the 15 years 1910-1924 no less than 120¾ millions of the existing State debts will mature ; or more than half the total public debts, whilst in the five years 1910-14, alone nearly £28,000,000 falls due. That the London money market will stand out for the best possible terms for conversion is evident. What makes the matter more serious, and may have the effect of causing interest to rise, apart from other considerations, is the fact that both the Commonwealth and States Governments, as far as indications go, are prepared to launch out extensively into new enterprises — the Commonwealth in connection with defence, continental railways, development of the Northern Territory and Papua, the building of the Federal Capital, etc., and the States Governments being desirous of making new railways and improving existing lines and equipment, etc. This at a time, too, when the Commonwealth Government is considering the desirableness of speedily taking over the management of the existing State public debts. Of course, if a spirited public loan policy be embarked upon for the purpose of constructing public works which will return 4½ per cent., whilst the money borrowed for the purpose is obtained at 3½ per cent., then financial safety is secured, but any increase in the rate of interest above 3½ per cent. must militate against the advantages which otherwise public borrowing would confer. It is significant that in New South Wales the rate of interest on local inscribed stock has recently been increased from 3½ per cent. to 3¾ per cent. If there be competition between the States as to the monetary accommodation desired, then the tendency to greater cost attending public borrowings must be accentuated. The situation would be aggravated by continuance of the depreciation of gold above referred to.

5.—THE IMPORTANCE OF NATIONALITY.

By Dr. HARVEY SUTTON, Education Department of Victoria.

At the present time much popular attention has been directed towards the Australian and his characteristics, and a good deal of vigorous language has been ventilated through the press, prophesying either ridiculous failure or superlative supremacy for the Australian and the Australian nation. The truth is that but little definite is known on the subject. The spirit of *laudatur temporis acti* condemns the present when judged against the "good old times" with its halo often the result of selective forgetfulness. The tendency has been to see only the faults of the new and the virtues of the old, so we get natives of the home-land suspecting or even condemning the progress of their own children under an environment acknowledged to be superior. Prejudice thus obscures the judgment of many, and it is only of recent years that in England the term colonial is ceasing to have an insinuation of inferiority.

The real difficulty is that we know little or nothing of the Australian because we have not paid attention to a simple method of classification. This is now being employed in Victoria in connection with the medical examination of State school children. The parents are asked to fill in a card for each child. Among the questions asked on this card is the nationality, *i.e.*, birthplace, not only of the child and his parents, but of the grandparents of the child. The information thus supplied is collected and recorded from the point of view of the degree of Australian nationality of the child. *E.g.*, each country is recorded by its initial letter—A. Australian, S. Scotland, E. England, etc. This is further condensed by awarding four marks for each parent and one mark for each grandparent.

$$\text{Thus} \qquad < \begin{array}{l} 4 < \begin{array}{l} 1 \\ \end{array} \\[1em] 4 < \begin{array}{l} 1 \\ 1 \end{array} \end{array}$$

Five main types are found.

$$E < \begin{array}{l} E < \begin{array}{l} E \\ E \end{array} \\ E < \begin{array}{l} E \\ E \end{array} \end{array} \quad E_{12} \qquad \text{Immigrant.}$$

$$A < \begin{array}{l} S < \begin{array}{l} S \\ S \end{array} \\ E < \begin{array}{l} E \\ E \end{array} \end{array} \quad A\ S_6\ E_6 \qquad \begin{array}{l}\text{Australian born.} \\ \text{Both parents immigrant.}\end{array}$$

$A < \begin{matrix} E < \begin{matrix} E \\ E \end{matrix} \\ A < \begin{matrix} S \\ S \end{matrix} \end{matrix}$	$A_4\ E_6\ S_2$	Australian born. One parent immigrant.
$A < \begin{matrix} A < \begin{matrix} S \\ S \end{matrix} \\ A < \begin{matrix} E \\ E \end{matrix} \end{matrix}$	$A_8\ S_2\ E_2$	Australian born. Of Australian-born parents.
$A < \begin{matrix} A < \begin{matrix} A \\ A \end{matrix} \\ A < \begin{matrix} A \\ A \end{matrix} \end{matrix}$	A_{12}	All grandparents Australian born.

It is worthy of note that these queries were in the great majority of cases answered satisfactorily by parents. Very few of the cards were not returned filled in, say less than 1 per cent., and as this includes a number of boarded-out children the total of refusals is a very small one.

From the first 1062 boys examined the following figures were obtained :—

		Percentages approx.		
Immigrant	13	1·2		
A	.. 102	10		Both parents immigrants.
A4	.. 213	20	24·3	
A5*	.. 25	2·3		
A.6*	.. 22	2		
A.8	.. 540	51	64·7	Both parents Australian born.
A.9*	.. 81	7·5		
A.10*	.. 42	4		
A.11*	.. 8	·7		
A.12	.. 16	1·5		

It will be seen that no less than two-thirds of our school-children are born in Australia of Australian-born parents, while only one in ten are the children born in Australia of parents born outside Australia or immigrants. This is probably a reversal of the conditions in our schools within only 10 to 15 years ago.

This table throws an important light on the controversy mentioned, as it shows that the majority of those whom we really can call wholly Australian—the children born in Australia of Australian-born parents—are at present in our schools, and have scarcely appeared in any number among the general population. If I am right in regarding them as the first fruits of the Australian nation, then all this talk about the Australian characteristics,

* At least one grandparent Australian born.

which can hardly be expected to have appeared to any pronounced degree till the second generation, may be regarded as so much beating in the air. At the same time it points the way to an important function of medical inspection in relation to the State. By means of careful measurements according to some uniform standard it should be possible to institute comparisons between these different types of children according to the degree of Australianship, so to speak, and so determine at the earliest possible moment what influence the environment of southern land and skies is having on our race. The responsibility of moulding and controlling the characters of that race falls on the shoulders of the present generation. This has recently been realised to be a matter of Federal importance. A white Australia is only practicable if the Northern Territory or tropical Australia can be successfully peopled by the white race. A party of University scientists is to visit the Northern Territory next winter, and Dr. Anton Breinl, Director of the Tropical Institute of Australasia, is already beginning investigations on the subject in North Queensland. What could be simpler, and at the same time more important in this direction, than to institute at once, following the above classification of Australianship, a systematic investigation of the child life of the various States—a veritable stocktaking. The British Anthropometric standards are available, so that uniformity can easily be obtained. Further, the various systems of medical inspection include in the examination measurements of the child which a very little arrangement in this way could make comparable. Recent investigations among New York aliens by Professor Boas, of Chicago, seem to show that the head of the child born in America is intermediate between the dolicho and brachycephalic types, no matter whether his parents are both dolichocephalic or both brachycephalic in type. The Australian chest is said to be altered in character to the measurements available for the British Isles, so that there is every possibility that measurements may demonstrate a new national type on the side of physical development.

Such work would, I believe, be of the greatest national importance.

Section G2

AGRICULTURE

ADDRESS BY THE PRESIDENT:

Professor WILLIAM ANGUS, B.Sc.,

Late Director of Agriculture, Adelaide.

THE RELATION OF SCIENCE AND THIS SECTION TO THE FURTHER DEVELOPMENT OF AUSTRALIAN AGRICULTURE.

INTRODUCTORY.—We have just been raised to the dignity of an independent Section, and by this action on the part of our fellow members it would seem that we have not been unmindful of our duties in the past. The great importance of the agricultural industry has now been recognised by this Association—an industry the success or failure of which affects, directly or indirectly, every individual in the Commonwealth. The condition of every phase of life and activity is dependent on that of the primary producer. Hence the justification for giving more prominence to this Section in the affairs of the Association. But, in addition to this, those members who moved in this matter had in their minds the important bearing that science is having on our Australian agriculture. It is in the nature of things that in a young country like ours, where the producer is labouring under new conditions, and where he has no long tradition of experience to rely upon, science should have a great field for work in the development of a national agriculture.

It is necessary, however, to bear in mind that we have undertaken increased responsibilities. We are now called upon to do a greater work, and to take an even more active part in bringing about a great development in the primary production of this fine country of ours. This is a grave responsibility. It is also a great opportunity to justify our right to take our stand alongside the other full-fledged sections of the Association. Moreover, the opportunity is a favourable one, in that we have been passing through a period of very great prosperity in Australia. The finances of the Commonwealth and States are buoyant ; public opinion is sympathetic towards the teaching of science, and the producer is looking towards this Association and other agencies of a similar kind for help and guidance. Political opinion, too, is also prepared to recognise the advantage to be derived from the application of science to production, and better provision is now being made in Government Departments for work bearing on the agricultural industry than has been done in the past. That being so, we must recognise our responsibilities. As expressed in the records of the Association, we are called upon—"to give a stronger impulse, a more sympathetic direction to scientific enquiry" in relation to the primary producer, and, secondly, "to obtain more general attention to the objects of science and the removal of any disadvantages of a public kind which may impede its progress." We are called upon not only to carry out our special duties as scientists, but we have to take the further duty upon us of guiding and directing public opinion just into those channels from which will come the greatest benefit to the industry. It therefore behoves us to see that everything is being done in order to worthily fulfil that position of trust to which we have been called.

To me has fallen the honour, which I most keenly appreciate, of presiding just at this important juncture in the history of our section, and I thought it might not be out of place in my address to you to refer briefly to the following :

1. The position of our agriculture during the last half century, with special reference to the part science has taken in its development.

2. Work urgently requiring to be done, and our relation to such.

3. The necessity for improved means being provided in the future for scientific work in relation to agriculture.

1. *The Growth of our Agriculture.*—The growth and extension of Australian production has been most rapid, and often under conditions anything but favourable. It is only, even in the oldest State, a little over a century since the very beginnings of the industry took place, and no real attempt was made to seriously tackle sympathetic production on a large scale until within the last sixty years. During that period, however, there has been an extraordinary increase in the areas under cereals and in the yields, and

also in the number of our live stock, as will be seen from the following table :—

TABLE OF PRODUCTION.—I.

	Area under Crop.	Total Yield.	Av. Yield.
WHEAT.—			
1860–1 ..	643,983 acres	10,245,469 bushels	15·7
1880–1 ..	3,054,305 ,,	23,356,749 ,,	7·6
1890–1 ..	3,228,631 ,,	27,118,259 ,,	8·4
1900–1 ..	5,666,614 ,,	48,353,402 ,,	8·5
1904–5 ..	6,269,778 ,,	54,535,582 ,,	8·7
1907–8 ..	5,383,911 ,,	44,655,673 ,,	8·29
1908–9 ..	5,262,474 ,,	62,590,996 ,,	11·89
*1909–10 ..	6,258,228 ,,	82,415,714 ,,	13·17

* Estimate far too high.

	Area under Crop.	Total Yield.	Av. Yield.
OATS.—			
1860–1 ..	125,962 acres	3,723,930 bushels	29·5
1907–8 ..	642,815 ,,	9,185,227 ,,	14·29
1908–9 ..	676,156 ,,	16,248,412 ,,	24·03
BARLEY.—			
1875 ..	61,920 ,,	1,244,369 ,,	20·09
1907–8 ..	131,099 ,,	1,991,652 ,,	15·11
1908–9 ..	140,247 ,,	2,874,204 ,,	20·49

TABLE II.—STOCK.

	Cattle.	Horses.	Sheep.	Pigs.
1860 ..	3,957,915	431,525	20,135,286	351,096
1880 ..	7,527,142	1,068,402	62,186,702	815,776
1894 ..	—	—	97,881,221	—
1895 ..	11,767,488	1,680,619	90,689,727	822,750
1907 ..	10,180,214	1,871,714	87,650,263	754,101
1908–9..	10,547,629	1,927,731	87,034,266	695,689

From these tables it is seen that it took 70 years to bring under wheat cultivation 643,983 acres. The next 20 years brought about a very great expansion—the area under this crop rising to 3,054,305 acres, working out at an average annual increase of 120,516 acres. During the next period of 20 years the area rises to 5,666,614 acres—the average annual increase working out at 130,615 acres, a better record even than that of the previous 20 years. It is noticeable, too, that this increase was greatest during the last 10 years of the century. In New South Wales the area under this cereal rose from 333,233 acres in 1890 to 1,530,609 acres in 1900—an extraordinary extension in this State's wheat area. In 1904-5 the Commonwealth reached its maximum area, when 6,269,778 acres were under this crop, giving a total yield of 54,535,582 bushels—an average yield of 8·7 bushels. The previous season, however, gave, I think, the record yield of 74,149,634 bushels from an area of 703,338 acres less, and giving an average of 13·32 bushels—the season reducing the average in each of the States, except Tasmania, and to greatest extent in New South Wales and Victoria in 1904-5.

From 1904-5 the area under wheat has gradually gone back until there were 1,007,304 acres less in the season 1908-9 than in that of 1904-5, but it would appear that during last season the area rose again to within a very little of the record year.

TABLE III.

Year.		Population.	Av. Yield of Wheat.	Produce of Wheat per 1000 population.
1860	..	1,145,585	15·7	8,948 bushels
1865	..	1,390,043	11·8	7,665 ,,
1870	..	1,647,756	10·8	7,337 ,,
1875	..	1,898,223	13·0	9,858 ,,
1880	..	2,231,531	7·6	10,489 ,,
1885	..	2,694,518	8·4	10,182 ,,
1890	..	3,151,355	8·4	8,606 ,,
1895	..	3,491,621	5·0	5,233 ,,
1900	..	3,765,339	8·5	12,842 ,,
1901	..	3,826,286	7·54	10,078 ,,
1902	..	3,883,079	2·40	3,162 ,,
1903	..	3,926,969	13·32	19,005 ,,
1904	..	3,984,390	8·70	13,793 ,,
1905	..	4,052,430	11·19	17,058 ,,
1906	..	4,119,481	11·06	16,180 ,,
1907	..	4,197,037	8·29	10,746 ,,
1908	..	4,275,306	11·89	14,784 ,,

Consider now for a moment the average yields during these 50 years. During the first 15 years we have a period of very high averages, followed by 22 years during which these are very much lower. The figures then improve considerably right up to date, but even now they are no better than they were 40-50 years ago. Doubtless bad seasons brought about this fall in the average to some considerable extent, but it is also quite certain that the large areas brought under crop affected the yield.

We mentioned above that between the years 1860 and 1880 the increase in area under crop was very large, larger than it has been during the last 20 years, and the average yields during that period were quite as good, if not better, than they have been within the last eight years. From that it is reasonable to infer that the development, so far as our wheat production is confirmed at least, has been more in the direction of extending our areas under crop than in any very marked increase in yield resulting from improved methods of agriculture.

The last column of this table is interesting as showing the relation our wheat yield is bearing to our population.

The other statistics call for no further comment than that they show from time to time the effects of bad seasons. Still, the record both in crops and stock constitutes a splendid gauge of what Australia is capable of doing under improved conditions of production.

This development is but in keeping with what is taking place in older countries, for the discoveries of the last century have practically revolutionised production. In no other period of history have events of such importance to agriculture taken place. In young as well as in older countries the application of Science and of scientific methods to the business of agriculture have brought about remarkable results.

In a young country like Australia naturally considerable time must elapse before a system of agriculture suitable to the peculiar conditions prevailing can be evolved. It is always the case, too, that the early stages of development draw largely from the experience of older countries, and this has been largely the case in Australia. At first the application of science to production was slow to be appreciated, from the fact that virigin soil was being handled. The farmer was getting such results from even his rough and ready treatment of the soil as to cause him to turn a deaf ear to the teachings and warnings of science ; but gradually his wheat soils worked out, his stock were attacked by disease, and returns were being reduced so considerably that he was compelled to change his attitude and to introduce more scientific methods into his system of agriculture. So far the work of he scientist has been more in the direction of demonstrating to the farmer the advantages of applying the results of investigations of older workers to his business of production and of introducing practices already in vogue in older countries than in dealing with the investigation of problems peculiar to Australian agriculture.

And first among the important innovations must be placed the use of fertilisers. No event in Australian agriculture has had such widespread effect as has the application of phosphates in cereal production. Together with its introduction came that of the seed and manure drill, and these mark a new era in the production of cereals in Australia. Their use has placed many a farmer whose outlook was hopeless ruin in a position of positive affluence. Land which was a quarter of a century ago worth £1 per acre is selling to-day at anything from £7 to £10 an acre, and its rise in value has largely been brought about by the use of superphosphates and the drill. Undoubtedly the scientist has been largely responsible for their use in Australia. To Professor Custance must be given the credit of demonstrating the need for phosphates in Australian soils and for pressing on the farmers their use and also that of the seed drill. Following him, Professor Lowrie did a very great deal to extend their use, and as the result of experiments, lectures, and publication of results throughout the various States their use has largely increased. From the results obtained from the application of fertilisers one would expect that their use would be almost universal. Such is not the case. In

South Australia, according to the latest statistics, 90 per cent. of the area under wheat is estimated to be manured. Western Australia comes next with 79 per cent., while Victoria has only 62 per cent. of the land under crop receiving manures. In the other States these figures are even lower, and this after their use for nearly a quarter of a century.

To this must be added the gradual adoption of a more rational system of soil treatment. The practice of fallowing has become more general, especially in those districts where the rotation is confined to production of cereals, followed by grazing. The expansion of this practice is bound to come about as farmers are realising the marked advantage to be derived from it. Then again, with the introduction of labour-saving machinery and implements, great advances have been made while stock-raising has been associated with cereal production with marked success, the result being the establishment of a thriving export trade in lambs. So in plant breeding, and in the treatment of diseases of stock, modern science has been playing an important part in the development of our Australian production; and I simply quote these as examples of the work with which the scientist has been associated during the last quarter of a century.

Naturally just here the attitude of the farmer towards scientific teaching calls for passing reference, as his attitude in this respect has an important bearing on the development of the industry. The farmer all the world over is conservative in his methods. This is even more the case in older countries, where his tradition has in this particular instance hindered him. In Australia the early farmer was not only conservative, he was not trained and educated as he is now. Moreover, as above mentioned, he was handling virgin soil—large areas of it—and the returns were for long satisfactory, considering the labour expended on it, and he could, when one part of his holding became worked out, go on to another. Hence his indifference to science, and even the experiences of other countries. As a rule, too, it must be admitted that many of those who were working in his interests had no practical knowledge of agriculture, and this was a distinct disadvantage in dealing with a man of this type, as they had very little to commend them to him or to bring them down to his level. It was too often a case of too much land and too little farming; but by tact and persistence teachers, experts and experimenters have carried their work right on to his farm and have demonstrated to him the fact that Science must go hand in hand with practice. Hence, within the last ten years the attitude of the farmer has materially changed. He has developed into what might be termed "the plastic condition," in which he is more easily affected by the reasonable teachings of modern science. He respects the application of science to his business and appreciates the work of the experimenter and the expert.

The farmer of to-day is in addition a better business man, and from this point of view he sees how much to his advantage these innovations have been, and hence his altered attitude towards science.

1. There has been a great development in our agriculture within the last half-century—more an expansion in the area than an improvement in our methods of cultivation.
2. Scientific teaching has been responsible for considerable improvement in all departments of production.
3. This teaching has been more in the application to our conditions of the experience of older countries than in active investigation work on problems affecting our peculiar conditions.
4. The attitude of the producer has changed considerably within the last quarter of a century, a better understanding existing between him and the scientist.

II. *Work Requiring to be Done.*—How this Section may help it on.—It would seem that we have come to a stage in the development of our agriculture at which much greater changes must be brought about, and in which the research worker is to be in evidence. Mr. A. D. Hall, of Rothamsted, has said :—" Agricultural science involves some of the most complex and difficult problems the world is ever likely to have to solve, and if it is to continue to be of benefit to the working farmer these investigations, so far as their actual conduct goes, must very quickly pass into regions where only the professional scientific man can hope to follow them."

With this statement we are in full agreement, and there is in Australian agriculture at the present time a great need for research work of the kind Hall refers to. The farmer and stockbreeder to-day are face to face with problems urgently requiring solution. They recognise that science can help them, and in many cases they are calling attention to the need for means to undertake their investigation. Some of these problems are causing a loss of thousands of pounds from year to year. In the investigation of several of them really good work has been done, but it has been left just at a stage in which it is of little practical use to anyone. The want of finality in much of this work has been due to a number of causes, some of which may be mentioned :—The want of investigators, trained men ; the multiplicity of occupation of those who are qualified to do the work ; the want of means and convenience to carry the work farther ; and the want of co-operation of effort amongst those who are working at a subject, and who, if they were working in conjunction, could bring about results that no single individual is capable of doing, however well qualified he may be. Let us now deal with a few of these.

1.—" Take-all." (*Ophiobolus graminis*, or the wheat stem-killing fungus). This disease of wheat is rapidly spreading in Australia, and especially in South Australia, where I have seen it practically ruin thousands of acres of wheat crop in a single season. The alarming thing about it is that it is spreading throughout the State, and is not confined entirely to the older or longer developed districts. I believe, too, that it is firmly established in the wheat areas of the other States, especially Victoria, and it is most desirable just at this stage to endeavour to do something to check the spread of this virulent wheat pest. Really good work has been done by Mr. McAlpine in definitely determining the cause of the disease. By careful investigation he has proved the presence of *Ophiobolus graminis* ; by exhaustive infection experiments he has shown that this is capable of causing the trouble ; but the work requires to be carried further, and it is with the intention of taking up the investigation just at the point where Mr. McAlpine stopped off that I mention the matter to this Association. It seems to me that much good would result if this Section were to take some active part in the investigation of this disease, which, if it exists in the other States as it does in South Australia, will cause great loss to the Commonwealth. I am also of opinion that the co-operation of several specialists will do more towards the solution of a matter of this kind than any one individual working at it can do. Doubtless the pathologist will be most in evidence, but I feel that the chemist will also be helpful, as well as the agriculturist. I mean by the latter, one who has considerable knowledge in working and handling soils. If a committee were formed, say, of the Government Pathologist of Victoria, the Government Micro-Biologist of New South Wales, the Government Agricultural Chemists of Sydney and Adelaide, together with someone with a knowledge of South Australian soils and of the districts in which the disease is most active, I am satisfied some real practical work could be done to check this fast-spreading pest, and such action would not only bring credit to this Section of the Association, but would also be of real benefit to Australian agriculture.

2. *"Bitter Pit" in Apples.*—This disease, not yet investigated and causing great loss to the fruit industry, is now requiring immediate attention. There has been some talk recently of this being undertaken, and what would appear to have been most needed was initiative, which could well have come from this Association. It would not be out of place even now to try and make some start with it by forming a committee of the pathologists and fruit experts of the States who are members of this Association to report to it and suggest a scheme of work. If the investigation is ultimately taken up in another quarter, certainly no harm could come from our dealing with it, and our action may help on that larger investigation which is at present under consideration.

3. *Dry Farming.*—In Australia there is a vast tract of splendid country just outside what we call, according to our present light—"the area of profitable wheat production." This line is of course extending as our farming practice improves, and to-day hundreds of thousands, indeed millions, of acres of land are being thrown open

and taken up in semi-arid areas. The Mallee country in Victoria and South Australia, opened up for wheat-growing, comes under this heading—areas with a rainfall of 10 to 16 inches. A good deal too, of the south-western and western tracts of country in New South Wales and the north and western districts of Western Australia are classified under what we might call " low rainfall areas "—lands that are gradually being opened up for wheat-growing. While this expansion of our wheat areas has been taking place, attention has been directed to the work being done in America. There this question has been taken up with great enthusiasm, not only by the scientists, but also by the intelligent practical farmer, and most valuable work is being reported by these every year at their Great Dry-Farming Congress. Now, if the Australian farmer can grow wheat profitably in, say another 2,000,000 acres of land in each of the four wheat-growing States, then this is a matter which ought to be taken up without delay, and with some of the spirit and in the business-like manner that practical men and scientists are doing in America. If, on the other hand, even with special methods of soil treatment and specially selected strains of wheat, this class of country is unsafe and unsuitable for profitable wheat production, then it is as clearly necessary to obtain definite and reliable information concerning it in order that men may be prevented from taking up for wheat-growing a class of country unsuitable for such. There cannot be a doubt as to the fact that a large number of people are taking up this country, believing that by special methods of soil treatment it can be worked profitably. Although this subject has been very prominently brought under public notice by Senator McColl and by the able report of the Surveyor-General of South Australia, yet very little work of a useful nature has been done here. What has been undertaken in South Australia would point to the fact that by the adoption of special means of conserving soil moisture, largely increased crops can be obtained. But what is really needed is the careful extension of these experiments throughout the whole of the dry areas of Australia and the putting of the trial work in the hands of trained men who are qualified to correctly gather and record full information as to the condition of the soils, the nature of the treatment given, the effect of such on the moisture content of the soil, the rainfall and especially its incidence, the nature of the sub-soils, the varieties best suited to such areas, the quantities of manures that can be safely and economically used, and so on. The South Australian Government has set aside an area of 4000 acres of scrub country in the Mallee district, with an average rainfall of 11 to 12 inches, for the trial of this system of soil treatment, and part of this has been under crop for two seas ns. The land had first to be made fit for carrying on work of this kind, and there is now somewhere about 1000 acres of it c'eared. I feel sure the Government and the Department of Agriculture in that State would willingly allow of this being used as a centre from which to carry on further investigation. If we could arrange for members of the section in Western Australia, Victoria, and New

South Wales co-operating with South Australia in this matter and working on lines arranged by the Section, we could then have something reliable, truly Australian and bearing the hall-mark of this Association on the question of dry-farming. A chemist, a geologist, and the experimentalists of each State would make a committee eminently qualified to deal with this subject.

4. *Soil Surveys.*—America has instituted a system of soil surveys, the envy of every progressive agricultural community. It is generally admitted that a proper knowledge of the condition of the soil is the first essential to successful production. The greatest investigations of the past century were in connection with soils—the chemical, then the physical, and lastly the biological conditions receiving in their turn special attention. America has gone far ahead of other countries in investigating the properties of the soils of her agricultural areas and in mapping them out so as to show those which are specially adapted to the growth of certain crops. They have dealt largely with the chemical, the physical and the geological condition of the soils. In other countries this work is also being undertaken, though less extensively, and certainly less thoroughly, and modifications of the American scheme have been adopted, just to suit the special requirement of each particular case. That work of this kind should be of value to the Australian producer must be evident to all, and what is most needed before anything is undertaken is an agreement among the States as to a definite system, so that from the very commencement they may be working on similar lines in this particular branch of work. I should like to see some action taken by our section in the direction of appointing a committee of members to draw up a scheme upon which a soil survey of our agricultural areas could be undertaken.

In the short time at my disposal I cannot do more than just mention some few of the other matters relating to agriculture, and requiring attention, viz., the work of wheat improvement by selection and cross-breeding. This work might well be done jointly by the States, not, as at present, independently, where considerable overlapping is going on. Investigation of such diseases as "dry bible"—further work on red rust in wheat, and the raising of varieties immune to its attack. The question of strength in flour, and the fixing of a uniform method of determining the same; the process of nitrification under Australian conditions; the arrangement of a more uniform system of experimental work, and the comparison and publication of results; investigation into the quality and composition of our surface and artesian waters, as regards their suitability or otherwise for irrigation. These and many others await the attention of the scientist. From this list it must be evident that there is a very large field of work bearing on our agricultural industry which sooner or later must be undertaken, and with results that can only be largely for the ultimate benefit of our production.

My justification for bringing these matters so forcibly under your notice, and of making those suggestions with regard to them is, first, because I feel that it comes within the scope of our work to take action with regard to them, and, secondly, on account of the urgency of the case. The solution of several of these has been delayed far too long. For example, "Take-All" was one of the subjects reported on by a commission on diseases in cereals as far back as 1868. Since then the disease has been thoroughly establishing itself in our Australian soils, while nothing has been done in regard to it, but to trace the cause as being due to a specific fungus. It would almost appear as if science could do nothing in this matter. That is far from the case. No real attempt has been made. What we want is not a Royal Commission to report on it, but a body of trained workers to tackle it on systematic lines. It is only in this way that satisfactory results can be obtained. Moreover, such action has been taken by organisations similar to ours. I need only mention the case of one or two such.

The Agricultural Education Association of Great Britain.—This Association has a series of committees appointed to organise and carry on certain investigations, the results of which are ultimately reported to the Association. They have, for instance, a committee which organises schemes of experimental work to be carried out at different centres throughout the length and breadth of Great Britain, and the results of these are collected, tabulated and reported upon to the associations and ultimately published. The members do not confine themselves to the reading of papers on various topics, and their discussion; they undertake work of a practical kind, and co-operate with one another in this work. Whatever experimental work they undertake, and indeed the same applies to any investigation work carried out in this way, is conducted on a uniform basis under supervision of the special committee in charge of it, and the results, as a matter of course, carry very considerable weight. The members consist of University professors, teachers of agriculture, science lecturers, experimenters, chemists, biologists, practical agriculturists, and others interested in the advancement of British agriculture, and undoubtedly they are doing useful work. So, too, from America, let me instance the case of the "Breeders' Association." From their report their special object is as follows: "To study the laws of breeding and to promote the improvement of plants and animals by the development of expert methods of breeding." And how do they proceed to do this? They appoint committees to deal with special phases of the subject. General problems were assigned to 30 of these; 15 undertook the study of special problems relating directly to animals, while 15 others dealt with problems of plant breeding. The membership of these committees included many of the foremost investigators of the country. Of course, from time to time, I am aware that the various sections of this Association recommend the appointment of special committees, but wish to quote examples of associations outside the one with which we are connected. If by our action we do nothing more than draw more prominent attention to the need for work of this kind being done, good will come of it.

I have drawn your attention to the need for action in regard to these matters, not in any spirit of carping criticism, but in order that an endeavour may be made to put things on a proper basis. The opportunity seems a good one for this Association, and more particularly this Section, to more intimately associate itself with questions of practical importance to the agricultural industry, and I have no doubt but that the Section will rise to the level of the opportunities offered.

The Future.—Any consideration of the future, and any action taken in regard to it, must have the following points in view:—

1. The work now requiring doing, and the means provided.
2. The necessity for science to come more intimately in touch with the practical problems of production.
3. The necessity for bringing the producer and the scientist as close to one another as possible.
4. The direction of future development—more intense agriculture—the production of the best in everything.

That we must move in the direction of developing a more intense form of production must be evident—the very best of everything, and plenty of it. This means that agriculture has to be run upon much more scientific lines, and that consequently the farmer must be even more of a trained producer than in the past. This means that there must be a re-organisation—a change in the relation of the scientist and the farmer; they must become more and more co-workers; be much more intimately in touch each with the other, and have many more interests in common. The scientist must come to know more of the producer and his production, while the latter requires to know more of the nature and meaning of the laboratory and the experimental field. Hence it would appear that there must be instituted some means by which this can take place—some half-way meeting place—and I can conceive of no institution better suited to these ends than the experimental farm, properly equipped and rightly conducted. This is the right place at which to carry out the investigation of those problems urgently requiring solution. There, too, the scientist and the producer can meet halfway and bring about that mutual respect which is so essential to a proper understanding of each other. There the farmer can learn more of the scientist's real work and aims, and there, too, the investigator can study more closely the difficulties connected with production, and by controlling these institutions he can not only use them for his actual investigations, but for demonstrating their advantage to the farmer by actual trial. Hence, just briefly:—

And first, as to what an Experimental Farm should be. It has two functions—investigation and demonstration. These, so far as our Australian experimental farms are concerned, have to a great extent been lost sight of. They have too often been made revenue-producing institutions. This is altogether outside the scope of experimental work, and the sooner that is realised and put right the better. To carry out experiments and research with the object of increasing or adding to our knowledge of a subject, to put this into practice and to demonstrate to the producer the benefits to be derived from such, constitute the lines upon which our experimental farms and stations should be run..

Further, in order that these institutions may carry on such work it is necessary that they should be controlled by trained men ; men should be in charge of them who are qualified to undertake work of this kind ; men who have been trained to it, and can be relied upon to do solid work and to see that the money provided to carry on such work is properly spent. Then there is needed the means for properly equipping them for work. Laboratories, workrooms, special implements and special conveniences in building all cost money, and until such is provided independently of what the revenue is to be in £ s. d., time and money spent on them are but wasted.

I would still further draw attention to another matter in respect to the part to be played by these farms, and that is in the need for organisation and co-operation in the work to be carried out. It is not asking too much of them to require that the money provided by the ratepayer should be spent to the very best advantage, hence the necessity for preventing overlapping of work. It is, of course, true that in each of the States there will be work to be done having reference to that particular State, and I can also see that in many instances it would be an advantage to have certain classes of investigation work duplicated or checked, and even these call for organisation and co-operation. I am satisfied, however, that unless the work is organised at these different stations there will be a deal of unnecessary duplication and working on different lines in the same sections by different investigators, provided some control is not exercised to prevent it. This overlapping and want of co-operation is evident in the work of the various State Departments at the present day. Now, one way of overcoming these difficulties appears to me to be in the establishment of a Central Research Station on the lines of that great institution at Rothamsted ; that some moneyed Australian should come forward and as richly endow an institution of this kind as did the late Sir John Lawes is much to be desired ; and we have wealthy men, even among the primary producers. Failing that, the establishment of a Federal Research Station, properly equipped and staffed by the very best men the Commonwealth can provide, would meet the case. From such an institution would emanate the organisation of all research work, and all results would be referred to it for classification, comparison and publication. Here, research of a general nature—that is, which applies to the whole of the Commonwealth—would be done by one staff of the best investigators, instead of having three or four establishments working at this, and surely this is economy. For other reasons, which do not, however, come within the scope of my paper, this scheme I am outlining is a most desirable one. Such a scheme of organised work through the medium of the experimental stations throughout the Commonwealth is bound to be a factor in our future developments, and although it may not come all at once, the gradual accomplishment of a scheme of this nature is assured.

These institutions are as essential to the successful development of the agriculture of a young country like ours as they are in older countries—indeed, more so : the very youth of our country and its want of experience make them a necessity. The possibilities of our Australian agriculture justify their establishment on a satisfactory basis, and I have not the slightest doubt but that within the next ten years we shall see them carrying on work making for the future good of the Commonwealth.

PAPERS READ IN SECTION G2

1.—AN HISTORICAL SKETCH OF WILLIAM FARRER'S WORK IN CONNECTION WITH HIS IMPROVEMENTS IN WHEATS FOR AUSTRALIAN CONDITIONS.

By W. S. CAMPBELL, late Director of Agriculture, New South Wales.

I MET the late William Farrer about 36 years ago, and from that time until his death enjoyed his friendship and confidence. Shortly before meeting him he had published an article of considerable interest, and exceptionally well written, called "Grass and Sheep Farming," a paper speculative and suggestive. He explained in his introduction that "the following paper is in a great part theoretical, but as far as possible theory has been made dependent upon practice and has been guided into what it is hoped may prove useful channels. Those who affect to despise theory will do well to recollect that a function of theory is to examine the foundations of practice and by this means to modify it and extend it advantageously."

He was at that time either directly or indirectly interested in pastoral matters, and one object, he told me, in publishing the article was to have a dig at Mr. John Robertson's Free Selection Land Act, which encouraged selectors to take up poor land in tableland districts which nature had evidently intended for pastoral purposes only. He enjoyed this "dig," as he termed it, and in talking about his article to me laughed heartily over some of his remarks.

It appears from the pamphlet that he had, even at that distant period, observed the great losses sustained by settlers in consequence of the spread of rust amongst their wheat crops, and it gradually dawned upon him that he might possibly be able to find or devise some means of checking its attacks, or perhaps for eventually stamping it out of the country.

After sustaining heavy losses in mining ventures, he studied for the profession of surveyor, and obtained his license. He occupied himself for some years at his profession in the field, and then settled down on a conditional purchase of his own, near the little village of Tharwa, some few miles south of the town of Queanbeyan. He suffered a good deal at times from ill health, and the climate of the district in which he settled suited him admirably. Here he set to work practically and energetically to solve the problem of making new wheats, of good milling qualities, to resist the attacks of the pernicious rust parasite, his object being neither for fame nor for gain, but for the sole benefit of his fellow beings in Australia.

At that time the wheats in general cultivation were notoriously weak, or low in their gluten contents, but no attempts whatever, so far as I can discover, had been made to improve them before Mr. Farrer began the work.

Being fully aware of the remarkable differences which exist in the climates and soils of the various districts and localities of the Colony, he aimed at making wheats of the desired qualities for the several wheat-growing districts. He obtained from various parts of the world varieties of wheats for the purposes of experiment and observing their pecularities, to select those which showed desirable qualities and to cross them with Australian wheats, or to make crosses amongst themselves. His correspondence became extremely voluminous, and the task he set himself, although congenial, became a heavy one, and became more so as the years passed on.

In 1889 the effects of rust attacks on wheat crops were disastrous in New South Wales, South Australia, Victoria and Queensland. It was estimated that the losses sustained in South Australia amounted to £1,500,000, Victoria £200,000, New South Wales £100,000, and Queensland £10,000, totalling about £2,500,000 altogether.

In consequence of this alarming state of affairs the Governments of the various colonies decided that a conference of officials, experts and others, should be held, and in 1890 a start began in Melbourne. The questions of cure and preventions were discussed, and plans proposed for investigations and so on, to be made in the various Colonies.

Next year a conference was held in Sydney, which Mr. Farrer attended as one of the New South Wales delegates, and he was able to supply much valuable information relating to experiments he had initiated many years previously, and which were in progress, and his experience enabled him to express something definite as to the best means of treating the pest. He said :—

"That after having for many years given much thought to the rust-pest as it affects the wheat-plant in this country, I have been led to the conclusion that the best manner of combating the pest appears to be to give special attention to the securing and creating of resistant varieties of the plant of such a character as our special requirements demand.— arieties possessing together with high milling quality, such a measure of physical and constitutional resistance to the pest as to have great value on that account. According to my belief the contagion of rust is generally—to all intents invariably—conveyed to the wheat-plant through the air in which the germs are always present during the warmest months of the year. It matters comparatively little whether the contagion is more or less abundant. If it be present at all, as it practically always is during the hot weather, infection is pretty sure to take place if the plant be susceptible to it. We may indeed do something to diminish the contagion ; but according to my views, and I hope to be able to show in this paper, we are likely to be able to do far more towards diminishing the susceptibility of the plant to the contagion and to work with greater effect for specifically directing our efforts in that direction. . . . I cannot think also that any curative agent could be applied so thoroughly on a large scale and so inexpensively as to be of any practical value."

I shall give one more quotation from this valuable paper (the whole of which deserves republication), and that is in connection with the necessity that exists in wheat soils of an abundance of vegetable or organic matter. He invariably and consistently advocated the addition of this when deficient.

"In well drained and porous soils the wheat plant seldom receives a severe check to its growth from drought, for a slight deficiency of moisture is more favourable to its health than an excess. The absorption of such (hygroscopic) moisture can be further increased very materially in most soils by making them richer in humus or decayed vegetable matter. This can be done by green manuring and ploughing in vegetable matter. So valuable do I consider vegetable matter to be for this purpose that I have come to regard as friends rather than as foes the great majority of our weeds, which can also be made to perform other important functions in the economy of the farm."

Another conference was held the following year, but in the meantime Mr. Farrer had invited to his farm the pathologist of the Agricultural Department, Dr. Cobb, and the artist, Mr. Grosse, to enable them to make microscopical investigations and drawings of rust-affected wheat plants ; and there Mr. Farrer afforded them every facility possible, with the result that a vast amount of information respecting the parasite was obtained.

At the conference held in 1892 in South Australia, the information Farrer had supplied to the previous conference was supplemented to a considerable extent by him. Referring to the physical qualities which enable wheats to offer resistance to rust, he said :—

"The work, then, which lies before us is to combine in one variety, in as high a degree as is found to be necessary, the above three qualities together with the other qualities of a good wheat ; and how to do this in the best manner is the subject to the consideration of which I shall now devote a few words. The most obvious manner in which we should set about effecting this object is, first, to find out what varieties possess in the highest degree one or more of the resistance-giving qualities we are seeking to secure ; and next, to cross them in such a manner as to combine these qualities with the other qualities which give value to a wheat, paying special attention in the first instance to resistance giving qualities. In regard to choosing the parents for crossing, I myself am minded to mate varieties of distinct types. By following this course at first I would expect to get a greater number of types to select from, some of which would possibly combine, in as high a degree as either parent, the special good qualities of both parents, on account of which each of them was selected. Breeding up, comprehending the elimination of undesirable qualities and the higher development of desirable ones, would be effected in the best manner by mating varieties of the same type and by line-breeding. Amongst the qualities, the importance of which it would appear to be impossible to over-rate, is that of making the chaff hold the grain firmly and well. I draw special attention to this quality, because all of the highly resistant varieties I have come across, with the exception of Ward's Prolific, and its probably more valuable strain, Marshall's White, shell too easily. I also attach additional importance to this quality in view of the fact that it has now been satisfactorily proved that it is more profitable to the farmer to allow his wheat to become ripe before harvesting it.

" There are still other methods," he continued," of getting rust-resistant wheats and resistant strains of existing varieties. The first end can be secured by looking out in rusty crops for plants that have remained *entirely* clean. Such entirely clean plants can occasionally be found in crops of a variety that is still young and has not lost the liability to spot, and less frequently in crops of an old variety. By following this system, as I have been doing for some years, I have become possessed of several strains of varieties which differ so widely from the parent varieties in their deportment towards rust and in offering resistance to it as themselves to constitute distinct varieties. That young varieties are the most likely to supply us with such spots has been proved by my own experience, as all the sports I have obtained in this manner, with the exception of one, have been produced by varieties which I know to be young and probably had not been firmly fixed.

" I may also note that the first suggestion that I ever threw out in connection with combating the rust-pest was that this method should be bred. This was in the year 1882, and the suggestion was made in view of the fact that the Indian wheats which were then being tested by Dr. Bancroft (in Queensland) had fallen short of being rust-proof. My simple suggestion was unfavourably criticised by the *Australasian*, and the controversy which ensued from this criticism led me to think that nothing systematic had ever really been done to combat the rust-pest, and that a legitimate field of inquiry was open to me.

" Resistant strains of existing varieties could doubtless be made by simply selecting seed from those plants which are in the least degree affected by rust, and by following up this system for a number of years ; such strains, however, could not, in my opinion, be considered to constitute distinct varieties, but would be no more than resistant strains of the parent variety, and would only retain the quality of resisting rust so long as the same care continued to be given to them as was used in establishing that quality. Qualities, I hold. that are given to va ieties by selection of this kind are of little or no permanent value to the practical farmer, and do not become valuable until they have been fixed by cross-breeding and made normal characteristics of a distinct variety."

" It would appear that many varieties which have been put forward as having claims to be resistant, and have really been valuable from being resistant of *Puccinia graminis* have been condemned when they have been tried on account of having been affected by *Puccinia rubigo-vera.* It is important I think that our farmers should be able to distinguish bet een these two rusts and know that the rust which appears as small spots on the leaves and sheaths, but mostly on the leaves, is *Puccinia rubigo-vera,* and is consequently harmless, and that the more fatal rust, *Puccinia graminis,* is known from appearing as larger and longer streaks, and patches, quite as frequently on the sheaths and stalks as on the leaves, and that these two forms of rust are as distinct as are wheat and rye.

I should like to invite particular attention to the remarks which followed the above :—

" A fact which is being continually brought before us is, that while certain wheats are, in their own and even in many other districts uniformly resistant, they seem to lose that quality when they are grown in certain other places. This seems to be the case with Blount's Lambrigg and with the various wheats of the Fife family of which Blount's Lambrigg is one when they are grown near the coast in our climate. . . . This is a difficulty which has had large influence in causing resistant wheats to be discredited. The fact is that although we may succeed in making varieties which possess as normal characteristics all the physical qualities which give protection against the rust fungus, we must not expect such varieties to prove equally resistant under all conditions of environment. We must constantly keep in mind that in dealing with the wheat plant we are dealing with a living organism—with a subject which possesses, associated with the indefinable attribute of life other equally indefinable attributes, and that one of these latter attributes is a constitutional fitness or unfitness for the environment in which it may be placed. So powerful in their influence are environment—conditions which without being unsuitable for the growth of wheat are uncongenial to the constitutional characteristics of a variety that some wheats, which M. H. L. Vilmorin received from Tashkend in Turkestan, were so severely affected by rust when they came to be grown in France as after two or three years to refuse to produce seed which would germinate." . .

" It is for the purpose of filling the requirements of our different districts that I am not proposing to breed and myself fix varieties in the expectation that the possession by them of all the physical qualities which give to a wheat the power of resisting rust which will cause such varieties to be valuable everywhere. I propose rather to confine myself almost entirely to the breeding which will possess all the physical qualities I have already enumerated as being specially resistance-giving, and to send to the different districts of Australia heads produced by plants of the first generation which have been so bred. By following this plan it will be possible for those types to be selected from the produce of such heads, and fixed as varieties within the district itself as may show themselves to possess, associated with all the physical qualities which give resistance to rust that indefinable attribute which we call constitutional fitness for the particular district in which they are fixed."

I may mention here that some years afterwards, as soon as I could obtain particulars of the recently unearthed Mendelian law of heredity, I sent the information to Mr. Farrer, who, although very much interested in the matter, was prevented, owing to pressure of work, from making any experiments in connection with this law, and hesitated in expressing any decided opinion as to its practical application to the work of making wheats.

Mr. R. H. Biffin, B.A., of the Agricultural Department, Cambridge University, who seems to have been engaged for some time in following in Mr. Farrer's footsteps, to make wheats resistant of rust and of high milling qualities, appears to consider, according to his article on " Studies in the inheritance of disease resistance "[1] that the only certain means of effecting this is by working on Mendelian principles, and in order to emphasise his views, he refers to an article read by Mr. Farrer before this Association on January, 10th, 1898, and wrote as follows :—

" In some countries a careful search has already been made for rust-resistant varieties, but, on the whole, with comparatively little success from the economic point of view. This partial failure has not been due so much to the difficulty of finding relatively immune varieties, as to the difficulty of finding immunity in combination with other features essential for the profitable cultivation of the crop. . . . The researches of the late William Farrer may be quoted as an example. The problem has proved an exceptionally difficult one, and even Farrer's patient work has not met with the success one hoped it would. Now, however, we are in the possession of the broad outlines of the inheritance of the more important characteristics of wheat, the attempt to combine in one variety such features as quality, proper time of ripening, cropping power, and so on, together with immunity to the commoner rusts may profitably be made. Such attempts will have to be made in each country where wheat is cultivated ; for wheats suitable for English conditions will certainly find no favour in Canada or Australia, for instance."

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1 *Journal of Agricultural Science*, Vol. II., part II., 1907.

It seems strange that such an erroneous conclusion was arrived at by Biffin, and notwithstanding the following paragraph by Farrer in the paper referred to :—

"I think from these data we may safely draw the conclusion that the making of varieties possessing suitability for our climate in conjunction with sufficient ability to resist the summer rust for our crops to be safe from serious (or indeed from any) injury by it is an easy matter, and only waits for its completion a few moist seasons, even if the next rusty season does not show it has actually been accomplished already."

It should be understood that every season in Australia is not generally a "rusty season," and hence Mr. Farrer's difficulty in thoroughly testing his varieties of wheats as rust resisters.

A considerable difficulty presented itself to Farrer in determining the values of his wheats for milling purposes, and the values he was able to assign to them were to a great extent arrived at, to all intents and purposes by guesswork ; but after consultation with Mr. Guthrie, who was attached to the Agricultural Department, as analytical chemist, both gentlemen very strongly urged on me the desirability of obtaining a small hand flour mill, by means of which wheats could be tested by manufacturing commercial flour, by baking, and so on, in the Department. Approval was given by the Minister for the purchase of a mill, and one was obtained. It seems to me only proper and fair to Mr. Guthrie to say, and I do not think this has been properly recognised, that without his enthusiastic efforts in co-operating with Farrer, the complete success of the latter gentleman's work would not have been attained.

As soon as the flour mill was put into working order Guthrie lost no time in perfecting himself in the manufacture of commercial flour, in bread making, in testing the colour of flour and other technicalities ; and then there were chemical investigations to be made. This wheat-testing business became one of the most interesting and important branches of the Department.

The value of Guthrie's assistance was fully recognised and appreciated by Farrer, who in December, 1897, wrote to me :—

"I am glad to see that new interest is being taken in the intrinsic milling value of wheats. Guthrie's work has done no end of good in that direction and is destined to do still more, not only in this colony and in Australia, but the world over. His is the best and most practical work that has yet been done anywhere, and it will be supplemented by much that will be done elsewhere. Some years ago Dr. Cobb sent me the proof of the descriptions of wheats which he published in the *Gazette* originally, when I sent back the corrections to him I told him bluntly that neither he nor I knew anything about the milling qualities which he proposed to give, and I recommended him to leave out all mention of them, as well as some other matter the soundness of which I doubted. I recommended him, in fact, to confine himself in that regard to what he was certain of. He did not follow my suggestion, with the result that all he said about the milling qualities was found to be incorrect."

In 1898 an opportunity occurred to appoint Farrer Wheat Experimentalist to the Agricultural Department, where it was thought his scope would be extended and his opportunities improved for carrying on the work which he had hitherto performed privately and entirely at his own expense in a most generous and unselfish manner, giving away to anyone he considered trustworthy the results of a vast amount of thought and also of expense. This appointment, it was considered, might be some little acknowledgment and recognition of his efforts.

He prepared a scheme of work, which included the breeding and crossing of wheats at Lambrigg, his headquarters, and supplying the different experiment farms with seeds of entirely unfixed and partially fixed crossbreds for the purpose of making at the farms varieties which are suitable to the districts of which they (the farms) are severally representative.

A number of experiments, having an important bearing on the wheat-growing industry, he proposed should be taken in hand as his work proceeded.

During his second season he had a good opportunity of observing the results of the planting of his wheats at Wagga farm. He wrote, "Beyond all doubt it is not sufficient (as I had hoped rather than expected it might be the case) to produce and fix wheats at Lambrigg alone in order to supply other parts of the colony with new varieties for their climates and soils."

He then adopted the system of carrying out the process of fixing his young varieties at different farms.

He met, unfortunately, many unexpected difficulties, which not only impeded his operations but affected his health to a considerable extent. These numerous "flies in the ointment," however, were neutralised considerably by many pleasing encouragements; and a great deal of enthusiasm in his work was forthcoming to encourage his efforts.

Much discontent was expressed from time to time at the slow progress of his experiments by those in authority, who really had no conception of the necessity for the utmost care and patience necessary, or of the injury to the Department which might arise from incautiously distributing new wheats, the proper values of which had not been proved. He found it necessary to publish in the Agricultural Gazette the following note :—

"Some misapprehension seems to exist in regard to the rapidity with which new varieties can be made by means of cross-breeding. It is true that the work can sometimes be done quickly. In a few cases, indeed, I have found as little as four years to suffice for becoming possessed of a fixed type, while in others (and they are the great majority) much longer is required. Also after a fixed type has been secured much more remains to be done before the new variety can be distributed. It has first of all to pass an examination at the mill, and this is an ordeal which leads to the rejection of the greater number of those which are subjected to it, and few are the new varieties which are found to satisfy the requirements which a high standard of milling excellence demands of all the qualities—(1) strength, (2) colour, (3) yield of flour; as well as (4) of gluten content; and (5) ease of milling. Moreover, after all these tests have been satisfied and the economic value of the new variety has been established, three years (at least) is needed to enable a sufficient stock of seed to be grown for a fairly wide distribution of it."

The selecting of the best strains, after testing them, of old varieties of wheats occupied some time, as he considered it advisable that good old strains should not be lost. These wheats were also tested by Guthrie to ascertain their milling qualities.

Few persons have any conception of the enormous amount of work which Farrer carried on personally. All his experiments and his crosses and the pedigrees of the hundreds of new wheats made by him were carefully recorded, as well as their peculiarities and qualities. A hard day's work in the blazing sun in the field was not infrequently followed by a sleepless night, for his active brain kept working out intricate problems for future developments. In April, 1902, he wrote to me :—

" In order to get away to the farms I have for months been working all the time I can get out of each day, getting up at six and beginning work at 6.30 a.m. The result is that I feel myself in such a condition of staleness that I can hardly struggle on to the finish. The additional amount of detail work which the new bunt departure has necessitated is very great. I feel impatient most of all at these incessant fights with ——. The fights themselves I do not mind, there is some entertainment and fun to be got from them, but there ought to be no necessity for them, the removal of the necessity of these fights is what we have a right to expect."

The " bunt departure " alluded to meant the experiments he had begun, to make bunt as well as rust-resisting varieties of wheats—a highly desirable aim in view of the enormous losses which often resulted from the bunt parasite. This work, I need hardly say, necessitated great care and attention, and it is pleasing to know that Farrer succeeded almost beyond his expectations in producing new varieties of wheats practically bunt-resistant, and paved the way for future work by others ; and all this in spite of ridicule and freely expressed opinions as to the absurdity of the idea.

Most fortunately for Farrer's future work the Government determined upon establishing a farm near Cowra, the centre of an important wheat-growing district ; and upon Farrer's strong recommendation it was decided to set that farm apart for experimental purposes only, and chiefly for experiments in connection with wheats and the growing of them under various methods of cultivation, as well as trials of various kinds of manures, and so on, under the control of the wheat experimentalist. I can hardly express the satisfaction and relief this afforded Farrer. He at once formulated a scheme of work for making the best use of the 200 acres it was decided to clear of timber and put under cultivation. At this farm he would have an opportunity of producing pure seed of the varieties he considered were the best suited to grow on other experimental farms and to distribute to farmers. And to his further great relief he was able to obtain the services of G. L. Sutton, who had for years taken a keen interest in Farrer's work, and who had thoroughly qualified himself for conducting all the trials and experiments required by Farrer at Cowra, from whom I received a letter saying :—

"You know I have long regarded the experimental work of the farms as the most important, and when things have been set going I shall do all I know to make this farm a success, and with Mr. Sutton as working co-operator I shall be badly disappointed if the success of it is not distinct."

In connection with the Cowra farm it was arranged that a small farm at Coolabah, in the dry West Bogan district, about 400 miles west of Sydney, should be devoted mainly to the testing of wheats for semi-arid districts and for trials in various methods of ploughing, cultivating soils, and conservation of soil moisture, the work being conducted under Sutton's supervision, assisted by Farrer's advice. At this farm a great deal of valuable information has been gained, which may result in wheat-farming being carried on profitably much further to the west than is at present supposed to be practicable.

Farrer expected that the Durum or Macaroni wheats (*Triticum durum*) might be found to succeed well at Coolabah. In an article on Macaroni wheats, published November, 1903, he said :—

"Bread wheats are already being grown in parts of New South Wales which are almost certainly too dry to allow them to be profitable, . . . while it is not improbable that if they (the farmers) change to macaroni wheats they will come out all right."

He quoted extensively from Mr. A. Carleton, Cerealist of the Department of Agriculture, United States of America.

"'Mr. Carleton insists,' he wrote, 'on the necessity of the soils for macaroni wheats being of the character of the Chernozem soils of Russia for the production of good grain. My experience with these wheats leads me to doubt whether this is the case. I myself have been growing them experimentally for fully 15 years, and have found that even here at Lambrigg on quite shallow soils I can grow at least as good grain as any that I have ever had sent to me from any other country, but in such cases I have always dressed the soil, which is naturally exceedingly poor in nitrogen, with a nitrogenous manure.'

"The objection to the use of the grain of these wheats for bread arises mainly from the yellow colour of the loaf. The preference for white bread is of the character of a prejudice, or is a mere matter of taste. The yellowness of the bread made from macaroni wheats probably comes from their greater richness in gluten, and is in reality indicative of their superior nutritive qualities."

I may mention that the Durum wheats are in high favour at the present time in the United States of America for growing in dry country, where they are found to thrive admirably. According to the Agricultural Year Book of 1905 the Durum wheats were first introduced from East and South Russia in 1899. Next year a considerable quantity of seed was imported, and in 1901 as much as 50,000 bushels of Macaroni wheat were produced in the United States. The production kept on increasing so much that in 1905 it was estimated that the yield was 20,000,000 bushels, and a considerable portion of this found a satisfactory market in Europe. The question of marketing that kind of wheat was settled.

The last published Year Book (for 1909) shows that it is estimated that the yield of Durum wheats that season would approximate 60,000,000 bushels. The Secretary for Agriculture in his report says that :—

" Durum wheat has now made its place as a semi-dry land crop in the middle Great Plains region, and is being rapidly extended into the inter-mountain dry-land districts."

A number of stations had been established in the dry country where experimental work is carried on, and according to the Secretary " the experimental work at each station is under the charge of men specially qualified along the lines of grain improvement and familiar with the territory in which the station is located. . . . It is found that many of the farmers in this region who are planting cereals grow mixed varieties. This alone has probably as much to do with the low average yield per acre in the United States as any other factor. One of the objects of the work in question is to enable farmers to obtain pure seed of drought-resistant kinds of wheats adapted to particular districts." I think I need hardly say that the growing of pure seed wheat for the supply of farmers was considered of the highest importance by Mr. Farrer, and he worked hard to accomplish that object.

The question as to manuring wheats was one about which Farrer was much concerned, and plans were formulated for making field experiments at Cowra.

Quite recently some references were made in the press concerning objections made by wheat buyers to one of the best known and most popular of Farrer's wheats—Federation—which was considered by these buyers to be of low milling quality, but in other parts of the country no such objections seem to have been made.

Referring to this wheat, in a letter to me dated 6th January, 1905, Farrer wrote :—

" A curious and interesting apparent indication of the poorness of plant-food, at anyrate in nitrogenous plant-food, of the wheat paddock in which last year's wheats were grown at the Wagga farm came under my notice only the other day. Federation grown at Wagga last year gave only 6½ per cent. of gluten ; grown at Wagga on my plots in 1901 it contained 11·3 per cent, not far off twice as much. It looks as if it may be that wheats which possess the quality (like the French " Blé siegle " or rye wheat) of thriving in poor soil do so because they can do with a less amount of plant-food than can others, and that those which need soil such as Farmers' Friend and Hudson's Early Purple Straw cannot do without plenty of nitrogenous food. In view of what may be a lowness in albuminoids the flour of Federation is weaker than usual, owing to lack of nitrogen."

Shortly before sending me the above information Farrer had written :—

" I have it in my mind to write to the *Daily Telegraph* pointing out that if farmers were to get their wheats tested before they sold them they would put themselves in a position to get good value for them, and that if some system of selling wheats according to their intrinsic value were established a force would be put into operation by means of which the improvement of wheats for economic purposes would become progressive. This is a subject I want to work at."

I do not think he ever found sufficient leisure to take this matter in hand, but he foreshadowed what must eventually and as certainly be brought about as probably the bulk-handling of wheats will be.

Federation was made to take the place of Steinwedel, a variety selected in South Australia and valuable for yielding well in dry districts, but having an objectionable habit of shelling out its grain before harvest.

"As Federation," said Mr. Farrer, "ripens at the same time as Steinwedel, and is much less rust liable and holds its grain satisfactorily, it is possible that it may replace that variety with advantage as a producer of grain, but the shortness of its straw unfits it for a hay-wheat."

In an article, Milling Notes on the Lambrigg harvest, 1897-8, by Messrs. Guthrie and Gurney (*Agricultural Gazette*, N.S.W., September, 1899), the effects or probable effects of manuring on the gluten of wheats are referred to thus :—

"The most striking feature in the present batch of results is the high percentage of gluten in the flour. This increase of gluten has been associated with weaker flour-strength. Mr. Farrer says that the wheats were all manured with sulphate of ammonia and bone-dust, and it is possible this excessively nitrogenous manuring may have been responsible for the result."

"Some of the differences are very striking, for instance in the Indian grown wheats. Some of these were examined in 1896. They were grown in India and imported. The difference between the glutens and strength of these wheats and the same grain after being grown at Lambrigg is shown in the following table :—

	Imported Grain		Same Grain grown at Lambrigg.	
	Gluten.	Strength.	Gluten.	Strength.
Pitsi Ekdam	9·61	50·8	12·94	47·4
Muzaffar Nagar (bald wheat) ..	10·29	61·2	15·50	62·8
,, ,, (bearded wheat)	6·07	57·0	13·72	51·2
Huzar	7·24	55·2	14·25	48·0

In the same way the sample of Purple Straw is extraordinarily high in gluten for this variety, previous samples which have been examined never going above 9 or 10 per cent, and being usually between 8 and 9."

The results of manuring experiments carried out by Mr. Guthrie more recently at Wagga and Bathurst are interesting in connection with the gluten contents of the wheats sown.

"In the Wagga results 1901," wrote Mr. Guthrie, "the effect of the ordinary dressing of sulphate of ammonia appears to be about nil both upon the gluten content and the strength."

"When this is combined with superphosphate and potash salts, however, the benefit both in strength and gluten content is marked, and the effect of increasing the sulphate of ammonia is very marked."

"In 1902 harvest the same condition of things was noticeable. Dried blood, though apparently without action on the gluten content, increases the strength of flow in a striking manner.

"At Bathurst, on the other hand, where nitrogenous manure had been found to directly increase the yield, the results show that it has an appreciable and favourable effect on the gluten. These notes are of a preliminary nature, and are to be received with caution."

The experiments, which promised most valuable results, were discontinued, unfortunately, for reasons which it is unnecessary to refer to here.

The continuous use of superphosphate alone, which was becoming general before Mr. Farrer's death, caused him a considerable amount of anxiety as to the collapse which seemed to be most probable ; and he particularly desired to demonstrate the value of green manuring and of other manures for wheats, and probably Mr. Sutton may throw some light upon results obtained in the paper which I understand he will read before this Conference.

The testing of wheats in Sydney had necessitated the use of water and, afterwards, electric power for working the flour mill, and the increased testing of wheats necessitated the purchase of a much larger mill, but even with such an addition the requirements of millers and others, together with the Departmental tests, increased the work so considerably that unavoidable delays sometimes occurred. Referring to this, Farrer wrote to me :—

"I think the time has come for the Sydney millers to organise means of testing their wheats and flours themselves instead of throwing the doing of them on us."

Towards the end of his life Farrer was clearly overtaxing his strength, notwithstanding many remonstrances and warnings. On the 6th January, 1906, he wrote : "My body is too tired every night for office work ; the red-tape about engaging men worries me, and I am unable to muster energy to pen a memo." ; and on the 9th March, not long before his death, he wrote : "You see, therefore, how in reality matters stand, and what the forces are I am having to contend against ; but I feel I am in the right so far as the real interests of the Department are concerned, and I mean to win."—And he won.

2.—THE REALIZATION OF THE AIMS OF WILLIAM J. FARRER, WHEAT BREEDER.

By GEO. L. SUTTON, W. A. Department of Agriculture, formerly of N.S.W. Department of Agriculture.

At a meeting of this Association held in 1898 the late William J. Farrer read a paper in which he defined his aims and described the work he was doing in connection with "The Making and Improvement of New Varieties of Wheat for Australian Conditions."

That he did succeed with this work is now evident to every one connected with the wheat or milling industry. Now that time has proved his success, it is fitting that some record of his work should be placed before this Association, which 13 years ago listened to him define his aims and how he meant to achieve them.

Probably the most striking evidence of Farrer's success is the national popularity of the wheat "Federation." It is unquestionably one of the most prolific grain varieties in cultivation, and certainly the most popular wheat in Australia to-day. It was purposely produced to suit the Australian method of harvesting with the stripper.

Since its introduction to the farmers in 1902-3 its cultivation has spread by leaps and bounds. This has taken place as the result of sheer ability to yield well, and despite an unattractive appearance in the field. No other variety has, up to the present, been found to give such uniformly good results in all parts of Australia.

So general is its cultivation in some of the wheat districts, that the aspect of the landscape at harvest time has actually been changed. No longer can the poets in such districts write about the "golden harvest tint." When "Federation" is ripe it imparts the brown or bronze colour of its ears to the landscape.

Such a transformation is probably unique in the history of wheat growing. A striking instance of the change effected was furnished last harvest. Mr. W. A. Gullick, our Government Printer, required for Great Britain some colour photographs of the "golden" harvest fields of New South Wales. To obtain these he sent his artist to take harvest scenes in the Cowra-Grenfell district. When the pictures in their natural colours were thrown on the screen to test them, it was found that the harvest fields in that district, due to the presence of "Federation," were no longer "golden," but "brown."

The British farmer is accustomed to a golden harvest. Pictures of a brown harvest would hardly convey to him an idea of fruitfulness. They would rather give colour to some of the extraordinary ideas which are said to be prevalent about Australia.

The rapid increase in the area planted with "Federation" in the district referred to is typical of what has taken place in other districts. It can, in consequence, be referred to in detail.

At the time the photos were taken, it had only been known in the district for five years. It was first grown at "Iandra" in 1904-5, when 20 bushels of seed were obtained from the Wagga Experimental Farm, and were sown on the farm of Mr. Rentz. At harvest time its appearance was so much against it that it was deemed unsuitable for the district. It however, yielded better than it looked, and produced some 24 bushels per acre. Because it yielded so much better than its appearance indicated, Messrs. Freebairn Bros., on the same estate, planted some, about 84 bushels of seed and planted 130 acres in comparison with one of the best of the old varieties—"Farmers' Friend." From the 130 acres planted, 1,166 large bags (4 bus.) were harvested, and about 15 tons of hay. This crop was fed off until end of June. Just before harvest the appearance of "Farmers' Friend" indicated that it would outyield the new "Federation." After harvest the results indicated that the new "Federation" had outyielded the old variety by some 8 bushels, the yields of the two varieties being respectively about 37 and 29 bushels per acre. After such a victory "Federation" has never looked back. Its progress has been a triumphant march, until now it is king throughout the whole of the district. A fair estimate of the area sown with "Federation" on "Iandra" to-day is 15,000 acres.

Another instance in the same district is worth recording. Two years after its introduction on "Iandra" an adjoining station, "Brundah" had 3,000 acres planted with "Federation." The average yield per acre from this area was 22 bushels. From the total area 13,040 bags (the old size of 4 bushels) were sold, the remainder being kept for seed the following year. It is probable that in New South Wales this was then the largest area planted with any one variety. It is also probable that the yield obtained was the largest average for a big area in the State.

It is significan that the winning varieties of "growing crop" competitions are invariably "Federation." This year in the Cowra district the competing crops, each of not less than 30 acres, were all "Federation." The average yields per acre of the three winning crops were respectively 41 bushels, 40 bushels and 29 bushels.

In Victoria "Federation" is also held in high esteem by farmers.

How important a factor this variety is to the wheat production of that State may be gathered from a statement of Dr. Cherry, the Victorian Director of Agriculture. Writing at the end of 1909 he stated: "The question of whether the present wheat harvest will realise the official forecast of 25,000,000 bushels depends to a large extent on the way that one variety of wheat, namely, 'Federation,' may have stood the test of an unfavourable winter's growth. . . . Up to the present the returns are all in its favour. Returns of 20 bushels in the Mallee and up to 35 bushels in the best parts of the Wimmera are being recorded. . . . . So rapid has been the advance of the new variety (introduced to Victoria in 1904—G.L.S.) that probably one-fourth ($\frac{1}{4}$) of all the wheat in Victoria this year is of the 'Federation' variety. As the yield is at least 3 or 4 bushels to the acre above that of all other varieties, the benefit during the year from the work of the late Mr. Farrer may be estimated at 1,500,000 bushels of wheat, representing a cash value to the farmer of £250,000."

In South Australia the success of "Federation" has been no less remarkable. The President of our Section (W. Angus, Esq., B.Sc.). when Director of the South Australian Department of Agriculture, wrote :—"We are indebted to the work of the late Mr. Farrer, of New South Wales, for the best all round variety of wheat now grown—one which is peculiarly suited to South Australian conditions, viz., 'Federation.'

"'Federation' is a grain producing variety, not a hay wheat, and there is probably no other variety to equal it in this respect. Not onl is it a very high yielder, but it has the power of adapting itself to the different conditions of climate and soil, a most important factor in a country like Australia. In the hot, dry north, in the cool south-east, on the light sandy soils of the Pinaroo and Loxton country, and on the heavier soils of the Salisbury plains, we find 'Federation' taking premier place amongst our varieties.''

In the South Australian variety trials in eight out of nine localities "Federation" had first place, being beaten in the other by its half-sister "Yandilla King."

From a popular standpoint "Federation" is considered to be Farrer's greatest success; but it is by no means the only one of his productions that have proved successful. Other well-known varieties now in general cultivation are "Bunyip," "Bobs," "Cleveland," "Comeback," "Jonathan" and "Thew."

Early last year a conference of the officers of the New South Wales Department of Agriculture, who were specially interested in the cultivation of wheat, was held at the Wagga Experiment Farm. This conference selected a number (17) of varieties of wheat which could be recommended to the farmers as being most prolific and otherwise suitable for the various farm and agricultural requirements of this State. No variety was included in the list of those selected, unless by actual trials under farmers' conditions it had proved consistently prolific, nor unless it was capable of producing flour of a certain standard strength. Twelve out of the seventeen varieties selected were Farrer's productions. This carries its own evidence of Farrer's success.

In 1909, under the supervision of the N.S.W. Department of Agriculture, 43 trials with varieties of wheat were undertaken by farmers in all parts of the State. To undertake this work indicates that these men were progressive. That nine of them were growing only Farrer varieties is therefore further proof of his success. The other 34 experimenters tried an old favourite in comparison with the Departmental productions. In 32 of the 34 trials the farmers' selection was beaten by one or more of the new wheats. This is additional proof of their success.

In his paper read before this Association Farrer defined his aims as being the production of wheat specially suitable for our peculiar climatic conditions, which should also be (*a*) of greater milling value than the old varieties, and (*b*) more resistant to rust. He required something more than to produce a prolific variety. His ideals were high. Perfection was his goal, though he recognised this as being unattainable. Each success gave him something more to aspire to, and rendered perfection still beyond his reach. It is fortunate for Australia that his ideals were lofty. To breed a wheat with no other recommendation than, that in a normal season it would yield well would have been comparatively easy, and would have quickly earned for him an enviable reputation. Such a policy was, however, too small and shortsighted for a man of his mental calibre.

As the result of his forethought Australia now grows a strong, as well as a white, wheat, and she need not fear the disastrous effect of the ravages of a rusty season, as she did before Farrer's success was achieved and his aims were realised.

That he succeeded in producing prolific varieties, specially suitable for our climatic conditions, is proved by the increasing popularity of his crossbreds, and notably by that of "Federation." That these varieties are also of superior milling value and more rust-resistant than the old varieties is proved in a less direct but none the less convincing way.

Actual tests in the Departmental laboratory and in the commercial flour mills have shown that New South Wales, with the aid of such varieties as "Comeback," "Jonathan" and "Bobs," has now no need to import Manitoba wheat for blending with our soft wheats. The varieties referred to are equal in flour production to the old varieties, and equal in strength to the famed standard Manitoba wheats. Though not so generally suitable for our varying conditions as "Federation," they have their place, and are decidedly suitable for cultivation in some districts. That they are grown in commercial lots is proved by the intention this year of the Chamber of Commerce to make a special standard for these varieties under the name of N.S.W. STRONG WHITE. This indicates that New South Wales is likely to become an exporter of STRONG wheat instead of, as in the past, an importer of it.

The local trade recognises the value of this class by paying premiums of from two pence to sixpence per bushel more for the wheats comprising it.

The success achieved in this direction of improving the quality of our flour and bread would have been of far greater pleasure to Farrer—had he lived to realise it—than the success and popularity attending "Federation" because of its ability to fill bags under so many varying conditions.

Mr. Guthrie's periodical tests of the f.a.q. standard sample of wheat indicate that it is gradually increasing in strength. It is possible, but unlikely, that this increase in strength has been due to seasonal characteristics. It is far more probable that it is due to the increasing quantity of Farrer's crossbreds now being harvested.

Because of the proved success of Farrer's varieties, the conference of Departmental officers previously referred to were able to exclude from the list of selected varieties any that had not a strength of 47, new estimation (50, old estimation). As the most popular of the old varieties—*e.g.*, "Dart's Imperial" and "Purple Straw"—had a strength of 44 or 45, the exclusion of such varieties meant that the standard of strength was raised at least two points. The economic value of this is that the bread-producing capacity of a 200 lb. sack of flour has been increased under the new standard by about 4 lb. There is also an additional advantage in an improvement in the quality of the bread baked from such flour.

Most of the new varieties now grown are more rust-resistant, or early enough to be more rust-escaping, than the old varieties. If caught by a rust season it is safe to expect that their resistance to the pest is sufficient to prevent the crop from being reduced from, say, 20 bushels to below 16 instead of to 4 or 5 of worthless grain, as was the case when many of the old varieties met with such a season.

Some varieties have, however, been produced—though the limit has not yet been reached—which are specially suitable for rusty districts.

For several years past a variety called "Thew" has been successfully grown for hay at the Hawkesbury Agricultural College, where it was produced. At this College the conditions favourable for the development of rust are present each season in a greater or less degree.

This same variety has proved in farmers' trials very suitable for the coastal areas, at places where because of the rust it was deemed inadvisable to attempt to grow wheat, even for greenstuff.

At the H.A. College this year a newer variety called "Warren" has quite eclipsed "Thew" with regard to its rust resistance. The conditions prevailing this season were extremely favourable for the development of rust.

At Glen Innes, "Jonathan" for some years past has proved so highly rust-resistant that it has been a prolific yielder, and has produced grain equal in strength to the world's best. Last season —which was so exceptionally rusty that even the "Fifes" were badly affected—a new variety called "Cedar" was quite free from the pest, and produced grain of exceptional excellence. This variety "Cedar" is also a bunt-resistant, if not a bunt-proof variety. It is an instance of the later aims of Farrer in the direction of producing varieties resistant not only to rust, but to all the diseases to which wheat is liable.

From what has been stated, it will be granted that Farrer realised his aims in a remarkable degree. That one man should have accomplished even so much in the space of a whole lifetime is a veritable triumph for scientific research and patient and careful investigation. With the fruits of Farrer's success before us, his triumph does not perhaps now appear as great as it really is.

When he read his paper his ideas were popularly supposed to be those of a visionary, more interesting from a purely theoretical and academical standpoint than from a practical or commercial one. How impossible his task seemed when it was undertaken may be gauged from the remarks made less than seven years ago by Mr. Martin Sutton, of the well-known seed firm of Sutton and Sons. Mr. Sutton's remarks are entitled to be taken as representing the leading commercial thought in the agricultural world. As head of the great seed firm, he could claim to have a special knowledge of what had been attempted and what done in the direction of improving our cultivated plants. Mr. Sutton said, "We should be grateful to the botanist and scientific men who carry on these abstruse experiments in cross fertilisation, but I would warn agriculturists against expecting any practical results in our generation." He further maintained that he was supported in his contention by an eminent agricultural scientist, who had stated that, " as a matter of fact, although he had watched wheat crossings conducted by eminent men on the continent of Europe for 25 or 30 years past, he was not aware of any single variety which has yet come on the market." Farrer, for one, has shown this contention to be ill-founded. He has realised his aims, as defined in 1898, almost to the full.

The *direct* result of his work has been of incalculable value to the Commonwealth, in that it has indicated what is possible and how to achieve the possible ; the *indirect* result of his work will in the future be of still greater economic value.

No record of Farrer's success would be complete without—as he did, and would now wish to do—paying tribute to his co-worker, Mr. F. B. Guthrie, the chemist of the Department of Agriculture. To Guthrie was left the task, by no means easy, of devising new methods to reliably test the milling value of the very small samples of grain, which were the only ones available. The fact that these methods have furnished results which when acted upon have been confirmed by commercial experience, is the best proof of their efficiency and the thoroughness with which they were devised. Fortunate indeed was Farrer that, in the early and critical stages of his investigations, he had in Guthrie such a sympathetic colleague. Without such sympathy and enthusiastic co-operation thus extended to him, Farrer would have been hampered and would have been unable to have accomplished all that he has.

3.—ON THE BEHAVIOUR OF CERTAIN AUSTRALIAN VARIETIES OF WHEAT WHEN GROWN IN SURREY (ENGLAND).

By A. E. HUMPHRIES, Chairman of the Home Grown Wheat Committee of the National Association of British and Irish Millers.

On behalf of the Home Grown Wheat Committee of the National Association of British and Irish Millers, of which Professor Biffen, of Cambridge, and Mr. A. D. Hall, F.R.S., Director of Rothamsted Experimental Station are members, I have grown experimentally a great number of colonial and foreign wheats. We have sought to ascertain—

1. Whether any one or more kinds were suitable without selection or hybridizing for distribution as seed to British and Irish farmers.
2. Whether among the commercial grades or kinds of wheat one or more varieties could be found, which when segregated and grown in Great Britain and Ireland, would be superior or at least equal in yield of grain and straw and superior as regards quality of grain to the varieties now generally grown by British farmers.
3. Whether any colonial or foreign variety retained or developed when grown in England any one or more

characteristics as regards quality of grain or straw, or habit of growth, which would render it valuable as a parent in Professor Biffen's work of hybridizing and selection on Mendelian lines.

In the course of this work I had grown wheats obtained from France, Germany, Hungary, Russia, Roumania, Canada, United States and other countries ; but had not sought to test Australian wheats, for we knew that the Australian wheats imported into England are not strong according to our definition of the term strength, and it seemed to me improbable that varieties suitable for Australian conditions would be suitable for England. However, in the late autumn of 1907 Mr. A. D. Hall received samples of several Australian varieties, and a request that they should be tested in England. He was unable to sow them at Rothamsted, so asked me to undertake the work. I therefore included them in the series raised for the Home Grown Wheat Committee at Addlestone, Surrey.

The soil is a light, sandy loam, over gravel, in a district marked on a geological atlas as " Upper Eocene, Bagshot Beds." The farm is situated in the Wey valley near to the Thames. The climate is relatively equable, the winters very rarely severe ; the rainfall moderate. For the calendar years 1908 and 1909 it was $22\frac{1}{2}$ and 24 inches respectively.

For the periods of later growth and maturation it was as follows :—

	In 1908.	In 1909.
May	1·71	1·57
June	1·72	4·08
July	2·61	2·36
August	2·40	1·63
	8·44	9·64

The figures as regards shade temperature taken about 4 ft. above ground are as follows, in degrees Fahrenheit :—

	May, '08.	June, '08.	July, '08.	Aug. '08.
Average maximum	$67\frac{1}{2}$	74	75	75
Average minimum	47	50	52	51
Mean	57	62	$63\frac{1}{2}$	63
Highest reached	83	86	90	90
Lowest reached	38	38	46	42

	May, '09.	June, '09.	July, '09.	Aug. '09.
Average maximum	70	66	71	76
Average minimum	41	47	54	$52\frac{1}{2}$
Mean	$55\frac{1}{2}$	$56\frac{1}{2}$	$62\frac{1}{2}$	$64\frac{1}{4}$
Highest reached	86	78	80	90
Lowest reached	32	36	46	44

The varieties passed on to me by Mr. A. D. Hall were Comeback, Federation, Gluyas, Marshall's No. 3, Nhill, and Yandilla King. As I did not get them in time for sowing under favourable conditions in Autumn I delayed planting them till February 26th, 1908. The late autumn and winter had been fairly favourable. This February was a very dry one, and the planting was effected quite satisfactorily. March was a month of "many weathers," wet at first, cold in the middle of the month, wet again at its end, so that the six varieties did not show above ground till April 4th. April was wetter than usual and we had two heavy snowstorms at the end of the month, so that the mean temperature was low and the conditions unfavourable. Comeback withstood them better than the other five Australian varieties. May was a beautiful month, rainfall below the average, but sufficient; temperature was high for the time of year. We escaped late frosts altogether. Nevertheless my note on June 7th was "Nhill is very bad and Yandilla King worse. Comeback is the best of the Australians and just about earing, though it is as yet only 18 inches high." From this it will be seen that although the conditions affecting its earliest growth were unfavourable, this variety required only 102 days to get from sowing to earing, and only 64 from the time it appeared above ground. Gluyas came into ear about a week later, and the other four, Federation, Nhill, Marshall's No. 3 and Yandilla King two or three days later still. This rapidity of growth is noteworthy, for an ordinary English variety sown in the same field about October 29th did not come into ear till June 20th, and Red Fife sown on October 25th till about June 10th.

The rainfall in June was below the average ; indeed, it was a dry month, except for some thunderstorms, and the general conditions were quite favourable for wheat, except during the first few days of the month, when rust showed itself on almost all our wheats. In July we had a normal rainfall. The weather, as a whole, was favourable early in the month and at its end, but we had a "very dull, miserable time" in the middle of it. This played havoc with these Australian varieties. Nhill and Yandilla King were already so poor that their condition could hardly be worsened without absolute extinction, but the others were previously at any rate presentable. However, in one week Federation was irretrievably ruined and had become absolutely worthless. The others were also damaged, but were able to survive and yield small quantities of grain. The weather for harvesting was good. We had practically no rain from July 20th till August 21st. Red Fife and an ordinary English variety grown in the same field as the Australian varieties were cut on July 28th and August 1st respectively. The dates on which the Australian wheats were cut were as follows :—

Federation	August	3
Gluyas	,,	8
Comeback	,,	10
Marshall's No. 3	,,	11
Nhill	,,	15
Yandilla King	,,	15

The following tables are extracts from those made at harvest time concerning all our trial wheats :—

	Red Fife.	Square Head's Master.	Comeback.	Federation.	Gluyas.	Marshall's No. 3.	Nhill.	Yandilla King.
1. Thickness of plant	Very good.	Very good.	Poor.	Very poor.	Very fair.	Very fair.	Very bad.	Very bad.
2. Tillering	Very good.	Very good.	Very good.	Very fair.	Very good.	Very good.	Cannot say.	Fair.
3. Length of straw ..	3′ 7″	3′ 10″	3′	2′ 7″	3′ 4″	3′ 6″	1′ 10″	2′ 5″
4. Colour and appearance of straw before harvest	Blue bloom, thin stems.	Good.	Bluish grn., poor, thin and spindly	Dk. bluish green, spindly.	Spindly, but relatively healthy.	Spindly, but relatively healthy.	Poor.	Bluish green thin and poor.
5. Ditto at harvest ..	Thin, very bright col.	Stout, good.	Very pale and brittle.	Poor, dirty, dark greenish yellow.	Pale yellow.	Bright clean yellow.	Dirty yellow, very poor.	Dirty yellow, very poor.
6. Length of ear ..	$3\frac{1}{2}''$ to $3\frac{3}{4}''$	$3\frac{1}{2}''$ to 4″	$2\frac{1}{2}''$ to $3\frac{1}{4}''$	3″	$3\frac{1}{2}''$	4″	$3\frac{1}{4}''$	$3\frac{1}{4}''$ to $3\frac{1}{2}''$
7. Shape of ear ..	Lax.	Dense.	Rather lax.	Rather lax.	Lax.	Lax.	Lax.	Lax.
8. Leafage	Small.	Large.	Small.	Small.	Small.	Small.	Small.	Small.
9. No. of florets ..	9.	11.	7.	7.	6.	7 to 8.	7.	7.
10. How set	3.	4.	3.	3.	3.	2 to 3.	2.	3.
11. Colour of chaff ..	White.	Red.	White.	Red.	Red.	White.	Cannot say.	
12. Rough or smooth	Smooth.	Smooth.	Smooth.	Smooth.	Smooth.	Smooth.	Smooth.	Smooth.
13. Bearded or beardless	Practically beardless.	Beardless.	Beardless.	Beardless.	Slightly bearded.	Beardless.	Beardless.	Beardless.
14. Rustiness and mildew	Fair.	Fair to good	Bad.	Very bad.	Bad.	Bad.	Bad.	Bad.
15. Shedding ..	Fair.	Good.	Poor.	Good.	Good.	Good.	Good.	Good.

The yield of grain from Nhill, Yandilla King and Federation was practically nil, from Marshall's No. 3 very small, from Comeback and Gluyas small. I milled and baked a little from Comeback and Marshall's No. 3. The former behaved well in the bakehouse; the dough was tough, resilient and stable, the loaves of good size and shape. Using our technical terms to comprise these qualities, it possessed "stability" in high degree, and was "strong," in both points giving clear evidence of its Fife parentage. Marshall's No. 3 was poor in both respects, as well in the absolute sense of the term as in relation to Comeback.

In passing I would like to note the further illustration these cases provide of the principle that there is no correlation, at any rate in England, between strength and rapidity of maturation. For it will be seen that whereas an ordinary weak English variety occupied 42 days from earing to cutting, Comeback in spite of its rapid early growth required (say) 62. Red Fife, it may be noted, occupied 48 days in that stage of its growth.

These results from our 1908 crop were so unfavourable that I had some hesitation in making further experiments in England with Australian wheats. However, bearing in mind that the results already recorded concerned spring-sown wheats, and that the apparently fatal streak of bad weather in July might not be encountered in another season, I determined to try Comeback, Gluyas and Marshall's No. 3 again. In the meantime I had received samples of Bobs, Florence and Jonathan, and I included them in the set for our 1909 harvest. It will be seen that in this case I was using for the former three varieties seed raised in England, and therefore sown again within three months of harvesting, and for the latter trio seed raised in Australia and sown at least ten months after harvesting.

The Florence was "sprouted." This variety in several respects reminds one of the New Zealand "Tuscan," which seems to be more susceptible than other New Zealand wheats to the blemish, from a miller's point of view, of a tendency to "sprout" readily in wet or broken weather. If this characteristic be inherent in Florence, it is *prima facie* unsuitable to our conditions. However, I tried it, and obtained a satisfactory "plant."

The figures already given indicate the sort of season we had for our 1909 wheats. The six plots were situated on the same farm and soil as for the 1908 crop, and were drilled about the end of October. The weather had been superb for the time of the year, and the land was in first rate condition for planting. November was a particularly dry month, and not unfavourable as regards temperature. On December 6th I noted that these Australian wheats had germinated well, and presented quite a favourable appearance. In December we had rather more rain than usual, and some snow, but the conditions on the whole were not unfavourable to wheat. My notebook records that on December 27th: "Comeback very noteworthy for its light green colour."

This characteristic it maintained. Gluyas was of a slightly darker green, Marshall's No. 3 darker still, but all three stood out by reason of their lightness of colour compared with the other wheats around them. January and February were particularly dry; the rainfall was only about one-third of the average, and the temperature was on the whole mild, with one cold week in January and one in February. March was wet and cold, a very trying time for individuals, but all the wheats seem to have withstood it satisfactorily, with the possible exception of Jonathan, which had grown substantially, but had become of a peculiar colour. Very curiously two Indian varieties had grown very much even under the unfavourable climatic conditions. Like the Australians, their "trying time" had yet to come. About this time I had received from Mr. Charles Harper, of Western Australia, who had visited me in the previous summer, two more varieties—one, Alpha, which he thought might help us in our search for a good spring wheat; the other, Huguenot, a Durum of lovely appearance, which he thought might yield a straw suitable for cattle feeding. In this connection I should like to remark that we are still seeking for a variety which possesses this characteristic, and are ready to incur many more failures in experimental work, if there be the slightest chance of securing such an one.

I also received from South Africa a sample of the Australian Gluyas, which had been grown there. These three varieties were sown on March 26th. April conditions were favourable, average rainfall and temperature above the average. On April 25th I noted that Comeback, Gluyas, and Marshall's No. 3 were particularly forward, Jonathan and Florence a little behind them, and Bobs later still in this early stage of development. The spring-sown wheats were well in row on April 18th, 23 days after planting. By May 9th the Australian wheats, which up till then had shown a very favourable growth and had looked vigorous in comparison with ordinary English varieties, became spindly. Thereafter their history is a dismal one. June was a very wet month, but the rainfalls for May, July and August were below the average. As regards temperature early May was cold, due to winds long continued from cold quarters; later May was summerlike. In the wet June temperature was low for the time of year and rust was prevalent. Comeback came into ear about May 26th, but its appearance was then quite poor. Gluyas and Florence came into ear about May 28th, Jonathan about June 2nd, Marshall's No. 3 and Bobs about June 8th. Red Fife eared about June 16th and ordinary English varieties about June 20th. Jonathan, Florence, Bobs and Gluyas were very rusty; Comeback, though on the whole very poor, was less rusty; Marshall's No. 3 was a much better plot, and not nearly so rusty as the others. At this stage the spring-sown Australians showed no sign of rust. Bobs and Florence degenerated a good deal in the unfavourable June. Florence, later, had a particularly blue stem. July was not unfavourable, and the weather in the first half of August was "glorious," but the damage done to all the Australian wheats was irretrievable. Comeback, Bobs and the autumn-sown Gluyas became extremely rusted, in ears as well as on leaves. Indeed, in all cases it was no longer a question of goodness but of badness in varying degrees, and Marshall's No. 3 was the least bad.

As regards five of the six autumn sown ones, rust practically killed them, and the tiny quantities of grain contained in their ears the birds wanted, and I made no effort to stop them. Marshall's No. 3 yielded a small crop, the others practically nothing. For a time it seemed that the spring-sown Australians would do better, indeed the spring sown Gluyas came into ear about June 24th, when it was free from rust. The same remark applies to Huguenot, which had a stem just below the ears of corkscrew shape and was very "blue," but Alpha even then was very rusty on its bottom leaves. By July 18th this spring-sown Gluyas was slightly rusty; of Alpha I then recorded "leaves practically all dead from rust, ears fairly free"; and of Huguenot, "well grown, very slightly rusty." A week later, of these three I recorded "Alpha valueless," "Huguenot all right," and Gluyas "well worth saving." At the end of another week, that is to say on August 7th, I wrote:—"Huguenot very largely gone wrong, mostly the purple headed and purple strawed plants." The finish of their story is that spring-sown Gluyas did yield a little grain, and could be described as "fairly free" from rust; the Huguenot suffered from mould as well as rust, and practically no grain ever formed in its ears. Alpha was an absolute failure, for the straw died when it should have ripened. It seems to me quite unnecessary to set out in detail our tabulated records of these wheats. The story is dismal, and need not be prolonged. Marshall's No. 3 and spring-sown Gluyas were the "least bad," but on no point could I discover anything of any value to us in any of the 11 varieties I tried in all.

In 1905 the Agent-General for South Australia sought the advice of the National Association of British and Irish Millers "as to any improvements which may be possible in the conditions and quality of Australian wheat." I ventured then to say that "wheat growers at the Antipodes should be left to work out their own salvation." It seemed to me, and in the light of our subsequent experiences detailed herein, it is now more than ever apparent that English and Australian wheat growers can usefully interchange ideas on principles only. For instance, Comeback is superior in quality to any Australian wheat I know, but I understand that it yields much less grain than, say, Federation. Therein lies an exemplification of our English experience, on an average of many cases, as regards Fife and our common English varieties.

Farrer's demonstration that the better quality of Fife can be inherited intact by its child Comeback, and Prof. Biffen's work in showing not only that such a result is possible, but that it can be reproduced at will in accordance with Nature's own laws, show that it is possible in Australia to produce a wheat which is Comeback (or Fife) as regards quality of endosperm, and Federation in all other respects. In England we are obtaining the same sort of results, with the greatly important addition of immunity to rust or high resistance to rust included. The principles involved are subjects on which Britishers in both countries may with advantage interchange notes, but it is clearly useless to assume or think that our experiences as regards varieties, or even as regards methods of cultivation, can be of direct service, one to the other. Indeed, I have in recent years, when actuated by the friendliest feelings of sincere regard for Australian correspondents, advised them to try our rejections rather than our successes, for it seems to me the former may perhaps contain something valuable for Australian environments, the latter most probably do not. The problem for all wheat growers remains that we have to find or produce a variety or varieties suitable for the many environments with which each of us has to deal. The quest is long and troublesome, but well worth the support of producers and consumers and of their Governments. The consumer wants a plentiful supply of cheap bread, the producer a good profit. A rise of price brought about by natural or fiscal means may suit one class, it cannot the other; whereas an increase in yield resulting from the successful application of the principle I have specified, will suit all, and it is well within the bounds of possibility.

4.—NEW FACTORS IN SOIL FERTILITY.

By Dr. GREIG-SMITH, Macleay Bacteriologist to the Linnean Society of New South Wales.

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[ABSTRACT]

THE fertilising effect that follows the treatment of soils with volatile disinfectants, such as carbon bisulphide, ether, chloroform, toluene and benzene and with heat, has been traced to the increased growth of bacteria which ensues after the evaporation of the disinfectant. It is accepted that the increase in numbers corresponds to an increase in the breaking down of the organic matter of the soil, and consequent greater liberation of plant nutrients.

It is known that the number of bacteria found in normal soils is not the maximum possible ; there is a limiting condition. It has been suggested that the limiting factor may be plant toxins, bacteriotoxins, or phagocytic protozoa. The action of disinfectants and of heat upon protozoa can be understood, but the behaviour towards toxins is not at all clear.

The plant toxin idea is an old one, and although it may explain the action of plant upon plant, it can have no bearing upon the increase of bacteria after treatment with a disinfectant. The bacteriotoxin hypothesis has been advanced by Whitney and others in America, and the protozoal conception has been advanced by Russell and Hutchinson. The latter arrived at the conclusion

that there are no toxins in normal soil from the considerations that nitrification is as active as ammonification in normal soils, and that nitrification does not occur in toxic superheated soils. If, therefore, toxins were present the nitrifying bacteria would be unable to exist.

Some work upon soil bacteriotoxins has been done in the laboratory of the Linnean Society of New South Wales, and the full paper will appear in Part IV of the 1910 volume.

Bacteriotoxins are undoubtedly present in soils, and I have extracted a greater quantity from a poor soil than from a good one. If several soils of varying fertility are treated for an hour with water and filtered through porcelain, extracts are obtained which either destroy bacteria or restrict their growth. Experiments with one of these extracts, preferably the most lethal, will show after the extract has been boiled for an hour that it behaves as a nutritive solution.

The toxic and reverse actions can best be shown by using a pure culture of a putrefactive organism such as *Bac. prodigiosus*, but the same occur, though not in so pronounced a manner, with the mixed bacteria of the same soil from which the extract was obtained. With the mixture of soil bacteria, the toxic action is shown as a retardation of the growth of the bacteria as compared with the growth in the same extract after boiling. So far as my experiments have gone, the soil bacteria are not so sensitive to the toxins of their own soil as *Bac. prodigiosus* ; in other words, they exhibit a certain degree of immunity towards their own toxins.

The toxic effect may be considerable. For example, the aqueous extract from a poor sandy soil made by extracting 200 grms. with 200 cc. of saline for an hour was heated at 94° for an hour. Two days after it was boiled for an hour. The extracts were infected and incubated overnight at 30° ; in the morning the numbers of bacteria in the experimental flasks were determined.

		1,000 bacteria became
1	saline extract of poor soil	0
2	,, ,, ,, ,, heated at 94° ..	2,000
3	,, control	117,000
4	,, extract (1 above) two days after ..	73
5	,, ,, ,, ,, boiled ..	3,250,000
6	,, control	70,000

The experiment shows that toxin is contained in soil and is soluble in dilute saline ; it is partially destroyed at 94° and rapidly decays in aqueous solution ; boiling either converts it into a nutrient or by destroying the toxin enables the nutrients dissolved in the saline to act. This is one of many experiments, all showing that the action of heat upon soil extracts and inferentially upon soils is to destroy the bacteriotoxin and possibly to convert it into nutritive or fertilising matter. There may be other effects, but this is enough to account for the enhanced fertility of heated soils.

The fact that toxin decays in aqueous solution is sufficient to show the impossibility of obtaining information regarding bacteriotoxins by growing seedlings in watery extracts of soils. The decay of the toxin also occurs during the storage of the soil in the air-dry condition.

The toxin is destroyed by sunlight. A portion of soil was exposed to the sun for 12 hours, while another portion beside it was protected. The temperature of the former averaged 62°, the latter 42°, while the control in the laboratory averaged 20°. The extracts from these soils were seeded with *Bac. prodigiosus* and incubated overnight at 30°.

	1,000 bacteria became
Soil exposed to light	227,000
,, protected from light	11
,, in laboratory	9

There can be no doubt that the recognised beneficial effect of sunlight upon soil is caused by the destruction of toxin.

The power of toxin is not diminished by salts, such as sodium chloride, potassium sulphate or magnesium sulphate, for the toxic effect of extracts of soil made with 0.5% solutions of these is very pronounced.

If a deep layer of garden soil is saturated with carbon bisulphide and exposed to a current of air, a greenish-grey efflorescence may be noted on the surface as the solvent evaporates. This is the soil-wax or " agricere," which is doubtless the remains of the " ether-soluble extract " of the residual organic matter of the soil. It consists of saponifiable and unsaponifiable matter and acts as a protective covering to the soil particles. It " waterproofs " the decomposable organic matter.

The action of the disinfectants is a double one ; they kill off the less resistant bacteria, dissolve the agricere and carry it to the surface of the soil. A redistribution is effected. Furthermore, on the evaporation of the solvent, the agricere is deposited not uniformly over the soil, but at points on the surfaces of the particles in the uppermost layers of the soil. This can easily be shown by experiments on sand with a chloroform solution of a dark-coloured agricere. There is the possibility that much of the toxin may be deposited in a similar manner, but this has not yet been determined.

The behaviour of heat and the volatile wax-solvents can now be explained more completely than has hitherto been possible. Heat destroys the soil toxin and the less resistant bacteria. Doubtless there are other effects produced, but I believe they are of minor importance. Upon moistening the soil, the more resistant bacteria multiply and become more numerous than before on account of the absence of soil bacteriotoxins.

The disinfectants, while destroying the comparatively inactive bacteria, simply remove the waterproofing from the soil particles, thus enabling the surviving bacteria to obtain a greater food supply, in consequence of which there is a greater availability of the organic nutritive matter of the soil.

5.—TASMANIAN AGRICULTURE, WITH SPECIAL REFERENCE TO THE SOILS OF THE COUNTRY AND THEIR TREATMENT.

By H. J. COLBOURN, Department of Agriculture, Tasmania.

(Abstract.)

The climatic conditions of a country have to be considered in reference to its soils. The temperature conditions of Tasmania are chiefly affected by altitude and have reference to liability to night frosts. Tasmania is just outside the zone for successful culture of the vine.

The rainfall of Tasmania shows a greater relative difference than its temperature, and shows great extremes between the east and west, being very scanty upon the former and abundant upon the latter. Pulverising the surface soil to a depth of two or three inches is found an effective means for retaining moisture in the soil, and the districts of light rainfall would further do well to keep the surface of their soils in a pulverised condition in order to prevent rain from running off the surface when it comes, and rather encourage it to sink to the moisture-retaining reserves of the sub-soil.

Much good would result from growing varieties of crops suitable for semi-arid conditions, but seed must not be imported from the warm localities of the mainland, but rather from the cooler districts. Success has attended the importation of seed oats from Canada to Tasmania.

Soils require an abundant supply of humus to promote moisture retention and render them readily penetrable by the roots of crops. The requirements of the latter in this respect must be considered, as crops like wheat and clover require a firm seed, but whilst potatoes, turnips and barley prefer one that is friable. Virgin soils are fertile because they contain much humus, but the sub-soil cultivation exerted by the roots of trees must be considered. Tree roots go deep, and in the process of decay leave channels for water and the roots of crop to travel down. After a time these channels close, hence the conditions for fertility are later on not so good. Deep-rooting crops should be employed to imitate the action of tree roots as far as possible. Humus, in decaying, produces carbon dioxide, which, dissolved in water, increases the solvent action of the water. This depletes the soil of its lime, which should be regularly applied at proper intervals wherever high farming is practised. Humus is best furnished by ploughing in green crops, and lime should be applied at this time to promote decay of humus and correct tendency to acidity which freshly ploughed in vegetable matter exhibits. Leguminous crops should be used for ploughing in, because these supply nitrogen to the soil.

Powdered limestone is a suitable form of lime to apply when the soil is deficient in organic matter. For this purpose the purer the form of limestone employed the better, as the presence of silicate of lime retards the assimilation of lime by most plants. Powdered limestone improves the permeability of clay soils to water.

Draining is an important means for ameliorating the condition of soils, and is much neglected. Soluble salts of iron and acidity of the soil are connected with bad drainage and consequent sterility of soils. Tasmanian soils are very variable and generally derived from the rock immediately underlying them.

Great difference is sometimes shown between surface soil and the underlying one in Tasmania which may be due to want of earthworm action in equalizing surface and sub-soil. This is a subject deserving further investigation. Arable sub-soils are frequently too compact in Tasmania, and not much evidence of earthworm action is shown. To neutralise this difficulty, sub-soil ploughing is recommended.

Of the manures used in Tasmania the phosphatic are largely employed, bones and super being the chief of these. The ferruginous soils of the basalt regions require phosphates, because iron renders the phosphatic acid present unavailable to a large extent. Potash and mixed manures are coming more and more into use, especially upon the worn-out soils.

6.—THE AUSTRALIAN ASPECT OF AGRICULTURAL EDUCATION.

By H. W. POTTS, F.C.S., F.L.S., Principal, Hawkesbury Agricultural College, Richmond, N.S.W

In the pursuit of agriculture the great body of our pioneer farmers have not accepted so far the full value of technical and mental training, mainly for the reason that in the occupancy of a new country, such as ours, with its vast areas and insufficient means of communication, they have been compelled to endure all the hardships of isolation, have had to struggle with the primitive stages of settlement and face muscular effort under the most adverse and discouraging circumstances.

With the rapid formation of roads, the construction of railways, the more reliable means of transport of perishable food to the best markets of the world, increased population and closer settlement, we find these rugged phases of agricultural life disappearing.

The dull daily routine of the untrained settler is being steadily replaced by one demanding greater skill and intelligent application. The avocation is perceptibly changing. Applied science is invading every section in which experiment, foresight, invention and expertness combine to effect a progress startling in its effect, and with the tendency to release the modern agriculturist from the tedious drudgery so long associated with farm work.

One is fully sensible of the fact that there are many aspects of successful farming which cannot be taught in an academic sense, and can only be acquired by experience. That experience, however, it must be fully admitted, can be enriched by a scientific grasp of the principles underlying all operations on the farm. It is a healthy reflection to note the pronounced and welcome attitude of public men towards the subject of technical and secondary education, more especially towards that section devoted to the primary industries.

The spirit of investigation and research is being substantially encouraged. Ideals of thoroughness are stimulated and are more keenly appreciated. Mr. Balfour recently stated : " Almost every discovery of Pasteur and Lord Kelvin found its immediate echo in some practical advantage to the industries of the world."

The unskilled workman indirectly benefits, and by reason of this he justly commands a much higher wage than his grandfather.

Is not the great prosperity and change effected in the past 50 years due to the progress of invention and the application of science reinforced by a better educated agricultural population ?

With our limitless opportunities, immense unoccupied lands, unrivalled climate and rich soils, we possess natural advantages of an unusual nature, and given a trained rural population, our lasting prosperity is assured.

What may be claimed as the healthiest of our pursuits in such an ideal climate demands the guiding spirit of specific training, and a system of education through which the attractiveness of nature and the glorious works of the Creator may be appreciated. This can only be awakened by the earliest contact with nature study and elementary training in agriculture in our primary schools.

Huxley states :

> " No educational system can have any chance of permanence unless it recognises the truth that education has two great ends to which anything else must be subordinated. The one of these is to increase knowledge and the other is to develop the love of right and the hatred of wrong."

With an adequate conception of the method of unfolding nature study, a teacher has the power to stimulate and fan into existence in the child mind a bias towards rural occupations and an affection for nature's beauties.

The fascination of the study and its refining influence, the habit engendered of keen observation, the discipline of the mind and the aroused mental efforts, combine in the child to aim at " seeing, understanding, enjoying, and practically learning from the natural world around us."

The child is taught to estimate the meaning of each natural object, be it bird or flower, tree or animal, river or rock, insect or weed. The training acts in relationship with our forces to create mental activity and to educate with definite efficiency and usefulness. A child intended for a country life has thus his earliest conceptions quickened into a love for nature's surroundings and an elevating interest aroused in what would otherwise prove a monotonous environment. He is brought into sympathetic touch with rural pursuits. A respect and affection is developed for a life on the land. The country lad in contrast with his urban *confrère* as a rule is handier, more self reliant, courageous and resourceful.

Nature study has been wisely termed " the sheet anchor of elementary education." " A touch of nature at first hand is the very breath of mental life." We realise that the inspiration, the knowledge of nature's laws, the spirit of enquiry to be brought into tangible being in the impressionable mind of a child depends much on the mental outlook, training and enthusiasm of the teacher.

Happily there is little cause for doubts as to the capacity, initiative and enthusiasm of our Australian teachers. The response to the call for special training in the work was highly satisfactory. The first Summer School held at the Melbourne University in 1902 was attended by 500 teachers, at which nature study formed a prominent feature in the curriculum.

A Summer School was established at the Hawkesbury College during the mid-summer vacation of 1905, at which 100 public school teachers went into residence for three weeks. The course of training included nature study, elementary science, school gardening, experiment work, with opportunities offered of instruction in the orchard, poultry yard, piggery and dairy. So far 600 school teachers, of both sexes, in New South Wales, have availed themselves of this training at the College, where they were under the direct guidance of a competent staff with a full equipment in each section of the work.

The effect throughout the country districts is substantially evident. The Department of Public Instruction's curriculum makes full provision for introducing nature study, school gardens, and experiment work in the schools. A travelling instructor is engaged to assist. Furthermore, the Education Department awards ten resident scholarships to students at their Training College in Sydney to complete the course of training at the Hawkesbury College for twelve months. This includes theoretical and practical agriculture, nature study, elementary chemistry, botany, zoology, meteorology, geology, with practical work on the farm, orchard, flower and vegetable gardens, school garden, poultry yard, dairy and piggery. This course is designed solely to prepare the teacher to deal with those subjects in an elementary and simple fashion for training children attending the primary schools. Thus the facilities and educational stimulus are provided for checking in a natural way the inflow of country children to the cities. The love for a country life, the farm, and domestic animals is awakened. The child is freed from depressing artificial agencies and develops a taste for a sturdy independent, congenial means of earning his living.

The introduction of the Rural Camp School by the Education Department provides another effective agency by which our city bred lads secure an opportunity of gaining an acquaintance with country life and its many attractive phases. This establishes a vital connection between the city schools, high schools, farm schools and the college. A perceptible outflow is already in progress to the land from this well thought out scheme.

Secondary education in agriculture, if wisely initiated and controlled, is bound to spread with as strong a wave of popularity in Australia as it has done in the United States and Canada. In those countries they have learned to think in agriculture and place their primary industries in the front rank of national importance. In 1889 there were but ten agricultural high schools in the States, and the training of teachers in agricultural topics with nature study had only started. At the present time there are over 60 agricultural high schools and 400 public high schools teaching agriculture. In addition, 125 State or County normal schools and 16 agricultural colleges are training teachers to understand agriculture and to include this with nature study in their course of training. In Australia a commencement has been made. The first continuation agricultural high school was opened by Sir John Cockburn in Adelaide, South Australia, in 1897, where provision was made to bridge the period between the time the lad left the primary school at 14 and entered the Roseworthy Agricultural College at 16. During these two years the subjects taught are advanced arithmetic, algebra, geometry, book-keeping, mensuration, land surveying, mechanical drawing, English, botany, elementary agriculture, chemistry and manual training.

In Victoria five high schools are established in which a similar course of training is pursued, but to each a considerable area of land is attached to use for gardens and a farm. This training prepares the student for entrance to the Dookie Agricultural College.

In New South Wales similar provision is projected in the extensive educational scheme recently approved by the Government. Each high school will furnish the requisite training between the ages of 14 and 16 to boys intended for entrance to the Hawkesbury Agricultural College. Already the Hurlstone Agricultural Continuation School has carried out excellent work in this direction. Several of the most prominent students at the annual examinations at the Hawkesbury College during the past three years have come from Hurlstone.

The aim throughout is the proper preparation of the student for the more complete, higher and thorough training at the agricultural college, and in this work admirable results have been achieved. Thus the connecting link of the educational chain between the primary school and the agricultural college is established.

The selection of an avocation by any lad is a serious step in his life, and if possible it should be made before the conclusion of the primary stage of his education.

To attempt to force a city lad to select an avocation most suitable to his inclinations and tastes without some direct knowledge of it is fraught with some difficulties, but it is evidently wiser to direct his education and training towards the land at an impressionable age. It is in this direction that the high school will prove most valuable. Where a break in his education takes place it is difficult to get him to resume it. Often a lad is sent into the country to ascertain if he is likely to care permanently for a rural career. This frequently ends in his staying there and missing the golden opportunity of his life. He gets out of touch with academic life and studies; discipline and mental training are relaxed; he abandons his elementary studies at a stage when their practical application is not appreciated or understood; he gets into a groove in the country and he fails to secure that mental and technical training which is so essential to his success. Such cases are constantly being met with in the bush. The argument that a lad may choose badly has no validity in practical experience.

Some 1300 students have been trained at the Hawkesbury Agricultural College, and 72 per cent. of these are known to be permanently engaged in agricultural pursuits. The agricultural college course of three years is adopted in three colleges in the Commonwealth—Roseworthy, Gatton and Hawkesbury. One year is allowed to students attending the full course in a high school or agricultural continuation school when entering Roseworthy or Hawkesbury.

The syllabus of the Hawkesbury College commences :—

"The primary object that the Department of Agriculture had in view in establishing the above-named College and Farm was to teach the science of agriculture and the various other sciences connected therewith, and their practical application in the cultivation of the soil and the rearing and management of stock, and to qualify its students as far as possible for the profitable management of farms, dairies, orchards, or vineyards, either as proprietors or paid managers of same. To this end it is deemed indispensably necessary that every young man who may be admitted to the College shall learn to labour and become proficient in the use of the various implements of husbandry employed on the farm, and in the management of the various kinds of live stock connected therewith. Each student therefore is required to perform a certain amount of labour."

Thus we have a combination of "brain craft" with "hand craft."

In pursuance of this policy students are engaged on alternate days in all the practical operations of the farm, orchard and dairy and in the management of stock. The work is arranged so that each student becomes familiar with every implement, horse and method on the farm, and acquires dexterity in each operation.

The aim throughout is to afford a student such training as will equip him for a useful and profitable life on the land. The general conditions to be observed in obtaining admission to this college include an entrance examination or the possession of a certificate showing that the applicant has attained a degree of educational efficiency from some public school or examining body equal to that prescribed for the college entrance examination. Each student is required to pass the annual examination at the end of each year of the course before being admitted to that of the following year.

I may here be permitted to emphasise the necessity for a change in the period allotted to the holding of annual examinations. We seem to have been guided by old world tradition in this regard. The period selected in England, viz., December, is cold in temperature and at a time when farming operations are not active. Here, however, climatic conditions vary. Despite these we adhere to the old system. Climatic conditions are not comparable. With the rapid advent of summer towards the end of the year farming operations are self-evident and urgently acute. Students and staff alike are busily engaged in harvesting and the other urgent farm work. At this period we are pestered with dust, flies and mosquitoes, and a rising, uncomfortable temperature. Thus with enforced extra work on the farm and abnormal natural conditions students are compelled to submit themselves to the crucial practical and theoretical test of their lives. On this the certificates of competency are awarded. It would be more sensible to hold the annual examinations in June each year.

The University has made excellent provision for training students through to the Bachelor of Science degree in Agriculture. From this source we will derive our much needed army of science teachers and research workers.

Apart from this system of training the lad from the primary school to the university, other sources of acquiring agricultural training have been founded under varied conditions. Our experiment farms are developing schools for training in farm work, and relieve to a great extent the tension on the college, more especially where a lad's preliminary education is weak, and his training will equip him for the heavy or laborious side of farm life.

Apprentice schools and other means of making provision for training are now being organised. The advent of the winter school has proved an effective response to a demand from farmers already settled on the land. Provision is made at the Hawkesbury College during the ordinary mid-winter vacation, when busy farmers have spare time available. Here they assemble for one month in residence and take up training in any section of farm work likely to be of service to them. This school is becoming very popular, and evidently has proved useful, seeing that every winter the numbers increase.

Another aspect of agricultural education in Australia demanding public attention is the low salaries offered to teachers of agricultural science and practice. Adequate salaries are not offered to attract the best men, who find other avenues more profitable. We require trained experts possessing special ability, enthusiasm, and pedagogic instincts.

We labour under a serious disability in this direction. It is often noted that large sums of money are readily made available for buildings, stock and equipment, but when the question of a proper remuneration is raised the tendency is to keep salaries down to such an ebb that it is difficult to secure the services of a competent staff, and no encouragement is offered to enter the service.

Teachers frequently meet instances where their pupils are enjoying the results of their skill and training in a much more profitable manner.

I may conclude with the affirmation that in the Australian boy we have excellent material for raising an educated yeomanry equal, if not superior, to that of any other country. He is finely tempered, easily controlled, endowed with superior natural alertness, keen, and with a continuous and well-balanced sense of fairness.

7.—SOME ASPECTS OF THE NITROGEN QUESTION.

By PROFESSOR R. D. WATT, M.A., B.Sc. (Agr.), University of Sydney.

THERE is no problem in the whole realm of agricultural science which has given rise to so much discussion and has been the subject of so much investigation and research as the source of supply and method of absorption of the element nitrogen by plants. The mere mention of the term "Nitrogen question" calls to mind the historic researches of De Saussure and Boussingault, the prolonged controversy between Liebig, on the one hand, and Lewes and Gilbert on the other, the illuminating discovery of Hellriegel and Wilfarth and all the later developments with which are associated, amongst others, the names of Warrington and Winogradski, Beyerinck, Ashby and Hall, and, more recently, Russell and Hutchinson.

To each of these we are indebted for some new light on the subject, either of the original source or the modes of absorption of the plants' nitrogenous food material. There are, however, still many obscure points connected with the problem which require elucidation. Anyone who has had the experience of studying crop results in conjunction with soil analysis in a moist and temperate climate like that of the British Isles, and also in a semi-tropical and semi-arid country such as the High Veld of the Transvaal, or the wheat fields of Australia, must have been confronted with puzzling anomalies, especially with regard to the nitrogen question.

People nowadays are inclined to belittle the value of the chemical analysis of soils, but, as far as my experience goes, the percentage of nitrogen in a soil has proved a fairly reliable guide as to the necessity or otherwise for nitrogenous manuring, when due allowance has been made for climatic conditions, for the nature of the crop and for the physical character of the soil. Thus, I think, it may be taken for granted that in Great Britain a clay loam or clay soil which contains less than 0.1 per cent. of nitrogen will respond to nitrogenous manuring in the case of both cereals and root crops. The results obtained from the historic wheat plots on the Broadbalk field at Rothamsted may be regarded as typical.

The soil on this field is a clay loam containing 0.099 per cent. of nitrogen, and the following figures give the average yield of wheat for 50 years on five of the plots :—

	Bushels.	Difference.
No manure	13·1	
Complete Mineral Manure each year	14·9	+1·8
Ditto, +Ammonium Salts, equal to 43lb. Nitrogen	24·0	+9·1
,, ,, ,, ,, 86lb. ,,	32·9	+8·9
,, ,, ,, ,, 129lb. ,,	37·1	+4·2

The results varied somewhat from year to year according to the season, but the same general order prevailed throughout, so that, I think, it is not too much to say that the main determining factor in the production of wheat under Rothamsted conditions is the supply of a sufficiency of readily available nitrogen.

Anyone who assumed that similar results would be obtained under widely different climatic conditions would find himself very much at sea. This was forcibly brought home to the writer by the results of the first accurate manurial experiments carried out in the Transvaal, South Africa. At the Government Experimental Farm at Potchefstroom, on a soil containing little more nitrogen than is contained in the Rothamsted soil, there was no increase in the yield of wheat, oats or maize due to the application of a nitrogenous fertilizer, either used alone or in conjunction with other fertilizers. Again, a soil containing only 0·075 per cent. of nitrogen, near Pretoria, failed to respond to a nitrogenous fertilizer with maize, and many similar examples from South African practice could be given in the light of more recent experiments.

In the wheat belt of New South Wales, which has a rainfall of 17 to 26 inches, very similar results have been obtained. Thus a soil at the Experimental Farm at Bathurst, containing exactly the same percentage of nitrogen as the Rothamsted soil, gives *no increase*, and a soil from the Wagga Experimental Farm containing 0·065 per cent. of nitrogen, a *very slight* increase through the use of a nitrogenous fertilizer. And a sandy loam soil occurring near Cowra, with only 0·042 per cent. of nitrogen—a hopeless quantity from an English point of view—has, during six out of the last seven years, given an average crop of 16½ bushels of wheat to the acre, thus showing no great need for a nitrogenous manure.

It is obvious, then, that a smaller proportion of total nitrogen suffices to give a full crop in semi-arid Australia than in moist and temperate England and that nitrogenous fertilizers do not have such an effect as one would expect from English experience, and the object of this short paper is to enquire into the reason for this.

One explanation offered in the Transvaal was to the effect that heavy rains washed soluble nitrogenous fertilizers into the sub-soil out of the reach of plant roots; but surely the holder of such a theory must be ignorant of the fundamental principles of soil physics and of the depth to which the roots of ordinary agricultural plants penetrate in semi-arid regions.

Another theory is that the addition of readily soluble nitrogenous fertilizers to a soil causes too great a concentration of salts in the soil water, and I have no doubt but that this accounts in some cases for the diminished yield sometimes obtained by the use of soluble potassic as well as nitrogenous fertilizers.

The real explanation, I think, is a two-fold one. In the first place, the optimum percentage of available nitrogen (chiefly nitrates) in the soil is lower the more arid the climatic conditions. It is well known that one effect of excessive nitrogenous manuring is greatly increased leaf development, whch means an unduly large transpiring surface—a condition of things which is inimical to successful crop production in a country with a limited rainfall and subject to hot drying winds.

In the second place the ratio of available nitrogen (nitrates) to total nitrogen in the soils of semi-arid and semi-tropical countries is greater than under more humid and temperate conditions, for two reasons, namely :—

(1) The diminution in the loss of soluble forms of nitrogen through drainage.

(2) The increased bacterial activity of the soil.

In a country like England, with a heavy rainfall and low evaporation, the surplus water is mainly lost by percolation, *i.e.*, by natural or artificial drainage, with the result that there is a considerable loss of soluble salts, especially nitrates, whereas in such a district as the wheat belt of New South Wales, with a limited rainfall and a high evaporation, the bulk of the water not used by the crop is lost by evaporation, and the soluble salts are therefore retained in the soil.

That there *should be* increased bacterial activity in the soils of warmer countries one would naturally anticipate, and that there *is* such increased activity as far as the nitrifying bacteria are concerned has been conclusively proved by some experiments carried out by the writer in the Transvaal.

The method adopted was as follows :—

A solution was made up containing the following quantities of the various salts per litre :—

Potassium di-hydrogen phosphate ..	0·25 grs.
Magnesium sulphate	0·125 grs.
Ferrous sulphate	0·1 grs.
Sodium chloride	0·5 grs.
and Ammonium Sulphate	0·5 grs.

This solution has been used by Ashby, Hall and others in nitrification experiments, and has been found to be very readily nitrifiable, when the necessary organisms are introduced. 200 cc.

of the solution were placed in conical flasks of 450 cc. capacity, and sterilised in the usual way. To each were added 0·4 grs. of sterilised calcium carbonate and exactly 0·4 grs. of each of the soils under investigation. The flasks were then put in an incubator at 29 to 30° C., and the solutions were tested from time to time for the presence of ammonia, nitrites and nitrates.

It is not my intention to give a full account of the results, the details of which will be found in the Annual Report of the Director of Agriculture for the Transvaal for the year 1907-08.

Briefly, however, the results were as follows :—The experiments were conducted with 21 soils, varying from poor sandy soils to stiff black clays. Nitrites and traces of nitrates were found in all the solutions within a fortnight. In periods varying from 19 to 32 days and averaging 25 days from the time of inoculation, all the ammonia contained in the solutions had been changed. In from 28 to 46 days nitrification was complete, all the nitrogen present in the solutions being in the form of nitrates, the average length of time taken for the completion of the reaction being 39 days.

The incubation temperature, strength and volume of solutions, etc., were purposely chosen so that the experiments might be comparable with some of a similar nature conducted at Rothamsted by Ashby. (See Journal of Chemical Society, 1904.) In the English experiments nitrites were seldom present in the solutions within a fortnight and rarely in three weeks, in 30 to 35 days the bulk of the nitrogen was still in the form of ammonia, and nitrification was often incomplete in 60 days.

It seems therefore reasonable to conclude that the nitrifying organisms are present in larger numbers or in a more active form, or both, in the soils of the High Veldt of the Transvaal than in England, and that with the higher average temperature prevailing in the former country they perform their functions much more rapidly and efficiently, and there is a strong probability that the same is true of Australia, where the climatic conditions are similar, namely in the semi-arid areas. Whether the increased activity is purely a question of temperature, or whether it has something to do with the generally drier conditions of the soil being less favourable to the enemies of bacteria (protozoa), than the bacteria to themselves is a matter for further investigation.

8.—ON THE PROPORTION OF FERROUS SULPHATE USED AGAINST THE "WHITE ROT" OF GRAPE VINES.

By M. BLUNNO, Department of Agriculture, Sydney.

It is generally known that the "pourridié," or white rot of the root system of the grape vine, is principally caused by a fungus which can live as saprophyte and as parasite *i.e.* the *Dematophora necatrix*, although various cryptogams occur. In Australia this vine disease occurs very frequently, for vineyards are often planted in ground but recently grubbed, and many root stumps big and small are left in the ground. The *Dematophora* infecting these stumps as saprophyte spreads to the vine ; or the soil itself, where the forest was, is infected, and in either case the fungus finds the vine a suitable host. It causes more damage in clay or other stiff soils, but even in sandy soils the vine may be affected, although in such cases the fungus principally responsible for it is the *Dematophora glomerata*. All vines are subject to such disease, which may be slow in its spreading, but certain n its deadly effect. Usually when the fungus finds suitable environment the vine is killed after about three years. An impervious sub soil with no natural or artificial drainage, apt therefore to get water-logged, is a factor that much helps to render the disease more fatal. It spreads very much like phylloxera, making round patches ever increasing in diameter, and the appearance of those vines suffering from the white rot is also very much like that of those suffering from phylloxera.

Some species of vines originally from North America, which are resistant to phylloxera, are just as liable to " pourridié " as the Vitis vinifera, and to the same extent are apt to suffer by it.

The Vitis rupestris, for instance, is specially subject to it, as have the roots a very narrow angle of geotropism, and therefore tend to reach the deeper layers of the soil.

The vineyard at the State Viticultural Station near Howlong in the Riverina was planted in 1899 and 1900, soon after the ground, which was a travelling stock reserve, had been cleared of its green timber. Two years after I first noticed the symptoms of " pourridie " in the block of Rupestris Metallica ,where the ground, which is very flat all through, takes a dip. It extended every succeeding year, and the affected patch was conspicuous for the chlorosis of the foliage, the terminal portions of the shoots being the first to show the yellow tint, which gradually gained the whole branch. Neither the leaves nor the branches attained their normal size. An examination of the portion of the stem underground and of the roots showed them to be affected with " pourridié," also an examination of the other blocks in the same vineyard proved that the fungus had a hold, more or less, all through the plantation. The worse affected after the Rupestris Metallica was the Riparia Grand Glabre, then the Riparia Gloire de Montpellier, and both these sorts are in a very light sand loam about two feet deep, resting on a stiff sub-soil at a varying depth. The roots of the Ripariæ have a very wide angle of geotropism, they run therefore closer to the surface, still the degree of infection was only next to that on the Rupestris Metallica. It is rather curious that the same Riparia Grand Glabre planted just alongside, but in a fairly stiff clay, showed little signs of the fungus. I believe that these apparent anomalies could be explained if we had a record tracing of the bush land showing the location of the biggest trees, or if we could locate the position of roots left behind in the clearing and their nearness to the layer within which the vine roots extend, that is, if we could locate the original foci of the Dematophora and allied fungi.

The Rupestris Martin, the Mourvèdre x Rupestris No. 1202, the cordifolia x riparia—Rupestris No. 106^{8}, the Rupestris du Lot, the Aramon x Rupestris Ganzin No. 1, the two Riparia x Rupestris Couderc, and the Riparia x Rupestris Millardet are affected in the order in which I named them. It goes without saying that I am speaking of my experience at the above mentioned State Institution, because in other countries, in France for instance, the Rupestris du Lot, which is one of the most popular Phylloxera resistant stocks, is found to be very sensitive to white rot.

Five years ago the block of Rupestris Metallica, which first showed to be affected, was uprooted, and this sort was not missed, because experiments here and in Europe proved it to be a stock inferior to the Rupestris du Lot on account of its failing vigor in rather dry climates, after a few years of good vigorous growth. Incidentally I might mention that the Rupestris Metallica had first been imported into Cape Colony, hence it was known in British vinegrowing communities as the Cape Rupestris.

The block formerly occupied by it was cropped with wheat, as cereals are the only plants that are not affected by white rot. Last year after draining that block through the hollow portion of it, the hollow portion was filled with surface soil taken from the adjoining paddock where the ground is a sandy loam. Last winter between six and seven hundreds of Riparia Gloire de Montpellier were planted. In the meantime I endeavoured to check the "pourridié" in the other blocks.

A complete drainage of the whole area under vines was considered a rather expensive undertaking in view of the lay of the ground; therefore I had to resort to the direct application to the vines of such substances as are generally admitted to have some effect in checking the spreading of the fungus. Five years ago bisulphide of carbon was injected at the rate of one ounce per vine, divided in five partial injections made within 6″ to 8″ from the stem.

The fumes of bisulphide of carbon applied in the proportion above-mentioned will kill the mycelium living externally, that is, during the first stage of the infection. Such dose, however, could be hardly sufficient to extinguish the old foci of infection represented by the roots of the once existing trees. Repeated and stronger doses would be necessary, but then the vines themselves would suffer before the fungi on the rotting timber were reached. I came to the conclusion then that a *modus vivendi* was the only success I could hope for under the circumstances. Having tried the bisulphide of carbon in a quantity that was within reasonable cost, I resorted to the application of ferrous sulphate in the next treatment. Thus in the winter 1908 I applied 8 ounces of ferrous sulphate in crystals per vine, followed by 16 ounces applied in the winter 1909. Having noted the beneficial results, 16 ounces more were applied last winter, that is 2½ lbs. in all per vine in three successive winters. The ferrous sulphate is applied in the usual way by digging a hole round the stem about 6″ deep and 12″ radius, at the bottom of which the chemical is evenly scattered and then the soil put back.

The reason for my reading this paper is to invite your attention to the very large proportion of ferrous sulphate applied to each vine. About 38 ounces of ferrous sulphate in all were applied in three consecutive winters to every vine within the worse infected blocks, instead of the proportion usually suggested of one handful of either copper or ferrous sulphate for two successive seasons, which would amount to 7 or 8 ounces in all, with which, however, the cure is not guaranteed.

The reason for my preferring the ferrous sulphate to the copper sulphate is, I think, a very good one in view of the fact that the price of the latter is four or five times greater.

An examination of all the vines, which is made every year at pruning time, showed last winter that hardly any trace of the disease was evident, which, when present, is plainly seen in the shape of whitish streaks or patches on the stem round or a few inches below the collar. Furthermore, during last winter, the ploughing and subsoiling of the whole vineyard commenced in the previous winter months was completed, and during the operation a few vine roots here and there were brought to the surface, and on being examined were found to be absolutely clean and healthy. Two vines, however, in the whole vineyard of full grown ones were the exception. In February, 1909, I noticed a Tokay vine grafted on the Mourvèdre x Rupestris No. 1202, and another grafted on the Rupestris Martin ; they were in the same row and about 40 yards apart. The foliage of both was quite yellow and the growth poor. An examination of the stem 5″ to 6″ below the ground showed that the " pourridié " had a hold of the two plants. There and then I daubed that part of the stem with a solution made up with 10 per cent. in weight of sulphuric acid and 50 per cent. of ferrous sulphate. The effects were not immediate ; we were in February, and there were but seven or eight weeks left of the vegetative and assimilative period, but on the 30th November last year, on the occasion of a visit from the Albury Vine and Fruitgrowers' Association, these two vines were as vigorous and healthy as any in the vineyard. The Tokay grafted on the Mourvèdre x Rupestris could be shown to the visiting party, the other vine grafted on the Rupestris Martin could not, because the superintendent, having forgotten to put a mark on the plant so treated, we were unable to discover which was which, as the vines looked all equally healthy and vigorous.

There is little doubt that for some time after the application the ferrous sulphate acts as a fungicide, but after a while it is likely that its composition undergoes a change. Under the influence of the complex ingredients of the soil, it may be assumed that the sulphate of iron will finally produce ferric oxide and some alkaline sulphate, probably potash sulphate. The application of ferrous sulphate to the soil would in consequence have an effect similar to that which is attributed to gypsum, and we know that the latter substance is a vigorous stimulant to vegetation.

9.—ACUTE BOVINE CONTAGIOUS MAMMITIS DUE TO BACILLUS LACTIS AEROGENES.

By PROFESSOR J. A. GILRUTH, D.V. Sc., M.R.C.V.S., F.R.S.E., and NORMAN MACDONALD, B.V. Sc., from the Veterinary Institute, Melbourne University.

THE paper records an outbreak of a contagious form of acute inflammation of the udder, due to the Bacillus Lactis Aerogenes. The bacillus in question, although common in dairying premises, and particularly in piggeries, has not heretofore been considered pathogenic for cattle, and is not so when introduced by the alimentary canal or subcutaneously. In this instance, however, it has been isolated by the authors from the outbreak in question, cultivated, and proved to be the causative organism by the reproduction of the characteristic features of the disease in experimental cows when introduced into the milk ducts of the lactating udder. Preliminary experiments conducted indicate the possibility of producing an anti-toxic serum which may prove useful in the treatment of ordinary cases, and these experiments are being continued by the authors.

The outbreak of mammitis dealt with was undoubtedly spread by the careless management and insanitary conditions of the milking machine employed on the farm, and this emphasises the necessity for the utmost care in attending to the cleanliness of such appliances.

10.—THE "BRAXY" TYPE OF SHEEP DISEASE IN AUSTRALIA.

By PROFESSOR GILRUTH, D.V. Sc., M.R.C.V.S., F.R.S.E., Melbourne University.

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" Braxy " is the popular term applied in Scotland to an enzootic disease of sheep chiefly characterised by its sudden fatal termination, with few or no premonitory symptoms, its predilection for young animals in good condition, its prevalence during winter months, its rare appearance at other times of the year, the rapidity with which putrefactive changes occur after death, and the presence of sero-sanguineous effusions within the serous cavities and subcutaneous tissues, and very frequently, if not constantly, acute congestion and even necrosis with ulceration of the mucosa of the true stomach or abomasum.

A similar disease of sheep is recognised in Norway, Denmark and elsewhere under the name of " Bradsot." In addition, a disease affecting young sheep feeding on turnips in New Zealand has been described by myself under the term " Braxy-like Disease of Hoggets." These will be discussed more fully later on.

During the past 18 months I have had an opportunity of examining several cases of a disease in two outbreaks (one in Tasmania, the other in Victoria) which, although differing in some slight respects from each other, yet correspond with " Braxy " in nearly all its essential features.

From each of these outbreaks have been isolated bacilli which in small doses of pure sub-cultures reproduce the essential lesions of the disease, and although the bacilli vary somewhat in certain minor characters, which serve to distinguish the one from the other, there is no doubt that at most they are but variations of the one organism-type.

The Disease in Tasmania.

History.—The disease appears to have been known for a number of years, and causes a definite, though varying, annual mortality on certain properties.

Season.—The months of August and September, I was informed, comprise the period of the year when the disease is most prevalent. It may appear earlier, however, much depending, according to the experience of observant stockowners, on the nature of the season ; the spring rains, which are followed by a growth of young grass, appearing principally to determine the onset of the mortality.

This was well illustrated in 1909, when, owing to the mild weather and copious rains in the month of June, the young herbage commenced to spring earlier than usual, and, as was anticipated, the disease occurred at a correspondingly early date.

Age and Condition Incidence.—Young sheep (hoggets) and those in good condition are almost exclusively affected. Rarely are adult sheep affected, while young sheep in poor condition, or suffering from debilitating parasitic affections, are apparently naturally immune.

District.—The centre of the island is said to be the principal part of the sheep country affected. It appears to be confined to the comparatively richer soils, but this may be only associated with the greater likelihood of such land carrying sheep in good condition.

Mortality.—This varies very considerably, but in some cases up to 15 per cent. of the total young flock has succumbed to this disease.

Symptoms.—Rarely are any symptoms observed, so much so that one sheepowner, who had had ten years' experience of its ravages, during that period only observed two living cases, one being seen curiously enough on the day of my visit. The almost invariable experience is for the affected animal to be found dead during the shepherds' morning round. The attitude is generally that of sleep, and there is no evidence of struggling prior to death.

Post-mortem Appearances.—Almost invariably the cadaver is in a more or less advanced stage of putrefactive decomposition, with much tympany of the stomach and bowels and frequently there is a blood-stained froth issuing from the nostrils. The wool is generally readily detachable, and the skin is often livid in the groin, armpits, etc., while the subcutaneous tissues are more or less emphysematous. That much, if not all of this, is of post-mortem occurrence is evidenced by the fact that in the living animal on the point of death these phenomena were absent, while in one dead not many hours they were but slight. In the subcutaneous tissues are patches of œdema more or less blood-tinged. The peritoneal cavity contains a varying quantity of clear, sero-sanguineous, or at times cloudy effusion, generally with a peculiar odour of putrefaction, but in a slaughtered animal such odour was absent. The abomasum, so far as I observed, did not constantly exhibit pathological changes, though, according to Dr. Willmot, there is always "a certain amount of blood-stained mucus, with œdematous patches, more or less tumefaction, and may be necrosis or gangrene." As later on, however, he states, "in no part of the body is there any evidence of inflammatory action having taken place," it is difficult to follow his description. That the stomach may exhibit well marked lesions was shown by examination of a sheep killed in the later stage of the disease, wherein the abomasum mucosa showed near the cardiac orifice, a well-defined inflammatory area about two inches square, the centre being necrosed. The small intestines are often injected and show patches of hæmorrhage. The liver is very often congested, and may show greyish yellow necrotic areas. Kidneys are more or less congested. Spleen may be normal or pulpy. Thoracic cavity generally contains clear serous or blood-tinged effusion, which, especially on exposure, tends to coagulate. The pericardium often contains a quantity, up to three or four ounces, of similar fluid. The heart may show ecchymoses.[1]

The Disease in Victoria.

So far I have had but one opportunity of examining cases in an outbreak of such disease on the mainland, but I fully anticipate its occurrence will, on investigation, be found more frequent than is generally appreciated. Indeed, from what I can gather that disease, known to sheepmen as the "Blacks" in New South Wales, is likely to prove on investigation to be of this nature, if not identical.

History.—The property affected consists of about 7,000 acres of land. The country is broken into shallow valleys by granite ridges. The soil is not rich, but carries about 1½ sheep to the acre. It is fairly well watered by means of springs, which issue at different parts of the bases of the granite ridges and generally result in the formation of a small swampy area around each. As a consequence, Fluke Disease is very common, although no great mortality appears to ensue therefrom.

The class of sheep kept is entirely merino.

For a number of years the disease has caused a greater or less annual mortality. In 1901, after the break-up of the drought, very great mortality amongst the sheep was experienced. The nature of the disease was not known, but the owner considers now that it was probably the same as that under review. Since then, although there have been losses each year, apparently they were not sufficient to cause undue anxiety.

Between the beginning of last year (1910), after the commencement of the dry weather, and the end of April, the disease was responsible for a mortality of about 500 four- and six-tooth ewes and wethers out of a flock of about 3,000, or over 16 per cent. Almost every morning one or more of the sheep would be found dead, although the previous day no evidence of sickness in any could be detected. After the March rains the mortality almost ceased for two or three weeks, to ultimately resume its monotonous toll till May, when the wet weather became general. It should be observed that not all the property is subject to the disease, there being over 4,000 acres in which the sheep mortality has never been above what may be considered the normal in any flock. The nature of the soil or character of the herbage were obviously not the main factors, for they did not materially vary over the whole of the property.

Season.—The disease occurs only during the dry weather of summer, and practically disappears after the coming of the general autumn rains, when only rarely is an animal dead of the disease seen.

1 For details see *Veterinary Journal*, Vol. 66, p. 254 (May, 1910).

Age and Condition Incidence.—It is confined almost entirely to young sheep, four to six-tooth (2 to 2½ years), especially those in good condition, and affects equally male and female.

Symptoms.—Seldom are any evidences of sickness observed; at most some dulness and disinclination to move may be detected, but this is rare. That the disease must be very rapid in its course I had personal evidence. The evening of my arrival 700 wethers had been mustered into a small paddock near the homestead for my examination the following morning. No evidence of sickness in any individual, not even a tendency of any particular sheep to lag behind, was noticed by the shepherd. Yet the following morning at daybreak two were found dead with rigor mortis well advanced and the bodies tympanitic and almost cold. That same evening I watched the sheep carefully as they were mustered in the larger paddock and driven into the smaller, but could detect absolutely no indication of sickness in any. Twelve hours later one was found dead and cold, the night having been cold and frosty. Death occurs quietly, there never being any evidence of struggling.

Post-mortem Appearances.—The carcase is always that of a very well nourished young sheep. Development of gas within the stomach and bowels occurs rapidly. Patches of gelatinous subcutaneous œdema, slightly blood-tinged, particularly about the thorax and abdomen, are very noticeable on removal of the skin. The peritoneal and pleural cavities contain a variable quantity of blood-tinged watery effusion, and the pericardium is often greatly distended with clear semi-gelatinous exudate, a feature especially noticed by the owner in many cases. There may be acute peritonitis, with slight formation of false membranes, but this is far from constant, being observed by me in only one case. The stomach is always more or less deeply congested, but I have observed no ulceration. The liver often presents a mottled appearance due to circumscribed irregular areas of necrosis. The spleen is somewhat enlarged and softer than normal. The kidneys are congested. The lungs are usually firmer than normal, due to œdematous infiltration. The heart may show sub-endocardial hæmorrhages. The lymphatic glands are more or less œdematous, and many may be very hæmorrhagic. Provided the post-mortem examination be made soon after death in cold weather no very definite odour of putrefaction is to be detected, although as a rule when dead sheep are found decomposition is advanced. (See Appendix BI.)

The Pathogenic Organism.

The bacilli isolated, although, as will be seen later, presenting certain differences, are in their main features so alike that for convenience and brevity they can be described as one.

In animals dead for some hours the characteristic bacilli may be found in the effusions, the organs, and even in the blood, but never in a state of purity. They are most numerous in the peritoneal effusion, but invariably associated there with other bacilli—some long, thin and filamentous, others broad and large, both sporulating and probably of intestinal origin, and putrefactive, while cocci, etc., may also be present. Sections of the inflamed stomach mucosa (see photo-micrographs) show the blood-vessels extremely congested, with small hæmorrhages, some interstitial œdema, and in the interstitial tissue especially, masses of the characteristic bacilli apparently pure, in such a case as the one killed for examination, or in experimental cases where examination is made immediately after death ; then the distended blood-vessels are quite free of any bacilli so far as microscopical examination can determine. The necrosed liver areas also show the characteristic bacilli in great numbers, the blood-vessels, however, containing chiefly the larger and broader putrefactive bacilli which have penetrated from the bowel in cases where death has preceded post-mortem examination for some time.

The organism in question is a strictly anærobic bacillus, and, as it is generally accompanied by other anærobes, is extremely difficult to separate. Even when secured in a pure state I have never been able to grow it on plates or on slope media by any of the ordinary anærobic methods. In my experience the other bacteria present in natural cases entirely inhibit the growth of this bacillus in culture media ; and this fact I believe will be found to explain the necessity experienced by Hamilton in his experiments on Braxy in Scotland, and Willmot in his experiments in Tasmania for employing, even with large doses of first cultures, a solution of acetic acid, in order to increase the virulence of their cultures.

Considering the bacterial flora present in the large intestine of all animals, not excluding the sheep, it would be surprising if even prior to death in such a disease other putrefactive bacteria did not reach the peritoneal effusions. That sheep, especially fat sheep in wool, rapidly putrefy after death from whatever cause is common knowledge to all sheepmen. I have seen carcases of sheep dead of suffocation in trucks putrid and emphysematous, the skin being livid, in six to ten hours. Even in cold weather I have detected putrefactive organisms in fair numbers in the blood of the right heart four hours after death by accident, and these must have travelled from the intestine by way of the blood stream. The wool, in addition to the subcutaneous fat, makes such an animal a perfect incubator for putrefactive organisms by preventing dissipation of the body heat.

For these reasons I have found it necessary in order to obtain the pathogenic organism in a state of purity to pass it repeatedly through either small laboratory animals, such as guineapigs, or through sheep. It is not only necessary to do so on account of the difficulty, if not impossibility, of isolating the bacillus by other means, but as experiment has shown that on account of its rapid loss of virulence when grown in artificial media, especially glucose media, it is the only method which is likely to render satisfactory results.[1]

Characters of the Bacillus.—Rod-shaped bacteria, single and in pairs (which often look like single bacilli). Size varies from 2 to 4 microns in length, but occasionally rods twice this length may be observed in the effusions, and in cultures; breadth varies from 0.8 to 1.0 microns. Frequently the pairing bacilli, especially in the wet preparations, are seen to form an obtuse angle. Motility is very feeble; with the Tasmanian bacillus I have always failed to satisfy myself that there was any progression of the bacilli either in œdematous fluids or in cultures, however freshly examined, at most a rolling motion being occasionally detected, whereas with the Victorian bacillus a definite but generally feeble motility can readily be observed: Gram positive if stain carefully applied: forms spores readily in tissues and body fluids and also in media, such as serum broth, but few are formed in glucose media: strict anærobe, although in common with other so-called anærobic bacilli may be grown, as will be seen later, under what are generally considered ærobic conditions: produces gas in all media, with more or less definite odour varying from a cheesy to a urinary odour, according to circumstances of growth.

Cultures in Liquid Media.—In ordinary broth, neutral or even slightly alkaline to litmus, no growth occurs even under the strictest anærobic conditions; the addition, however, of one-fifth to one-third of ordinary sterile serum of any origin (*i.e.*, cow, horse or sheep) enables a rapid growth and copious growth to be secured.

In glucose media (+ 0.4 to + 1 to phenolphthalein) if freshly prepared and under anærobic conditions, the growth is rapid, and may be rendered more copious by the addition of 10 % to 15 % of alkaline serum, non-coagulable by heat. In such fluid media containing glucose the reaction rapidly becomes definitely acid, and the bacilli soon fall to the bottom of the tube, forming a deposit. In media without glucose the reaction remains neutral to litmus.

Special Method.—The simplest method of securing cultures after the organism has been procured in a pure state consists in employing a small portion of the affected muscle from an experimental sheep, which muscle has been cut into strips and dried at about 55° C. In such dried muscle the virulence may be retained indefinitely—at least after 18 months I find no diminution. If a small portion, about one to ten centigrammes, of such dry muscle be placed in a test tube containing ordinary broth, neutral to litmus, and boiled for thirty seconds in order to destroy any organisms which may have settled on the surface during drying, and rapidly cooled, after six to ten hours at 37° C. growth is manifested by a

[1. See *Veterinary Journal*, Vol. LXVI., No. 419, p. 254 (May, 1910), and Appendix B. II.]

slight liberation of gas and a faint opalescence of the fluid. In 12 to 15 hours definite cloudiness will be apparent, and much gas formation will be evident. Although at first sight this growth seems to be ærobic in nature, I am convinced this is not strictly so. Before any cloudiness is evidenced the gas bubbles can be seen to definitely escape from the swollen muscle tissue, and, further, the cloudiness can be seen to spread upward therefrom, being always most definite at the bottom of the tube. The multiplication of the organisms evidently therefore occurs within the tissue, the newly-formed bacilli passing outwards into the surrounding fluid. Such a portion of muscle may be transferred from tube to tube, still giving rise to fresh growths after the medium has been cleared by all the bacilli becoming deposited at the bottom of the fluid, but this transference cannot be continued indefinitely, six times being the limit in our experience. On the whole, I am not inclined to consider the second and later growths resulting from the transference as subcultures, though, perhaps, strictly they have a right to be considered such. Without the portion of muscle tissue no sub-cultures can be made in ærobic broth of the same or any other nature. It is my custom to test for accidental ærobes by pressing a few drops of the liquid culture in a fresh broth tube.

Anærobic sub-cultures can most conveniently be made in the liquid media already specified when covered with a thin layer, about $\frac{1}{2}$ to 1 cm., of pure olive oil, after the manner recommended by Hamilton. The routine now employed by me is as follows :—To glucose broth or ordinary broth (+ 1 to phenolphthalein) one-third of dilute alkaline serum is added, and covered by a layer of oil. The whole is then gently raised to boiling point in order to free the liquid of all trace of air, and especially care must be taken to see that the oil also is boiled, otherwise the traces of oxygen retained therein may be sufficient to inhibit the growth of the bacillus. The inoculations from tube to tube are best made by means of a sterile Pasteur pipette.

Cultures in Solid Media.—In Stab glucose agar the growth is seen on the second day as a faint streak, which develops a beaded appearance not unlike a culture of Blackleg, but without any radial penetration whatever of the medium ; in such a growth there is little gas formation. In shake cultures on glucose agar, where the bacilli are separated so as to produce separate colonies, the shape of the colonies, which appear in 24 hours at 37° C., is very characteristic. No colonies are to be found for a centimetre below the surface, no matter how rapidly cooled. The size of these colonies varies with the number present, and they show no tendency to coalesce. Whatever the size of these colonies, they are very uniform in the tube, and show no tendency to increase beyond a certain point. The size varies between 0.2 mm. and 1 mm. in diameter, depending on the number present. On examining these colonies with a lens they are seen to be biconvex discs, with no tendency whatever to form radiations. They occupy different planes to each other, the plane probably depending upon that of the first bacillus on coming to rest in the medium. (See photograph). Gas formation occurs, but the medium is not completely shattered as with many other anærobic gas-producing bacilli.

In glucose gelatine at 22° C. separate colonies appear in 48 hours after inoculation. These colonies are less definitely disc shaped, and are composed of a central dark mass with a clearer zone. No definite liquefaction is seen until the eighth day at least, and there is little gas formation. The colonies, unlike those in agar, appear to continue to grow, although this is probably due to the progressive liquefaction of the surrounding medium.

Sporulation.—The bacilli sporulate very readily within the tissues, especially within the blood infiltrated muscle. In the œdemas, before death at all events, there is little tendency to form spores, evidently owing to the facility for reproduction. In œdema, blood, etc., within pipettes at 37° C. sporulation is rapid. In serum broth sporulation is definite and spores are numerous. In glucose media, even with serum, however, they are rare, often entirely absent so far as microscopical examination can detect. In glucose agar especially I have failed to observe any attempt to form spores. The spores are ovoid and generally terminal or situated close to one extremity.

Odour of Gas Produced by Bacilli.—Provided a cadaver is examined soon after death often no definite gas formation and no definite odour can be detected. Frequently the odor is what may be described as an aggravated "muttony" or "sheepy" smell. The quantity of the gas and the odour seem to depend greatly on the extent to which the muscles are invaded by the bacilli, which generally in experimental animals depends on how deep the needle has penetrated. In any case where post-mortem examination is made early if a slight putrefactive odour be present it rapidly disappears on removal of the skin.

In muscle (ærobic) cultures the odour, especially of the Tasmanian bacillus, is definitely "cheesy"; in anærobic cultures under oil, especially again with the Tasmanian bacillus, it is definitely more that of stale urine. These observations have been repeatedly confirmed, and refer to cultures in tubes. When in bulk of 50 to 100 cc. the odour is rather a mixture of a cheesy and peculiar putrefactive odours indescribable, and can be detected with both bacilli.

No odour is detected in agar cultures.

Virulence of Cultures.—In ordinary serum broth the virulence is retained to a very great extent, even though successive subcultures. In glucose media, however, the virulence rapidly decreases, so much so that within a week an orginally virulent and very fatal culture will prove innocuous, even in large doses, although they are capable of conferring a definite immunity, as will be shown later on. This phenomenon, it is possible, may be turned to practical advantage in the preparations of a preventive vaccine, as will be discussed. (See Appendices A., IV. and V., and B., IV.)

Pathogenicity.—The bacillus is pathogenic for the sheep, the rabbit, the guineapig, and the pigeon, small doses being fatal: *e.g.*, for the sheep, 0.25 cc., and the smaller animals, 0.1 cc. of subcultures are sufficient to cause death, unless in the case of the rabbit, which shows a much greater resistance to the Victorian bacillus than to the Tasmanian. The calf is as readily affected with the Tasmanian bacillus as with the Blackleg bacillus, while the Victorian bacillus is resisted in the tests made by me.

Agglutination.—Serum from animals dead of the disease and serum from animals immunised alike fail to produce the slightest indication of agglutination when added even to the extent of 10 per cent. to broth cultures of the bacilli.

Toxin.—This has not yet been investigated. That it is an endotoxin is indicated by the following:—Guineapigs inoculated intreperitoneally with 5 cc. filtered (virulent) first culture from muscle remained normal. Fourteen days later, on being inoculated with 0.15 cc. culture, death resulted in less than 20 hours, so that no marked immunity was conferred by such filtered material. (See Appendix A, VII., and Appendix B, V.)

Differences between Tasmanian and Victorian Bacillus.

The bacilli isolated from the two States have, as already indicated, the same general characteristics. The following are the differences detected:—

While the Tasmanian bacillus has never shown definite motility the Victorian is undoubtedly definitely motile both in animal fluids and in cultures.

The Victorian bacillus, especially in animal fluids (œdemas), is the narrower—0.8 microns as against 1 microns.[1] It shows a greater tendency to be arranged in rows of four to six both in animal fluids and in cultures. It stains less deeply and definitely by Gram's method. The odour of cultures in test tubes of broth is much less marked, indeed often barely discernible. Muscle (ærobic) broth cultures and glucose broth (anærobic) cultures are not so opaque, and gas formation is not quite so abundant. Liquefaction is decidedly slower in gelatine cultures. Virulence is more rapidly lost in glucose broth. Above all, the Victorian bacillus, while equally as virulent as the Tasmanian for sheep and guineapigs, is not nearly so virulent for the rabbit, which withstands a larger dose than even the sheep, or apparently for the calf. Stomach lesions are more definite as a rule in sheep inoculated with Victorian than in those inoculated with Tasmanian cultures.

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1 In my first report on the Tasmanian disease the breadth of the bacillus is given as 0.5 microns—a typographical error over-looked.

Notwithstanding these slight differences, that the bacilli are at most but different types of the same organisms is proved by immunity to one implying immunity to the other as shown later.

Results of Inoculations.

I. TASMANIAN BACILLUS.[1]

Sheep.—Sheep of various ages, even up to five years old, have been used in experiments, the inoculations having almost invariably been made into the subcutaneous tissues of a hind limb on the inner surface of the thigh. Small doses of animal fluids containing the bacilli and small doses of pure and young cultures are always fatal. Death may occur within 18 hours with 0.5 cc. and with even 0.2 to 0.25 cc. of cultures, generally in less than two days, sometimes in less than 24 hours. The experimental disease is characterised by the development of lameness and swelling of the inoculated limb, the skin of which may or may not become congested, and generally there is some formation of gas at the seat of inoculation. The animal loses appetite, the temperature rises to a varying degree, there is uneasiness, dulness, followed by coma and death without struggling if not disturbed.

If post-mortem examination be made soon after death no tympany or frothy discharge from the nostrils will be found, though both generally appear later if undisturbed. The subcutaneous and intermuscular tissue is found greatly infiltrated with œdema, extending usually from the coronet to the pubis and along the abdomen towards the shoulder. This œdema, unless near the site of injection, where it is often blood-tinged, is usually clear and semi-gelatinous. The muscles of the thigh are more or less hæmorrhagic, infiltrated with serosity and a certain variable amount of gas. Often no odour beyond a well-marked "muttony" odour is to be detected, though on incising the dark muscle a slight odour suggesting that of putrefaction, but not exactly the usual odour, may be detected; it almost immediately disappears, however.

The peritoneal, thoracic and pericardial cavities contain varying amount of effusion, which may be clear or blood-tinged As a rule the peritoneum contains from one-half to one pint, and the thorax several ounces, but the effusion may be absent from one or both cavities.

The liver is generally contested, and may show small areas of necrosis. The kidneys are more or less congested. The spleen is usually somewhat pulpy and dark, though at times quite normal. The abomasum may be normal, but it may show inflammatory changes varying from injection of the blood-vessels to an acute congestion throughout, which is rare. Frequently the congestion

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1 For details, see *Veterinary Journal*, Vol. 66, p. 355 (June, 1910), and Appendix.

is limited to the pyloric opening. The submucosa is often œdematous, especially that of the folds. The small intestines, especially the duodenum, may show congestion. Generally the submucosa is somewhat œdematous, and very often the lumen, empty of ingesta, contains more or less serous effusion, which has all the characters of the effusions elsewhere. In one instance this effusion was observed to possess a coagulated central core, so tenacious as to permit several inches to be pulled through an incision of the bowel wall. The large intestines are generally normal. The lungs are usually normal, but may be very œdematous. The heart may show sub-epicardial and sub-endocardial hæmorrhages. No odour is to be detected throughout the cadaver, provided the post-mortem examination is made soon after death.

Attempts to transmit the disease by feeding with from two to five cc. of virulent cultures have proved negative.

Cattle.—Only one animal has been inoculated—a three-months' old calf in good condition—0.5 cc. virulent broth culture being injected subcutaneously. Death resulted 54 hours after inoculation. Post-mortem examination disclosed extensive infiltration of the subcutaneous tissues with œdema, pleural and pericardial effusions, congestion and hæmorrhagic patches of the abomasum mucosa, œdema of the lungs, etc. (See Appendix.)

Guineapigs.—Guineapigs inoculated with small doses, 0.1 to 0.25 cc., of young pure sub-cultures generally succumb in less than 20 hours. The post-mortem appearances are very similar to those of the sheep, there being intense œdematous infiltration, with some hæmorrhage and gas formation in the muscles of the whole limb, and subcutaneous tissues of the abdomen. Effusions into the serous cavities are common, and vary in amount and character. The liver frequently shows small areas of necrosis in its congested tissue. Spleen often pulpy and at times enlarged. Kidneys usually congested. The stomach may show slight congestion of the mucosa, as may the small intestines. Very frequently the small intestines are distended by more or less clear effusion into the lumen.

Rabbits.—Both tame and wild rabbits are very susceptible; 0.10 to 0.25 cc. of pure young subculture invariably causes death in from 16 to 24 hours, generally under 20 hours. Beyond an extensive subcutaneous œdema, clear and semi-gelatinous, there is little pathological change to be observed.

It should be here noted that rabbits immune to a certain strain of malignant œdema bacillus proved on subsequent inoculation with this bacillus to be equally susceptible with other rabbits not previously inoculated.

Pigeons inoculated with 0.1 to 0.25 cc. broth culture die in less than 24 hours, the muscles of the inoculated breast being swollen and œdematous. Generally there is no other pathological change, though in one instance a small quantity of sero-sanguineous effusion was present in the abdomen.

Adult fowls are refractory to small doses—0·25 cc.

II. VICTORIAN BACILLUS.

(For Details see Appendix B.)

Sheep.—Sheep of various ages have been used, but always in good condition. Inoculations have invariably been made in the subcutaneous tissue of the inner surface of the thigh. Small doses of animal effusions containing bacteria and of young pure cultures always cause death. The duration of the disease when virulent cultures are employed varies, death occurring within 24 hours with 0.5 cc., and 40 hours with 0.25 cc. The course of the experimental disease is characterised by lameness and intense swelling of the inoculated limb, prostration, pyrexia and coma, death resulting without struggling if undisturbed.

The pathological changes observed on post mortem examination if made immediately are subcutaneous œdema of the inoculated limb, extending from the coronet to the pubis and often some distance along the wall of the abdomen. The skin may or may not be discoloured, but is generally puffy. This œdema is more or less blood-tinged near the seat of inoculation, but elsewhere, especially from the hock downwards, is clear and gelatinous. The muscles around the site of inoculation are more or less hæmorrhagic, dark in colour and infiltrated with gaseous bloody serosity; but much depends apparently on the depth to which the needle has penetrated. There is usually some odour noticeable on incising the muscle, but it soon disappears. The odour is more like that of blackleg muscle than that of ordinary putrefaction.

The peritoneal cavity contains more or less fluid, though occasionally none may be present.

In only one instance (an animal inoculated with blood and pleural effusion of a natural case) have I observed any evidence of peritonitis. The liver frequently shows areas of necrosis, and the whole organ may be more or less degenerated. Necrotic areas are not constant, however, either in these experimental cases or in the natural cases. The spleen is usually pulpy and dark, and the kidneys are more or less congested.

The abomasum almost invariably shows pathological changes. Frequently the whole of the mucosa is deeply congested, the submucosa being more or less œdematous, the mucous folds markedly so. At other times the acute congestion is confined to patches, varying in size situated towards the pylorus. Occasio ally hæmorrhagic areas may be seen under the serous coat of the viscus. Very rarely, if ever, is gastritis entirely absent.

The small intestines are generally congested, especially the anterior portion; the submucosa is more or less œdematous, and there is generally more or less serous exudate into the otherwise empty bowel. The large intestines generally show ecchymoses, often patches of congestion, and at times small hæmorrhages staining the contents. The lymphatic glands are more or less swollen, œdematous, and often hæmorrhagic.

The pleural cavity generally contains more or less clear semi-gelatinous effusion, which may be present even when there is no peritoneal fluid, or may be practically absent when there is a considerable quantity of peritoneal effusion.

The lungs are often very œdematous, the interlobular tissue being much distended by clear serosity, and in the sub-pleural connective tissue small hæmorrhages are frequently present. Petechiæ are common in the sub-epicardium and sub-endocardium; they may be present in one and not the other, and may be absent from both.

Attempts to transmit the disease by feeding experiments with virulent cultures have so far been negative.

Cattle.—Only one animal has been inoculated—a three-months' old calf in good condition—0.5 cc. broth culture virulent for guineapigs and sheep being injected subcutaneously. Beyond a passing swelling the results were negative.

Guineapigs.—Guineapigs inoculated with small doses, 0.1 to 0.25 cc., of fluids containing the organisms or of pure cultures rapidly succumb, generally within 20 hours of inoculation. Post-mortem examinations show a large quantity of subcutaneous clear or slightly blood-tinged effusion infiltrating the whole areolar tissue of the limb, and often extending forward along the flood of the abdomen to the shoulder. The muscles are usually hæmorrhagic at the point of inoculation, and there is more or less emphysema. There may be no gas and no odour present, however, especially if the muscles be little affected. Usually a small quantity of fluid is present in the peritoneum. The spleen and kidneys are congested. The liver, beyond congestion, rarely shows any change. The stomach is often congested, and the small intestines are generally deeply congested, the mucosa infiltrated, and the lumen frequently distended with clear, semi-gelatinous effusion. The pleural cavity rarely contains fluid, but the pericardium is frequently distended with effusion.

Rabbits.—Rabbits inoculated with 0.1 to 0.25 cc. of cultures which have proved fatal within 20 hours to control guineapigs remain normal, exhibiting no swelling or symptom of illness. With 0.5 cc., however, death results in less than 20 hours, the post-mortem appearances being similar to those of guineapigs, with the exception of bowel lesions, which are absent.

Pigeons are readily affected, and succumb in less than 20 hours with small doses of virulent cultures, the pathological changes being confined to the muscles at the site of inoculation, which are dark, swollen, and œdematous.

Adult fowls at least are refractory to small doses.

The Situation of the Pathogenic Bacilli in the Naturally and Experimentally Affected Animal.

Judging by examination of fluids, blood and organs in the Tasmanian case killed for examination, and in the Victorian cases on which post-mortem examination was made soon after death, which fluids, etc., were free of pathogenic bacteria, although not sterile so far as other accidental organisms were concerned, as proved by incubation of such material in previously sterile pipettes, the bacilli do not travel far, or at least in numbers, from the primary situation. For experimental animals almost the same may be said, with the exception that when stomach or intestinal congestion is present the bacilli may always be found in such affected areas. Although present in large numbers near the original site of inoculation, especially in the hæmorrhagic and degenerated muscle, it is to be noted that in the clear œdema they are very scarce, often absent, as proved by pipettes of such œdema, particularly when secured from the subcutaneous tissue of the hock or lower part of the limb, remaining sterile at blood heat and the contents being innocuous for other sheep. The peritoneal fluid is nearly always contaminated by other bacilli, such as large putrefactive bacilli, long filamentous organisms, tetanus-like bacilli (all of which are anærobic and of intestinal origin), cocci, and other ærobic bacteria. The pleural and pericardial effusions are generally sterile at the moment of death. The heart blood is generally apparently sterile to microscopical examination, but if a quantity be incubated in sterilised pipettes the pathogenic bacteria can as a rule soon be demonstrated, though not always in a state of purity. The liver especially is frequently contaminated by accidental putrefactive bacteria, as may be seen in sections of the necrosed patches, both from natural and experimental cases, where, while the pathogenic bacteria may be observed lying throughout the parenchyma, the accidental putrefactive bacteria are chiefly confined to the blood stream.

Sections of the abomasum, whether in natural or experimental cases, show in the congested areas intense dilatation of the capillaries with frequent minute blood extravasations. Although when the tissue has been fixed soon after death, the blood-vessels are seen to be free of bacilli, the interstitial tissue between the gastric glands is found to contain masses of the characteristic pathogenic bacteria, a few of which may also be found in the œdematous sub-mucosa.

The evidence, therefore, is that the bacilli during the progress of the disease do not travel far from the original point of entrance, and that any which do enter the blood-stream are more liable to be arrested in the capillaries of the stomach and intestinal (small) wall—that, in other words, the general nature of the disease is a distinct and severe toxæmia, the stomach and intestinal lesions being either due to direct inoculation in natural cases (which seems doubtful) or to hæmatogenous infection in both natural and experimental cases by the bacilli. There seems to be a considerable resistance to the invasion of the blood-stream during life, as in the allied disease, blackleg ; but immediately prior to death, and especially soon after death, the bacilli multiply readily and very rapidly within the blood as do other anærobic putrefactive bacteria ; hence the general state of putrefaction with emphysema in which the cadaver is usually found.

Diminution of Virulence in Cultures and Immunization by such Cultures.

This occurs very definitely in all media, but much more so in glucose media than in ordinary broth or serum broth. If sub-cultures be made from day to day on ordinary serum broth, the virulence may be retained through a number of successive generations. Should, however, inoculations from tube to tube be only made at intervals of several days the virulence is gradually lost. For example, a sheep (lamb 3) inoculated with 0.3 cc. of a sixth sub-culture three days old, which had been transferred at irregular periods for two months from tube to tube of serum broth, showed no marked sign of illness for 36 hours, and death occurred only fully three days after inoculation, the post-mortem picture being typical. Another sheep (sheep 4) inoculated with 0.5 cc. of the ninth sub-culture five days old showed slight swelling with lameness and rise of temperature the following day, after which recovery was rapid. Another sheep (lamb 5) inoculated with 0.5 cc. of a tenth sub-culture, four days old (transferred at intervals during three months) remained normal but for a transient swelling. Similar experiments carried out on guineapigs gave like results, and further inoculation with virulent material indicated that a certain degree of resistance was acquired as a result of inoculation with these weakened cultures.

More definite and more rapid weakening of virulence was found to be obtained by cultivation in gulcose broth, both with and without serum.

For example, 0.15 cc. of such cultures, when a day old, proved fatal for guineapigs in less than 20 hours, yet seven days later the same doses of the same cultures proved innocuous for similar guineapigs.

These results suggested further experiments on sheep, the following being the results :—

Tasmanian Bacillus.—Sheep 19 was inoculated with 3 cc. 4th sub-culture, seven days old, in glucose serum broth. Result : Remained normal, but for passing lameness and slight rise of temperature. Fourteen days later this animal proved immune to 0.25 cc. first sub-culture on ordinary serum broth, while a control sheep inoculated with a similar dose of the same culture succumbed.

Another sheep (26) was inoculated with 5 cc. second glucose serum broth sub-culture seven days old. Result : Remained normal but for slight swelling and rise of temperature. A guineapig inoculated with 1 cc. of the same culture developed a slight swelling, from which it rapidly recovered. In these cases, however, immunity to ordinary doses of young serum broth cultures was not established, for on being inoculated 19 days later, the sheep with 0.25 cc., the guineapig with 0.15 cc. of such a culture, the former succumbed in 60 hours, the latter in 20 hours.

Another sheep (No. 28) inoculated with 5 cc. first sub-culture in glucose serum broth six days old died in 40 hours, while a guineapig (152) inoculated with 1 cc. died in 20 hours.

These experiments did not give much prospect of using such cultures as vaccines, although indicating a definite weakening.

The Victorian Bacillus proved, however, more uniform and gave better results.

A sheep (No. 20) inoculated with 5 cc. eight days old of fourth sub-culture in glucose serum broth remained normal. Twenty days later it was inoculated with 0.25 cc. second sub-culture in serum broth two days old, and remained normal beyond passing lameness and rise of temperature, whereas a control sheep (No. 25) inoculated with a similar dose died in 38 hours.

Another sheep (No. 31), inoculated with 3 cc. of an eight days old third sub-culture in glucose serum broth, beyond a slight swelling and passing lameness, remained normal. A guineapig (149) inoculated with 1 cc. of the same culture also remained normal. Twenty days later the sheep was inoculated with 0.25 cc. 24 hours old first culture in serum broth, and the guineapig with 0.15 cc. The sheep developed no swelling but slight lameness and definite rise of temperature for the first day, after which it resumed normal. The guineapig died within 12 hours.

Another sheep (No. 30) was inoculated with 5 cc. of a six days old first sub-culture in glucose serum broth, and a guineapig (153) with 1 cc. of the same culture. The guineapig died in 18 hours. The sheep the following day was lame, the limb œdematous and the temperature 104.2 ; but next day the animal was normal. Fifteen days after this inoculation it received 0.25 cc. 24 hours old first culture in serum broth from muscle, which the following day induced lameness with slight swelling and some rise of temperature, but complete recovery resulted 24 hours later.

(For details, see Appendix A IV. and V., and Appendix B IV.)

It is evident from these experiments, that by the use of cultures on glucose media at least six days old one may hope to provide a vaccine for at any rate the Victorian disease.

Sheep immune to Victorian Bacillus, immune to Tasmanian Bacillus.—That animals immune to the Victorian bacillus are also immune to the Tasmanian bacillus is shown by the following :—

Sheep (20, 30 and 31), which as shown were immunised against virulent cultures of Victorian bacilli, proved when inoculated, 27, 19, and 15 days later respectively, with 0.25 cc. first culture of Tasmanian bacillus, to be immune also to that inoculation, the only abnormality shown being a slight rise of temperature the following day. These inoculations were controlled by injecting a control sheep with a similar dose, and by inoculations of guineapigs, which proved the virulence of the bacilli by the sheep dying in less than 48 hours, the guineapig in under 18 hours.

The following table shows the results of these inoculations with weakened bacilli, and the subsequent effect of virulent cultures :—

TABLE I.

Sheep.	Age.	First Inoculation.				Second Inoculation.					Third Inoculation.				
		Source	Culture.	Age of Culture.	Dose.	Days Later.	Source.	Culture.	Age of Culture.	Dose.	Days Later.	Source.	Culture.	Age of Culture.	Dose.
19	2 yrs.	Tas.	4th sub. G.S.B.	7 days	3 cc.	14	Tas.	1st sub. S.B.	1 day	0.25 cc.					
26	1 yr.	Tas.	2nd sub. G.S.B.	7 ,,	5 cc.	20	Tas.	1st sub. S.B.	1 day	0.25 cc.	Died in		60 hours.		
28	2 yrs.	Tas.	1st sub. G.S.B.	6 ,,	5 cc.	Died in		40 hours.							
20	3 yrs.	Vic.	4th sub. G.S.B.	8 ,,	5 cc.	20	Vic.	2nd sub. S.B.	2 days	0.25 cc.	27	Tas.	1st sub. S.B.	1 day	0.25 cc.
31	1 yr.	Vic.	3rd sub. G.S.B.	8 ,,	3 cc.	18	Vic.	1st cult. S.B.	1 day	0.25 cc.	19	Tas.	1st cult. S.B.	1 day	0.25 cc.
30	2 yrs.	Vic.	1st sub.	6 ,,	5 cc.	15	Vic.	1st cult. S.B.	1 day	0.25 cc.	15	Tas.	1st cult. S.B.	1 day	0.25 cc.

G.S.B., glucose serum broth. S.B., serum broth.

Immunization by Feeding with Virulent Cultures.

Hamilton recommended the administration of virulent cultures per oram to sheep during his so-called "immune season" as a means of producing an active immunity to British braxy during the danger period of the year, and actually drenched with such cultures the flocks on several farms, the results of which he considered highly satisfactory, but I understand this method of prevention has been entirely discontinued for several years in Scotland.

Now, although we have not been able to demonstrate any seasonal period of immunity to the experimental production of the disease here, and sheep have been tested each month, yet we have been able to demonstrate that a definite immunity may readily be established by the simple process of administering virulent cultures per oram.

A sheep (27) was drenched with 2 cc. virulent Tasmanian culture mixed with an ounce of milk, and sheep 29 of the same age was similarly drenched with 2 cc. virulent Victorian culture. A month later sheep 27 was inoculated with 0.25 cc. virulent blackleg culture, to which it succumbed thirty-seven days after drenching. Sheep 29 was inoculated with 0.25 cc. virulent Victorian braxy culture, to which it proved immune. Nineteen days later it was inoculated with 0.25 cc. virulent Tasmanian culture, to which it also proved immune.

Two nine-months old lambs (34 and 35) were dosed with 1 cc. each of virulent Tasmanian culture in the following manner :—The culture, mixed with gelatine, in which was a considerable quantity of roughly ground glass, was placed in a gelatine capsule, so as to make a "bolus," and this was administered in the usual way.

The experiment was conducted in the anticipation that some portions of the ground glass contaminated with the bacteria would pierce the mucosa of some part of the alimentary tract, thereby producing the disease and so demonstrating as fairly as possible the presumed role of prickles, parasites, etc., in the natural production of the disease. The animals, however, remained perfectly normal.

A month after lamb 34 was drenched it was inoculated with 0.25 cc. virulent Victorian culture. Of the same culture and from the same syringe sheep 29 received 0.5 cc. (a month after the previous inoculation), and lamb 33 (same age and breed as 34) received as control 0.25 cc. The result was that 29 and 34 remained practically normal, but for a slight and passing rise of temperature, whereas lamb 33 was dead in 18 hours.

Lamb 35, six weeks after drenching, was inoculated with 0.25 cc. virulent Tasmanian culture (0.01 cc. being fatal for an adult guineapig in less than 20 hours). For two days the animal remained normal, then a slight lameness with a faint swelling of the inoculated thigh was observed, the temperature being 103.5. Gradually the lameness and swelling increased, though slowly, and the animal died five and a half days after inoculation. This indicated a great increase of resistance, but not quite sufficient to withstand such an inoculation, which it should be remembered is really a greater dose than that given with the same quantity of the Victorian bacillus, the broth cultures of the Tasmanian being much more cloudy than those of the Victorian.

The post-mortem picture was typical, there being slightly blood-tinged froth issuing from the nostrils ; no odour of putrefaction present ; much peritoneal fluid and more pleural fluid than usual ; the stomach was normal, but for a very slight œdema of the folds ; the kidneys were soft and degenerate, and the lungs very œdematous ; the bronchi and trachea containing a quantity of frothy slightly blood-tinged fluid.

Lamb 36 (10 months old Leicester) was drenched with 3 cc. virulent culture of Victorian bacillus as injected into lamb 33, and remained normal. Seventeen days later on being inoculated with 0.25 cc. virulent culture Victorian bacillus, beyond a temporary lameness the lamb remained normal, the temperature not rising beyond 103.5.

The following table shows the effect of these feeding experiments* :—

TABLE II.

Sheep.	Dose Fed.	Source.	First Inoculation.			Second Inoculation.			Third Inoculation		
			Days Later.	Source.	Dose.	Days Later.	Source.	Dose.	Days Later.	Source.	Dose.
27	2 cc.	Tas.	30	Blackleg	0.25 cc.	Died in two days.					
29	2 cc.	Vic.	37	Victorian	0.25 cc.	19	Tas.	0.25	27	Vic.	0.5 cc.
34	1 cc.	Tas.	27	Victorian	0.25 cc.	17	Vic.	1 cc.			
35	1 cc.	Tas.	42	Tasmanian	0.25 cc.	Died $5\frac{1}{2}$ days later—Typical Braxy.					
36	3 cc.	Vic.	17	Victorian	0.25 cc.	20	Vic.	2 cc.	Swelling, lameness, and rise of temperature occurred, which continued for several days, after which complete recovery resulted.		

*Since reading this paper further experiments have confirmed these, and this method of minimization is now being treated on several properties.

European Braxies.

Under the popular term "Braxy" a peculiar and fatal disease of sheep has been known for at least a century in certain parts of Scotland, while a disease known as "Bradsot," now recognised to be identical in almost every respect, has been prevalent in Iceland, the Faroe Islands, and certain parts of Norway since at least the middle of the eighteenth century.

The first scientific investigation of the etiology of the disease appears to have been undertaken by Ivar Neilsen, a State Veterinary Surgeon of Norway, who in 1888 described the causative bacillus, but attempts to transmit the disease by means of cultures, whether by the mouth or by subcutaneous injection, always failed.

Later on the study was resumed by C. O. Jensen, who in 1896 published an exhaustive treatise dealing fully with the pathology and bacteriology of Bradsot, in which he confirmed the observations of Neilson, but recorded the isolation and cultivation of the specific bacterium and the reproduction of the disease by subcutaneous inoculation, although not by feeding.

In Great Britain the Disease Braxy has been the subject of various investigations and reports, notably by Duncan, in 1805, Wm. Hogg in 1828, Cowan in 1861, and Wm. Robertson in 1862-3, these investigations and reports having been made at the instance of the Highland and Agricultural Society of Scotland. In Britain the scientific study of the disease by modern methods remained untouched, however, till 1897, when the late Professor Hamilton, of Aberdeen, commenced an investigation which was subsequently continued by a special committee of the British Board of Agriculture (of which Hamilton was chairman), the results being fully recorded in a voluminous report.

The disease in Scotland attacks chiefly hoggets under a year old, two-year-old animals being rarely affected, while those three years old and upwards appear to be exempt. In Norway and Iceland, however, yearlings and two-year-olds appear to be equally affected, three-year olds are less susceptible, but still show a heavy mortality; but older animals are rarely attacked, judging by Hjaltelin's figures. Neilsen draws special attention to the heavy mortality amongst one year old sheep.

Braxy and Bradsot are almost confined to the late autumn and winter months, during summer cases being extremely rare. Both are generally reported to be most prevalent during frosty weather, especially when the ground is free of snow.

As regards symptoms, very frequently none are observed. Jensen states:—"The older writings, in fact, declare that the animals often show no sign whatever of the disease until they suddenly fall and die; but more recent and critical observations tend to controvert this. The sheep suddenly appears ill, is dull, lies about, and cannot be induced to rise; all movement seems to give pain, and from time to time the animal groans; the posterior parts of the body become swollen, and a little froth often escapes from the mouth. This condition may last some hours, and always ends in the animal's death ; sheep, which overnight had shown no signs of illness, are often found dead in the morning."

Hamilton apparently seldom observed naturally affected animals exhibiting symptoms :—"Under natural circumstances the sheep die so rapidly that opportunity is seldom afforded of studying the manifestations of the disease from their commencement to their termination. All accounts, however, seem to agree in describing a short, quick step as perhaps the first noticeable symptom. The animal next day is off its feed and is restless, with a tendency to lie down and get up suddenly, expressive, so far as one can judge, of a certain uneasiness. Quite likely it does not rise so readily to the dog as others do."

As to the condition of the sheep being a predisposing factor Neilsen and Jensen appear to offer no comment, and Hamilton dismisses it shortly, thus :—

"In the commencement of the outbreak of the disease the fat animals are usually first attacked ; indeed the disease may be limited in great part to them, even although they may happen to be in close propinquity to others less well nourished."

The chief post-mortem lesions of Bradsot observed by Jensen are :—A hæmorrhagic infiltration of the abomasum wall, which may extend to the small intestine, and even to the omasum, the stomach usually containing no food, but often a certain amount of bloody fluid ; congestion of the rest of the intestinal canal ; serous effusions in the pleural and peritoneal cavities ; spleen may be swollen or normal ; liver usually light coloured, soft, and degenerated ; kidneys degenerated, enlarged and soft or almost fluid in consistence. The rapid decomposition of the carcase after death is remarked. "The carcase decomposes very rapidly ; within a short time of death the belly is distended with gas, the rectum protrudes at the anus ; the skin assumes a blue colour in places, and the wool falls out ; sometimes the skin bursts, revealing the presence in the subcutaneous tissue of a sero-hæmorrhagic fluid. Braxy is, then, a primary violent hæmorrhagic inflammation of the abomasum, with or without secondary general infection."

Hamilton in his summary of the morbid anatomy deals very fully with the rapid putrefaction after death, and the definite odour, which, however, is not peculiar to Braxy. There is œdema of the subcutaneous tissues, especially on the side where the carcase has rested. The abomasum is empty, but often contains a little blood-stained mucous liquid ; the mucous membrane is often congested in parts, "its folds infiltrated and thickened and the surfaces of them abraded or distinctly ulcerated," but in other cases "circumscribed black gangrenous sloughs without any great tumefaction and congestion around them" may be present. In spite of this it is stated "under no circumstances have we observed evidences of the organism being productive of *inflammatory* . . . phenomena."

Effusions into the peritoneal and pleural cavities are commonly observed, and have often a muddy-looking aspect. Hæmoglobin staining of various parts of the body is frequent, being of post-mortem occurrence. The spleen is seldom abnormal—is, in fact, usually " collapsed and inconspicuous."

It will be observed that in several points the diseases Bradsot (as described by Jensen and others) and Braxy (as described by Hamilton) vary so far as age, incidence, symptoms and pathological changes are concerned, but that nevertheless these variations are of a minor character.

Other Braxy-like Diseases.—Here it may be well to observe that Hamilton recognises three other morbid conditions of sheep under this heading, these being termed provisionally " Disease A," " Disease B " and " Malignant Œdema." The distinctive characters are as follows :—

Disease A.—Commences in September and disappears by the middle of December. A full description of one case (dead 3 days) is given. The carcase was dry, serous effusions were little in quantity, and the stomachs were normal, but for post-mortem alteration. The bacillus present in great numbers morphologically quite different to that of braxy.

Disease B.—Season, October to January. Apparently some symptoms (not detailed) observed, the disease terminating fatally within a day or so after the symptoms have declared themselves. Little gas or odour, and peritoneal fluid clear or only slightly turbid. The bacilli found in the peritoneal liquid, etc., are morphologically different to that of braxy.

Malignant Œdema.—Season : as for braxy. Small quantity of blood-stained opaque and muddy serum in peritoneum ; hæmorrhagic patches in intestinal walls ; " congested spots " on the mucosa of the fourth stomach, but no ulceration or gangrenous sloughs ; spleen soft ; kidneys congested ; gelatinous œdema covering the external surface of the pericardium ; pericardium distended with serous liquid ; hæmorrhagic areas in lungs, etc. The peritoneal liquid contains long thin rods similar in morphology to the common Vibrion septique of Pasteur.

As apparently no experiments were carried out with the bacilli of these so-named diseases, the true significance of the bacilli described cannot be estimated. It is worthy of note that the majority of such cases were found on farms where the sheep had been treated by Hamilton's method of immunisation, viz., dosing with cultures of the braxy bacillus during the so-called " immune season."

Bacteriology of European Braxies.

Bradsot. — The bacillus of Bradsot was first described by Neilsen in 1888, and termed by him *Bacillus gastromycosis ovis* (a sporulating rod $2{\cdot}6\mu$ in length by 1.0μ in breadth), but apparently he never succeeded in securing pure cultures of the organism. All attempts at infection with the bacillus he had cultivated failed "whether food was moistened with cultivations, or the material injected subcutaneously" (Jensen). Pure cultures of the bacillus of Bradsot were, however, later secured by Jensen, who found it as stated by Neilsen anærobic, growing slowly in ordinary gelatine and agar, but growing rapidly in these media where blood serum is added, also in ordinary broth and blood serum equal parts. He lays stress on the similarity of the growths of this bacillus and those of Blackleg and Malignant œdema, and while pointing out certain minor differences, concludes "at the present time I am unable to give final indications for distinguishing between the gelatine and agar cultures of the three bacilli, the differences being slight." He distinguishes the bacillus from that of Blackleg, "which it somewhat resembles in general appearance, and of which it reminds one by its ability to produce hæmorrhagic inflammation of the muscular tissues" . . . by its being "pathogenic to swine, mice, pigeons and poultry," and by the fact that a sheep immune to Bradsot succumbed to inoculation with Blackleg virus. Further, Blackleg is said to be unknown in Iceland where Bradsot is common.

Experiments with cultures proved the bacillus fatal to guineapigs in 12 to 16 hours, to pigeons and hens in from 12 to 18 hours, but the doses are not mentioned in the translation at my disposal.

Three lambs subcutaneously inoculated with serum-gelatine-agar cultures died in from 12 to 15 hours, the post-mortem appearances closely resembling blackleg, *e.g.*, extensive subcutaneous hæmorrhagic œdema, with hæmorrhage into the musculature of the inoculated limb ; a little blood-stained fluid in the abdominal cavity, slight enlargement of spleen, liver yellowish and degenerated, lungs œdematous, kidneys almost pultaceous, a condition which in spontaneous Bradsot is regarded as characteristic, but no mention is made of stomach lesions being present. A calf six or seven weeks old inoculated with 2 cc. serum broth culture died in 48 hours, but the muscles were greyish and soft where inoculated and not like those of blackleg infection. A pig six months old died in 36 hours after subcutaneous inoculation. Rabbits were not so susceptible as guineapigs ; of four inoculated only one died, the post-mortem appearances being as those in guineapigs.

As to vaccination against Bradsot, both Neilsen and Jensen had some success experimentally by employing tissues containing the bacillus, which were dried and pulverised, indeed Neilsen had used this method in his own district with apparent success. Whether such material was simply dried at an ordinary temperature or at very high temperatures as employed in the making of blackleg vaccine is not stated, but the latter is most probable.

Braxy.—As already stated, the bacteriology of braxy proper in Great Britain has only been studied by Hamilton. The bacillus is rod-shaped and varies in length from 2·8 to 7μ long, and from

·7 to 1μ broad. Usually quite immobile both in effusions and in artificial cultures "it may happen, however, that under certain circumstances it develops some amount of mobility." In the lesions and œdemas it sporulates readily. It is often in pairs, rarely in chains. It may or may not stain by Grams' method, this method of colouration being uncertain. The bacillus is a strict anærobe. Endeavours to separate from possible accidental bacteria of similar nature by plate methods were unsuccessful by every method adopted.

Cultures were generally made in glucose broth, in which some peritoneal liquid containing bacilli and spores was placed, and covered with ½ to 1 cm. of pure olive oil. The liquid was heated to 80 C. for 20 minutes to destroy all but spores, and then incubated at 37 C. Provided the glucose broth is alkaline in reaction, a pure culture by this means is said to result. Growth ceases by 36 hours, and the bacilli deposit at the bottom of the liquid in "particulate sand-like masses," considered characteristic. Stab cultures on glucose agar results in an abundant growth, which disintegrates the medium by gas formation, and so the growth is not distinctive. In glucose gelatine at 21° C. the growth is distinctive, but only after a week to ten days, "when little cup-shaped areas of liquefaction form at intervals along the growths, and from these coarse arms are thrown upwards and outwards."

During the first two years of Hamilton's investigations he failed to transmit the disease by feeding or by subcutaneous inoculation, whether blood or peritoneal effusion was employed, experiments being conducted on 12 sheep.

Another experiment was conducted later, six hoggets from braxy-free country and six from braxy country being inoculated with peritoneal fluid from a typical case, and all being depastured on braxy pasture. One died in 60 hours, with much subcutaneous œdema, muscle hæmorrhage, peritoneal effusions, and stomach lesions; another became ill but recovered, and the remainder remained normal. As none of the sheep from braxy-free country showed more than passing lameness, the experiment was considered indicative of a certain amount of resistance on their part.

Cultures in glucose broth do not seem to have been very virulent: Of six young sheep, each being inoculated with 1 cc. of 48 hours old first culture, one died in 36 hours, 2 died in 50 hours, one became very ill and recovered, and the other two remained normal. Post-mortem examination of the dead sheep some time after death showed much general emphysema, œdema and intermuscular hæmorrhage of inoculated limb, fluid in some cavities, but no definite stomach lesion. 2 cc. of a third generation of broth culture proved non-pathogenic, and was considered attenuated.

Experiments by feeding with cultures were generally negative, those considered positive being on land naturally affected with the disease, hence at least doubtful.

As to the pathogenicity of this bacillus for other animals, Hamilton is silent, beyond stating that it is *usually fatal for guinea-pigs* *in a few hours.* Two cases are mentioned in which inoculation of large doses (1 cc.) of peritoneal effusion and of culture were negative.

Hamilton affirms that the seasonal nature of braxy is due to the blood being bactericidal to the bacillus during the period of year when the disease does not appear, but his observations have not been confirmed. This led him to suggest the immunisation of sheep by drenching with cultures during the "immune" season, in order to induce an active and permanent immunity, and this in spite of the fact that he showed the bacilli thus introduced may multiply in the alimentary canal and be continuously passed for at least two months by the fæces. Numerous experiments were conducted in the field on these lines, which by the report seem to have been satisfactory, but I am advised that this method of immunisation has not been continued in any part of the country affected with the disease.

Disease of Braxy Type in New Zealand.

On many farms in the South Island where hoggets (yearling sheep) were fattened on turnips growing in paddocks, for a number of years an annual mortality was experienced varying from five per cent. upwards. Owing to difficulties in communication and the rapidity with which putrefactive changes occurred in the cadavers, attempts to make any investigation regarding the cause were not satisfactory until Mr. H. C. Wilkie, F.R.C.V.S., then a Government Veterinarian, had an opportunity of making careful observations on the disease occurring in a valuable flock of pure merino ram hoggets. Generally the disease appeared when the turnips became eaten down fairly close to the earth, but with the flock in question death had occurred more or less for months while being turnip fed.

Mr. Wilkie only observed one animal prior to death, when the chief symptoms exhibited were separation from flock, dulness, arched back, knuckling over at fetlocks, head carried high, pulse thready and weak, and temperature 107·0 This animal was so observed in the evening. The following morning it was found dead, as was another which the previous evening was apparently normal. A number of post-mortem examinations on animals recently dead were made by Mr. Wilkie, the following being a summary of his observations :—

More or less froth, at times blood-stained, about nostrils ; subcutaneous sero-sanguineous patches ; blood-stained peritoneal effusion, varying in quantity up to a pint ; pleural effusion often blood-tinged, present at times in large quantity, but often absent ; generally some pericardial blood-stained exudate ; kidneys, lungs and liver sometimes congested, and, except in one case where there was slight congestion of the abomasum, the intestinal tract was normal. In these cases, which were examined very soon after death (in one immediately afterwards), no mention is made of putrefactive odour.

An experiment demonstrated the specific nature of the disease. Doses of ½ and 1½ cc. of heart blood from cases recently dead were injected subcutaneously into two crossbred hoggets which had never been on turnips or in contact with affected sheep. One died in 24, the other in 52 hours. The chief changes observed post mortem were intense hæmorrhagic œdema in the subcutaneous tissues near the side of inoculation ; in one, pericardial effusion with petechiæ of the endocardium ; in the other, a quantity of pleural effusion.

From specimens Mr. Wilkie forwarded to me, then chief Veterinarian in Wellington, a short bacillus often in pairs, gram-positive, anærobic, non-motile, was isolated and cultivated on agar broth, etc. Both with original *materia morbes* and with cultures experiments were conducted on guineapigs and on sheep.

Guineapigs inoculated with small doses succumbed as a rule in 24 hours or less. Post-mortem examination showed extensive subcutaneous sero-sanguineous extravasation, and at times a small quantity of peritoneal serous effusion.

Sheep inoculated with agar cultures died in from 50 hours to four days, one recovering from the inoculation of a small dose. Post-mortem examination showed extensive subcutaneous and intermuscular sero-sanguineous extravasation, a varying quantity of sero-sanguineous effusion in abdomen, in the pleural and pericardial cavities in one case a quantity of similar exudate, in others none ; ecchymoses in varying situations as heart, pulmonary pleura, peritoneum, etc.; spleen at times pulpy but not enlarged, etc. No evidence of putrefactive odour immediately after death was detected.

At the time owing to pressure of other work the investigation was not continued, it being considered certain it could be readily resumed the following winter. Unfortunately for this, however, by the following year the farmers were found to be following the recommendation made by the Veterinary Department, with so much success that Mr. Wilkie failed entirely to secure specimens satisfactory for the continuation of the work, so that up to the date of my departure from the Dominion it was found impossible to complete this work from the scientific standpoint. Leaving aside, however, the rarity or slightness of stomach lesions, the close similarity of the disease with the others under review particularly in regard to seasonal occurrences, age incidence, condition-predisposition, suddenness of death without premonitary symptoms, and the general post-mortem picture, together with what has been recorded of the bacteriology, impels one to the conclusion this is but another phase at most of "braxy."

Diseases Allied but Distinct.

Malignant Œdema and Blackleg.—Malignant œdema and blackleg in many respects are diseases which simulate the one under review. Malignant œdema frequently, however, attacks sheep after shearing, castration, docking, &c., the bacilli gaining entrance through the wounds. The disease is common on stations where braxy or a similar disease has never appeared, and on many stations where the latter is common malignant œdema ("blood-poisoning") is unknown.

In comparing the braxy disease with malignant œdema it should be remembered that both morphologically and culturally the two bacteria vary definitely. An opportunity offered, however, to test the two by a very satisfactory method.

A sheep which had been inoculated with a malignant œdema culture and gradually recovered after being very ill for two days, during which necrosis of the inoculated limb occurred, the necrosed tissue ultimately sloughing, and healing of the wound finally taking place, was inoculated a month after recovery with 0·25 cc culture of the Tasmanian bacillus. The result was death in 30 hours with the typical symptoms and post-mortem appearances, proving that no immunity to braxy had been conferred as a result of the attack and recovery from malignant œdema. (See Appendix A, viii.)

Blackleg of cattle in many ways more approaches the sheep disease. It has also a great preference for young animals in good condition. The natural disease is very like the experimental braxy, the bacilli are morphologically very like, and even in cultures are in appearance similar. Where blackleg is common in cattle on many holdings, however, it has not been observed that sheep are liable to a similar disease, and *vice versa*, holds good. Although stab cultures in agar show a resemblance, yet separate colonies are quite different, the braxy colonies being biconvex discs, and not spherical. Further, sheep immune to braxy are in no way immune to blackleg, as the following experiments show :—

Sheep 20 and 31 which had been immunised to at least the ordinary fatal dose used of both the Victorian and Tasmanian bacilli (see Table 2) were inoculated each with 0·25 cc. first broth culture from virulent dry blackleg muscle ; another sheep (27), which had resisted feeding with virulent Tasmanian culture, as a control received a similar dose. The typical course of experimental blackleg in sheep ensued, the control sheep (27) dying in 54 hours, sheep 31 in 60 hours, and sheep 20 in 70 hours after inoculation. It is rather interesting to note that the post-mortem picture presented in each of these cases was in many respects similar to that of the braxy disease. The muscle lesion was more intense, while the subcutaneous œdema was comparatively small in amount, though still considerable. The abomasum mucosa was congested throughout, with patches of a deeper, almost purple, colour here and there. The sub-mucosa was distended with much serous infiltration, causing thickening of the stomach wall to nearly an inch in extent, this lesion being very definite in each case. The intestines were also congested more or less throughout. The liver and kidneys were congested. The lungs were œdematous, and the pericardium distended with clear effusion. These lesions are especially interesting in view of the fact that Blackleg is by some considered not uncommon in sheep.

Predisposing Causes of Braxies in General and the Natural Method of Infection.

While youth and condition are undoubtedly very important factors in predisposing sheep to the disease, yet they are by no means the sole or perhaps the most important. Season exerts apparently a most powerful influence, but it is evident so far as the Australian disease is concerned that this is only secondary. Hamilton, in the group of diseases he studied, which included braxy, louping-ill, black-leg, etc., claimed a bacteriolytic substance presence in the blood during that period of the year when animals are not attacked, or, as he considered, "immune." His observations have not been confirmed, however, and general practice does not bear out his conclusions so far as blackleg is concerned. In my own experiments no evidence of immunity has been observed at any period of the year. We should seek, therefore, for additional predisposing influences. So far as the European disease is concerned, I have not sufficient kuowledge to enable me to discuss the question further than to suggest the winter incidence may be due to the necessity for close grazing inducing the prehension of contaminated portions of soil, and so inculation through the mouth.

In New Zealand the "braxy-like disease" only appears, to a noticeable extent at all events, in young sheep during winter when feeding on turnips in the ground, and generally not until the roots are eaten close to the soil. In Tasmania the earliness of the spring growth seems (as recorded above) to be concomitant with the appearance of the disease. In Victoria, or at any rate on the property mentioned, the disease is practically confined to the very dry months, and even then disappears for a time with a rapid growth of grass following a summer soaking of the ground. The predisposing factor of importance in each of these cases, therefore, may be the impossibility of the sheep avoiding the ingestion of soil along with the food: in New Zealand to the "shells" of the turnips adheres much soil; in Tasmania the young grass carries up a certain amount of soil in its rapid growth, as does often a mushroom; and on the Victorian property during dry weather the sheep graze about the marshy places where the springs debouch, and drink the water which is rendered muddy by the slightest movement. Such ingestion of earth, provided it be contaminated with the braxy germs, would seem to explain the entrance of such an organism into the intestinal tract, and also the transmission of the disease.

But still other conditions are required. We found, for example, in New Zealand that provided sheep were allowed a "run off" from the turnips to rough pasturage, or were fed with straw while on the turnips, that the mortality became reduced to a minimum, which seems to indicate that an empty state of the stomach prior to swallowing the earth contaminated roots is a necessary favourable condition.

But even then something seems to be wanting. We have seen that adult life an l even old age confers little or no immunity to the bacteria when experimentally introduced into the subcutaneous tissues, while every attempt to confer the disease by feeding (this applied to Jensen's and to the bulk of Hamilton's experiments also) has failed. The explanation may lie in the much greater liability of young sheep to harbour gastric and intestinal parasites, and that such might introduce the germs into the depth of the mucosa, if not into the sub-mucosa, where they, becoming freed of air, may readily multiply, seems possible. In this connection it should be observed that in my experience young sheep may harbour considerable numbers of internal parasites without manifesting any symptoms of intestinal derangement, provided their food supply is nutritious and their general comfort attended to. Yet it should be remembered that while the stomach lesions may be very evident the deduction that the gastric mucosa is necessarily the point of penetration is not warranted, for we have seen that experimental cases frequently show marked lesions of the abomasum, while the real site of entrance may only show intense œdema ; therefore intestinal as well as gastric introduction of the bacilli is not to be excluded. Parasites seem rarely to be able to remain long in adult sheep in comparison with young animals, and this may explain their apparent immunity.

But notwithstanding the above arguments in favour of the possibility of alimentary infection, the evidence against is very great —indeed overwhelming.

Neilsen and Jensen always failed to transmit bradsot by feeding. Hamilton never transmitted it by feeding during his so-called immune season ; and even when he did succeed, his experiments were open to the objection of being conducted on naturally infected farms. Likewise, I have not only failed by administering pure cultures in the ordinary way per oram, but even when such cultures were intermixed with numerous glass splinters, which should have favoured, to say the least, the introduction of the bacteria into the gastric or intestinal sub-mucosa.

Further, these experiments, so far as the Victorian bacillus was concerned, were conducted during the period of the year— the summer months—when the Victorian disease is prevalent.

The mere failure to produce the disease by these feeding experiments does not of itself disprove the possibility of alimentary infection ; but *the fact that by the introduction of small doses* (*and one cubic centimetre of a liquid culture is not a large dose to introduce into the alimentary tract of such an animal as a sheep*) *of virulent bacilli, a decided and active immunity is rapidly produced, does in our present state of knowledge regarding the disease certainly completely disprove the possibility of natural infection by the digestive tract.*

A preliminary experiment seems to indicate that the same holds good of blackleg.

We are, therefore, forced to consider other means of infection conveyance operating naturally, and the only available hypothesis seems to be that the bacterium is naturally introduced into the derma and subcutaneous tissues or the submucosa of the mouth, by vegetable prickles, thorns, etc., or it may be through the teeth alveoli while the temporary teeth are being shed. At first sight thedefinite seasonal incidence seems to militate strongly against such a theory ; but on the other hand it must not be forgotten that all the phases of braxy we have dealt with in different countries occur when the ground is bare—the European during frost without snow, the Tasmanian at the end of winter, the Victorian in the dry summer when herbage is at its minimum growth, and the New Zealand when the lambs are forced to lie on the puddled ground. In New Zealand the great reduction of the cases which followed the provision of the dry camping ground of a grass paddock attached to the turnip paddock is especially noteworthy.

The absence in the naturally-acquired disease of the extensive subcutaneous œdema noted in experimental cases is the chief objection to this theory ; and against it may be placed the fact that subcutaneous œdemas are always more or less present in naturally-affected cases, though they may not be extensive. The muscle lesions may be almost entirely avoided by the experimenter being careful not to introduce the syringe needle into the musculature. The age incidence is probably explained by natural immunization through the alimentary canal.

To anticipate a possible criticism to the effect that the bacilli in question may not be the actual *causæ causans*, and that the real agent may be a filterable virus, it may be stated that the latter has been eliminated. Experiments conducted with filtered serosity, with blood containing no bacilli, and with serosity remaining apparently sterile after incubation have proved always negative.

That the organism isolated and described is the actual cause of braxy diseases investigated cannot be doubted, on careful comparison of the general lesions in the natural and experimental cases as detailed, bearing in mind the pathology of the lesions as well as their situations.

Prophylaxis.

Both Neilsen and Jensen found that with dried tissue containing the bacteria they could confer immunity to bradsot, but the latter considered the method dangerous, although the former reported general good results in his district in Norway.

Hamilton recommended the drenching with cultures of sheep in the "immune" season, and professed to have demonstrated the efficacy of this method, which is also considered by Dr. Willmot likely to be of value in Tasmania. I am informed on good authority that later on further experiments demonstrated that sheep treated by this method did not display greater resistance to the natural disease than did sheep on the same farms not so treated, and the method has been entirely abandoned in Great Britain. Although I have actually demonstrated that at any time definite immunity can be produced by drenching with virulent cultures, one would hesitate, at least at present, to recommend the adoption of such a method on a large scale, especially in view of Hamilton's statement that he found the braxy bacilli thus introduced being still expelled by the fæces two months later. If an unburned and unburied carcase of an animal dead of the disease is, as admitted by Hamilton in common with others, a certain source of contamination of the surrounding soil, and even at some distance by water, etc., sheep continuously passing quantities of the pathogenic germs are more likely to be spreaders of future infection; and indeed, in view of the frequent moving of sheep over a country, to become definite carriers of infection to hitherto clean farms. Disease carriers, themselves immune, are well known to exist with other maladies.

As I have shown, it is possible to immunize sheep to experimental injection by means of weakened cultures, but whether this method would prove satisfactory from the economic and practical view point is another matter. So far no opportunity has presented itself of testing this method, the reason being apparent later. That it would be efficacious from the scientific standpoint is to be anticipated from the experiments and from the success attendant on blackleg vaccination.

With sheep diseases, however, in view of the small value relatively of each animal, the large numbers to be treated, it is always advisable to seek for the most practical measures in the prevention of disease, bearing in mind that an annual mortality of even two per cent. is generally viewed with great equanimity by the flockowner. An example of such a measure is afforded by the success of my recommendations for the prevention of the New Zealand hogget disease. These recommendations shortly were as follow:—

1. Destruction by fire or burial of all carcases, and
(2) the provision of dry food, as straw, hay, etc., or, preferably, a "run-off" to rough herbage.

The result has been that the disease has almost disappeared.

In Tasmania the recommendation was made that on the approach of the dangerous period of the year the young sheep should be removed for two or three months from the affected areas, and the ewes, which are rarely if ever attacked, placed thereon; in other words, I considered some system of management should overcome the mortality to a very great extent. Whether this has been attempted, or if not, why it has not been tried, I have not been advised.

On the Victorian farm where the outbreak detailed occurred I recommended the drainage of the small swampy areas and their cultivation, where possible, around the springs, the collection of the drinking water from the springs in troughs, in order to abolish what appeared to be the principal immediate source of infection. This is being accomplished. It is too early for definite results of any value to be obtained, specially as this summer—1910-11—has been remarkable for its unusual rainfall, a circumstance that in itself would readily account for the very slight mortality experienced to date. Needless to add that wherever a disease of this nature occurs it is imperative carcases should be destroyed, preferably by fire, and that at least they should not be allowed to remain gradually disintegrating on the surface of the soil.

Nomenclature.

Ivar Neilsen suggested the term "Gastromycosis Ovis" for bradsot. Hamilton found objections to this on account of the fact that it might with equal justice be applied to other diseases, and substituted "Morbus subitarius ovis" for both braxy and bradsot. While agreeing with Hamilton that Neilson's term is unsatisfactory, not only for the reason that he advances, but because according to Neilsen's own report the "mycosis" is not limited to the stomach, and further because the "gastritis" is not characteristic, it cannot be considered that Hamilton's designation is an improvement, for to it there are obvious objections. In my preliminary report to the Tasmanian Minister of Agriculture on the "braxy-like disease" as occurring in that State, I suggested the term "malignant transudation."

Further, careful consideration of Jensen's description of bradsot (as summarised in the *Veterinarian* of 1895) and of Hamilton's description of braxy, leads one to the conclusion that while there are certain definite points of distinction between bradsot and braxy, they are not sufficiently marked either from a pathological or bacteriological standpoint to warrant the conclusion other than that they are but varieties of the same disease. Again, although, as this paper shows, there are certain definite distinctions between the winter disease of yearling sheep investigated in Tasmania and the summer disease of older sheep in Victoria, and although the bacilli have certain though slight distinguishing characters that these two diseases are but really varieties of the one, cannot be doubted.

In addition, however, the complete review of the sheep diseases mentioned, "bradsot" of Norway, etc., "braxy" of Great Britain, the Tasmanian, the Victorian, and the New Zealand sheep diseases, including what is known of the bacteriology of each impels the conclusion that they are at most but varieties of the same disease. Hence it being obviously as unwise as it is unprofitable to establish new names with Latin terminology where an old established and general name is available and distinctive, it seems to me preferable from every point of view to discard all others for this class of disease and adhere to the one "*Braxy*" as being short, convenient and free from any objection.

Summary and Conclusions.

1. A group of diseases of sheep exists in various parts of the world, which though not absolutely identical are so closely allied that they may be dealt with under one general term—Braxy.

2. The diseases of this group already investigated, at least partially, are "braxy" in Britain, "bradsot" in Norway and Iceland, "braxy-like disease" in New Zealand, "hogget disease" in Tasmania, and a disease of sheep in Victoria, Australia.

3. The diseases are alike in that young sheep, especially those in good condition are prone to attack. Seldom are symptoms observed, the course being rapid and early fatal, the pathological lesions are in the main identical, post-mortem putrefaction is very rapid, the nature is endemic, the occurrence is seasonal, recovery (if such occurs) is extremely rare, and they are due to anærobic gas-producing bacteria.

4. Experimentally the pathogenic lesions of the disease can be readily reproduced by effusions and morbid products containing the bacilli, and by pure cultures, when injected into the subcutaneous tissues, but ingestion experiments are generally, if not always, unsuccessful.

5. In the above paper the diseases as appearing in Tasmania and Victoria (Australia) are especially studied, but a summary of investigations on the other diseases is also given.

6. The causative organism studied here is an anærobic sporulating bacillus morphologically similar to that of blackleg, the chief distinguishing cultural characteristic being the bi-convex, disc-like colonies in agar media.

7. The most convenient method of cultivating the bacilli after isolation is to place in broth or serum broth media a small portion of dried m scle containing spores, exclusion of the air being unnecessary.

8. The Tasmanian and Victorian diseases, though similar in all essential details, yet differ in minor points, such as seasonal and age incidence (the former occurring in winter and practically confined to yearlings, the latter occurring in summer and practically confined to two-year-olds), in the virulence for cattle and rabbits, and in some slight morphological and cultural characters of the pathogenic bacilli.

9. That the diseases are but varieties of the one is, however, definitely proved by immunity to one implying immunity to the other.

10. Cultivations of the pathogenic bacilli (at least those studied here) in glucose broth results in a rapid though gradual weakening of virulence.

11. By the use of such weakened cultures immunity may be produced, but experiments in the field are required to ascertain if such a method may be used economically and with safety.

12. The group of diseases is allied to malignant œdema and to blackleg, but there are certain definite phenomena which clinically serve to distinguish them, while the results of immunity experiments negative a very close relationship.

13. Feeding with virulent cultures of the bacilli results in the rapid and definite production of immunity, the season of the year being immaterial.

14. Certain circumstances predispose to the infection, notably condition and age, but probably the seasonal influence which appears to be a predisposing factor is due chiefly to the opportunity under natural conditions for skin punctures by contaminated prickles, etc. occurring at definite periods of the year. The direct introduction of the bacilli by means of internal metazoan parasites is very improbable, if not impossible, in view of the results of feeding experiments.

15. For the group of diseases dealt with the established British name " braxy " is recommended in preference to any other.

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APPENDIX A.

TASMANIAN DISEASE.

Details of Experiments.—The results of the first series of experiments in which the pathogenic bacillus was secured in a state of purity by passage through guineapigs have already been published. (*Veterinary Journal*, Vol., 66, pp. 254 and 355 (May and June, 1910).

The following are the details of the further experiments referred to in text.

I.—FURTHER EXPERIMENTS ON GUINEAPIGS AND RABBITS WITH SUBCULTURES IN SERUM BROTH UNDER OIL.

Guineapig 18.—Inoculated with 0·05 cc. first serum broth subculture from blood of pigeon. Death occurred in 48 hours. Post-mortem: much subcutaneous œdema, extending along floor of abdomen; internal organs normal, but for patches of necrosis in liver.

Guineapig 21.—Inoculated with 0·25 cc. four days old first subculture from lamb 1 in serum broth. Death occurred in less than 16 hours. Post-mortem: much subcutaneous œdematous swelling extending along abdominal floor; little change in organs, except liver, which shows necrosed patches.

Guineapig 24.—Inoculated with 0·25 cc. first subculture from blood of guineapig 21. Death within 16 hours. Post-mortem: much subcutaneous œdema, effusion in pericardium, necrotic areas in liver, liver congested, kidneys, petechial points, otherwise normal.

Guineapig 52.—Inoculated with 0·1 cc. 24 hours old second subculture of amb 1 in ordinary serum broth. Death occurred in less than 20 hours. Post-mortem: typical, with much peritoneal effusion; no liver necrosis. (See Lamb 5).

Rabbit 2.—Inoculated with 0·1 cc. 12 days old first subculture in serum broth from lamb 1. Animal dead within 16 hours. Post-mortem: subcutaneous œdema not so extensive as in guineapigs; small quantity of peritoneal fl id.

Rabbit 5.—Inoculated with 0·1 cc. three days old seventh subculture on serum broth from lamb 1; this being a subculture from that used for lamb 3 made a week after lamb 3 was inoculated. Animal found dead 16 hours later. Post-mortem showed comparatively little subcutaneous effusion, and otherwise normal. Apparently there was little loss of virulence for the rabbit. (Compare lamb 3.)

II.—Experiment on Calf.

A calf, three months old, in good condition, was inoculated behind the left shoulder with 0·5 cc. 24 hours old first culture from sheep 1. In 24 hours the animal was slightly lame, and there was a considerable swelling, hot and painful, behind the shoulder. Although the temperature was high the appetite was good and rumination was normal. The next day the swelling had become more diffuse, was not painful, and the animal was not apparently ill. Temperature 102·2. About 50 hours after inoculation grave symptoms developed, the animal breathed as if with difficulty; later on signs of dyspnœa appeared, and death occurred suddenly at 6 p.m., 54 hours after inoculation. Post-mortem examination was made two hours later. Practically the whole of the subcutaneous and intermuscular tissues of the inoculated side of the body (the left side) extending from the front of the shoulder to the hip were infiltrated with clear amber-coloured semi-gelatinous serous effusion, this being specially voluminous towards the inferior surface of the body. The muscles were pale, with large patches dark coloured and hæmorrhagic. No gas present and no odour of any kind, the dark muscles presenting none of the other characteristics of blackleg-infected muscle. The liver was deeply congested. Spleen and kidneys normal. Abomasum much recently ingested food. Sub-mucosa not œdematous. Mucosa irregularly covered with petechiæ 2-3 mm in diameter; towards the cardiac orifice several patches of sub-mucous hæmorrhage, and near the pylorus, congestion of the mucosa with slight surface necrosis and numerous irregular hæmorrhages. Intestines normal. Pleural cavity, about a pint of clear straw-coloured effusion. Lungs very œdematous, the septa, especially of the anterior lobes and the superior half of the main lobes being distended with clear semi-gelatinous effusion. Bronchi, much pinkish froth. Trachea and larynx congested. Pericardium distended with clear effusion; epicardium in region of auriculo-ventricular groove thickly studded with ecchymoses. Heart otherwise normal. Microscopical examination; the œdema at some distance from the region of inoculation fails to show any bacteria. The haemorrhagic muscle shows typical bacilli generally in pairs and very uniform in size; pleural effusion, liver, blood, spleen, etc., apparently sterile. The post-mortem picture it will be seen is that of a case of braxy in the sheep, and is very distinct from that of a case of blackleg, in spite of certain points of similarity. After incubation, pleural fluid and blood contained many typical bacilli, although previously apparently sterile.

III.—Experiments with Diseased Muscle dried at 55° C.

Guineapigs 23 *and* 26.—Inoculated with fragment dried muscle, lamb 1, mixed with broth. Death in 16 and 18 hours. Post-mortem: sero-sanguineous to clear effusion subcutaneously extending forward to axillæ: little peritoneal fluid, sero-sanguineous effusion in pleura and pericardium; liver, small areas of necrosis in 23, but no necrosis in 26.

Guineapig 25.—Inoculated with 0.05 cc. subcutaneous œdema of guinea-pig 23. In two hours a swelling the size of a walnut was present and the animal uneasy. Three hours later the swelling had increased, was hot and painful. Six hours after inoculation the animal was very ill; evidence of great pain, squeaking convulsively, breathing rapidly. An hour later intermittent muscular spasms appeared, head shaking; does not move when disturbed; swelling now extending forward to elbow; prostration followed, and death occurred about 12 hours after inoculation. Post-mortem: much subcutaneous effusion; a little peritoneal and pericardial fluid; liver congested, and one or two patches of necrosis.

Guineapig 38.—Inoculated with about 0·1 cg., of ground muscle as used for sheep 3 and lamb 2. 24 hours later no swelling was observed. 12 hours afterwards, however, there was a considerable swelling, and the animal was prostrate. Death occurred about 36 hours after inoculation. Post mortem: typical, but no liver lesions.

Sheep 3 (5 years old).—Inoculated with 2 cg. dried muscle from lamb 1, ground up and mixed with 2 cc. sterile broth. Twenty-four hours later animal normal, with little swelling, and feeding well. Next day great lameness observed, with swelling of whole limb. Sheep drowsy, uneasy, grinding teeth intermittently, no appetite, temperature 100°. Illness rapidly became aggravated, and death occurred 54 hours after inoculation. Post-mortem examination: much subcutaneous œdema extending from foot to pubis and several inches along abdomen. Œdema semi-gelatinous and clear, but for faint blood tinge in thigh; intermuscular tissue greatly infiltrated; muscles œdematous and pale, with little hæmorrhage. No odour beyond a marked muttony smell. Small quantity of clear effusion in pleural and peritoneal cavities, and on exposure this rapidly became semi-gelatinous. Liver congested with small sub-capsular areas of necrosis. Kidney congested; spleen normal; abomasum—mucosa shows patches of intense congestion, some with the surface necrosed with diphtheritic appearance, these areas varying in diameter up to an inch. Submucosa not œdematous. Small intestines: irregular areas of congested mucosa. Microscopical examination showed no organisms present except in muscles and no œdema near region of inoculation.

Lamb 4 (10 months old).—Inoculated with 2 cg. dried muscle of lamb 1, ground up and mixed with 2 cc. of sterile broth. Twenty-four hours after little swelling observed, animal feeding well. The following day animal drowsy, no appetite, much swelling and lameness, but not so intense as in Sheep 3. Temperature 103°. Symptoms gradually became aggravated and death occurred during night, or about 60 hours after inoculation. Post-mortem examination.—Subcutaneous tissues of inoculated limb greatly infiltrated with straw-coloured œdema, which extends forward to apex of sternum. At point of inoculation œdema blood-tinged and gas present, with slight odour. Muscles pale and hæmorrhagic in patches; one area of necrosis about two inches in diameter being present where needle entered. Peritoneum: a pint of blood-tinged effusion; liver congested, no necrosis: kidneys congested; spleen pulpy, but not enlarged; sub-lumbar muscles very œdematous. Abomasum: very slight congestion; at pylorus small definite area deeply congested; submucosa slightly œdematous; duodenum congested for about the first two inches; pleural cavity about 10 oz. of straw-coloured effusion; pericardium and heart normal. Microscopical examination.—Many typical bacilli in œdema and muscles in inoculated region; subcutaneous œdema elsewhere sterile; sub-lumbar œdema typical bacilli. Peritoneal fluid: Typical bacilli, and long, thin bacilli, also bacilli morphologically like those of tetanus ; pleural fluid, blood and spleen, no bacilli.

NOTE.—Sheep 3 and lamb 4 indicate how the post-mortem appearances may vary considerably.

IV.—Weakening of Virulence in Cultures in Serum Broth (without glucose) under Oil.

Guineapig 30.—Inoculated with 0.1 cc. one day old *fifth subculture* from lamb 1. Death occurred in 36 hours. Post-mortem examination : much subcutaneous œdema, with a little gas ; small quantity of effusion in peritoneal, pleural and pericardial cavities ; small area of liver necrosis ; a little intestinal effusion.

Lamb 3 (one year old).—Inoculated with 0.3 cc. three days' old *sixth subculture* from lamb 1, being a subculture made from that used for guineapig 30 a week after guineapig 30 was inoculated. For two days the lamb remained normal apparently but for slight swelling without definite lameness ; then distinct lameness appeared, with swelling, the animal having no appetite. Death occurred 72 hours after inoculation. Post-mortem examination : Limb swollen ; much subcutaneous œdema extending from coronet to near sternum ; slightly blood-tinged around point of inoculation, but elsewhere clear and semi-gelatinous ; muscles pale and œdematous, with areas dark, blood-infiltrated. and friable ; little odour. Abdominal cavity : about a pint of amber-coloured serosity ; spleen slightly enlarged and softened ; liver congested, but no necrosis ; kidneys dark and congested ; abomasum mucosa congested, and folds œdematous. Thorax, about 2 oz. clear effusion. Heart normal.

Guineapig 42.—Inoculated with 0.1 cc. tenth subculture in serum broth as used for lamb 5. Result : remained normal. Two days later re-inoculated with 0·1 cc. 21 days old seventh sub-culture in serum broth from lamb 1. Result : remained normal. Ten days later, inoculated with 0·25 cg. muscle of lamb 1, as used for other guineapigs 23 and 26 and sheep 4. Result : remained normal, but for passing swelling.

Guineapig 45.—Inoculated with 0.05 cc. *six weeks' old eighth sub-culture* from lamb 1. Result : local swelling and stiffness developed, from which gradual recovery occurred.

Sheep 4 (old ewe, incisor teeth worn-out, with three months' lamb at foot).—Inoculated with 0·5 cc. five days' old ninth sub-culture, carried on for two months at intervals. Twenty-four hours later slight swelling, no lameness ; temperature, 102·6°. Lameness appeared later, the swelling slightly increased, and temperature rose to 103°, but oth rwise the animal remained normal. The following day the lameness and swelling had disappeared. (Compare guineapig 39.) Seventeen days after this inoculation sheep 4 was re-inoculated with 2 cg. dried muscle of lamb 1, a large dose being employed, as it was thought the age of the animal might have induced natural immunity. Twenty-four hours later there was œdema of the limb ; temperature 104·5°, which rose by evening to 106°. Next day the swelling had increased ; the animal showed disinclination to move ; temperature, 103°. Gradually the œdema spread along floor of abdomen ; by late evening animal was prostrate. Death occurred about 70 hours after inoculation. Post mortem examination : skin of thigh slight livid. Subcutaneous œdema extends from coronet to pubis and along abdomen for several inches ; clear unless at region of inoculation, where blood-tinged. Muscles pale but hæmorrhagic where inoculation made. No gas and no odour unless just where muscle incised. Peritoneum and pleura contain small quantity of clear effusion. Abomasum normal, but for slight submucous œdema. Duodenum deeply congested for about ten inches from pylorus. Heart : some petechiæ on epicardium ; otherwise normal.

Lamb 5 (four months old, progeny of sheep 4, and had remained in same pen throughout). (See also guinea-pig 42.) Inoculated a month after sheep 4 with 0·5 cc. four days' old tenth subculture in ordinary serum broth from lamb 1. Beyond a passing swelling the lamb remained normal. A month after this inoculation, re-inoculated with 0·5 cc. 48 hours' old second subculture from lamb 1. (See guineapig 52, inoculated with 0·1 cc. as control.) Next day no change observed. Following day leg carried, with large œdematous swelling, dull, no appetite, temp., 105·8°. Condition gradually grew worse, and death cccurred in about 56 hours. Post-mortem examination could not be made for about eight hours after death. Abdomen much disturbed. Subcutaneous tissues all infiltrated with gas. Post-mortem discolouration at thighs and elbows ; bloody froth from nostrils ; much œdema infiltrating whole tissues of inoculated limb ; odour on incising skin marked, but disappears rapidly ; little peritoneal effusion ; spleen pulpy ; kidneys softened and dark ; abomasum practically empty, mucosa congested, and folds œdematous. Pleura : about 10 oz. deeply blood-stained fluid. Pericardium distended with similar effusion. Lungs œdematous. Heart, normal.

Guineapig 37.—Inoculated with 0·1 cc. 30 days' old first subculture from muscle lamb 3. (Culture only shows a few spores in deposit.) Beyond a slight swelling, which disappeared next day, the animal remained normal.

Guineapig 39.—Inoculated with 0·1 cc. *one day old* ninth subculture on ordinary serum broth carried on for two months. Death occurred n two days, during which time a large subcutaneous swelling had gradually developed. Post-mortem : typical swelling of subcutaneous tissues, small quantity of peritoneal fluid ; no liver necrosis. (See sheep 4 inoculated with 0.5 cc. of same culture four days later.)

Guineapig 115 *and Rabbit* 30 inoculated with 0·15 cc. first culture 30 days old.

Guineapig 116 *and Rabbit* 31.—Inoculated with 0·15 cc., first culture, being a culture derived from the fifth transfer of the same portion of dried muscle as used to prepare culture for previous experiment. This culture showed much gas formation, but no odour could be detected. It was parallel to an ordinary fifth subculture, with the exception that the same portion of muscle was transferred each time, and the weakening effect of each successive transfer would be on the bacteria within the muscle.

Result of Inoculations.—Guineapig 115 and Rabbit 30 remained normal.

Guineapig 116.—1st day : large typical swelling ; 2nd day : swelling smaller and firmer ; 3rd day : animal dull, swelling increased ; 4th day : dead by daybreak, about 80 hours after inoculation. Post-mortem : large subcutaneous œdematous swelling, extending forward to both axillæ ; large quantity of clear peritoneal effusion, pinkish in colour, otherwise little change.

Rabbit 31.—In 24 hours a large subcutaneous œdematous swelling present at region of inoculation. Death occurred about 36 hours after inoculation. Post-mortem examination : much subcutaneous œdema, no peritoneal fluid, liver affected with coccidiosis ; otherwise normal.

Guineapig 115 and *Rabbit* 30 were re-inoculated 21 days after this experiment with 0·075 cc. first culture from sheep 1 muscle. The guineapig died in less than 18 hours. Post-mortem examination showed typical subcutaneous œdema, but otherwise little change. The rabbit died 46 hours after being inoculated, post-mortem examination showing typical subcutaneous œdema, and internal organs little altered.

V.—Cultures in Glucose Serum Broth : Rapid Loss of Virulence.

Sheep 13, 3 years old.—Inoculated with 0·25 cc. 24 hours' old first culture from muscle of lamb 1. Death occurred within 28 hours. Post-mortem examination : typical subcutaneous œdema, no gas and no odour, except marked muttony odour, muscles dark and hæmorrhagic; no fluids in serous cavities, except pericardium, which is distended with clear effusion; kidneys and liver congested; spleen dark, pulpy, but not enlarged; abomasum congested and folds œdematous; heart, subepicardial ecchymoses. Microscopical examination: typical bacilli in muscle and surrounding œdema; subcutaneous œdema elsewhere, blood, etc., sterile.

Guineapig 129.—Inoculated with 0·15 cc. 24 hours' old first subculture. Animal dead in 20 hours. Post-mortem appearances typical.

Sheep 19 (5 years old merino ewe).—Inoculated with 0·25 cc. four days' old fourth subculture and *Guineapig* 134 with 0·1 cc. as control. The following day both animals being normal they were re-inoculated with the same culture as used for guineapig 129 (now eight days old), the same doses being used. The animals both remained normal. Four days later sheep 19 was inoculated with 3 cc. seven days' old fourth subculture, and still remained normal. Fourteen days later sheep 19 was re-inoculated with 0·25 cc. first subculture two days old in ordinary serum broth, and *Guineapig* 134 with 0·1 cc. At the same time *Guineapig* 143 (not previously inoculated) received 0·1 cc. of the same culture. The two guineapigs died in 24 hours with typical post-mortem appearances. Sheep 19 was lame the next day; temp., 103·4°. The following day the condition was worse; temp., 104·3°. Death occurred about 56 hours after inoculation. Post-mortem examination: no skin discolouration at region of inoculation; subcutaneous tissues of inoculated limb from coronet to pubis infiltrated with effusion clear and semi-gelatinous, unless just around point of inoculation; muscles pale but for one patch, where hæmorrhagic. Peritoneal cavity, a small quantity of clear effusion; spleen pulpy and slightly enlarged liver and kidneys deeply congested; abomasum deeply congested throughout whole of mucosa, especially at pyloric ring; submucosa œdematous; duodenum deeply congested: this gradually gives way to injection of blood vessels; submucosa very œdematous, and lumen of bowel contains much albuminous œdematous effusion; pleura, about 6 oz. of clear effusion; heart normal; pericardium, little excess of fluid. The typical bacilli were very numerous in the hæmorrhagic muscle and the surrounding œdema, but no organisms could be detected in the œdema some distance from the site of inoculation. Spleen and blood apparently sterile. Peritoneal and pleural effusions, a few typical bacilli. Intestinal œdema, many shed epithelial cells and mixed bacteria, very few being of the morphology of the inoculated bacillus. Abomasum mucosa, many bacilli in groups morphologically identical with those inoculated.

Sheep 26 (2 years old).—Inoculated with 5 cc. seven days' old second subculture, *Guineapig* 148 receiving 1 cc. of same culture. The following day sheep 26 showed a little swelling where inoculated, but there was no lameness; temperature, 102·6°. The guineapig showed but a slight swelling. Next day both animals were normal. Nineteen days later these animals were re-inoculated with 24 hours' old first culture in ordinary broth—the sheep with 0·25 cc., guineapig 148 with 0·15 cc., guineapig 160 receiving also 0·15 cc. as control. Both guineapigs died within 20 hours. Guineapig 148 showed much subcutaneous œdema, much peritoneal effusion, and numbers of necrosed patches in liver, while guineapig 160 showed comparatively little subcutaneous effusion and no other lesions. The day after inoculation sheep 26 was slightly lame, a little swelling was present, temperature 105·5°. The following morning the swelling had increased greatly, the whole of the inner surface of the limb being implicated; temp., 104·6°. During the day the swelling extended along the abdomen, the animal became dull, the temperature fluctuated, and death occurred 60 hours after inoculation. Post-mortem examination: extensive subcutaneous œdema from coronet to shoulder, no skin discolouration and no crepitation; small quantity of peritoneal pleural and pericardial effusion; spleen, kidneys and liver normal; abomasum, slight congestion but not marked; lungs œdematous; bronchi and trachea frothy exudate; heart, ecchymoses in subepicardium. Microscopical examination: many typical bacilli present in œdema and dark muscle tissue of region of inoculation; mixed organisms in peritoneal effusion; otherwise organs, etc., apparently sterile.

Sheep 28 (2 year-old merino).—Inoculated with 5 cc. six days' old first subculture, *Guineapig* 152 receiving 1 cc. of same culture. (This culture when 24 hours old was used for guineapig 150 in a dose of 0·075 cc., and death resulted in less than 24 hours, typical lesions being present post-mortem). Guineapig 152 was dead in less than 20 hours. Post-mortem, typical, with no liver necrosis. Sheep 28, lame the following morning, ; subcutaneous tissue of thigh slightly swollen and œdematous; temp. 103°; death occurred 40 hours after inoculation. Post-mortem examination: much œdema of subcutaneous tissues from coronet to pubis and along abdomen for several inches; clear and semi-gelatinous but for a few inches around point of inoculation. Muscles pale, but superficial areas hæmorrhagic. Peritoneum: small quantity sero-sanguineous effusion; vessels injected; abomasum deeply congested, and patches of submucous hæmorrhage near pylorus; submucosa of folds œdematous. Small intestines diffuse congestion, with some œdematous effusion into lumen; spleen pulpy but not enlarged; kidneys and liver slightly congested; pleural and epicardial cavities contain a small quantity of clear effusion; lungs enlarged and œdematous; heart, normal. Microscopical examination showed typical bacilli in hæmorrhagic muscle, and in surrounding œdema, but none in clear subcutaneous fluid. Peritoneal fluid: typical bacilli, some long filaments, and tetanus looking sporulating bacilli. Pleural fluid apparently sterile; blood, a few typical bacilli. Spleen and other organs sterile.

VI.—Experiments with Clear Sterile Œdema from Sheep.

Guineapig 40.—Inoculated with 0·1 cc. subcutaneous œdema from hock of sheep 3, which, kept at 37°C. for two days, remained apparently sterile. The following day a considerable swelling of the inoculated limb was present, extending into the abdominal subcutaneous tissue, but the animal remained bright and ate well. Next day the swelling had decreased markedly. The decrease continued until by the third day only a small localised groin nodule was present, which had also disappeared by the fifth day. Fifteen days later this guin apig was inoculated with 0.5 cg. dried muscle of lamb 1, and death occurred within 28 hours. There was considerable subcutaneous swelling; internal organs affected with putrefactive changes, examination having been unavoidably delayed.

Guineapig 41.—Inoculated with 0·1 cc. subcutaneous exudate from shoulder of lamb 4, which kept at 37°C. for 3 days remained apparently sterile. A swelling similar to that noted in guineapig 40 developed rapidly, but the animal remained in good health otherwise and with good appetite. By the fourth day the swelling had disappeared. Fifteen days later, re-inoculated with 0·5 cg. muscle from lamb 1; death resulted in less than 20 hours; post-mortem conditions being similar to those of guineapig 40.

VII.—Filtered Culture.

A five days' old culture, showing many bacilli (some degenerating), grown from muscle of sheep 1 and which proved fatal for guineapig 110 in less than 20 hours, was filtered through a Chamberland B filter. Of the filtrate 5cc. was injected intraperitoneally into guineapig 112. The animal remained normal. Fourteen days later it received a subcutaneous injection of 0·15 cc. culture as used for sheep 14, guineapig 117 receiving a similar dose as control. Result: both dead within 20 hours. Post-mortem: typical—no liver necrosis in either.

VIII.—Malignant Œdema and Braxy Experiment.

Sheep 14 (two years old).—Inoculated with typical culture of malignant œdema bacillus. Animal on following day prostrate, with large emphysematous swelling and dark-coloured livid skin at region of inoculation.

Next day improvement in general condition was observed, but animal was still lame. General recovery occurred later, but for large patch of necrosed and gangrenous tissue in inner surface of thigh. This sloughed, leaving a large wound, which, however, ultimately healed. Thirty-nine days after above inoculation sheep 14 was inoculated in opposite thigh with 0·25 cc. first culture from muscle of sheep 1. Guineapigs 112 and 117 were each inoculated with 0·15 cc. of same culture as control. Death occurred in under 20 hours; post-mortem examination typical.

Sheep 14 the day after second inoculation showed a typical swelling. Temperature 103·5. Illness rapidly increased, and death occurred about 30 hours after inoculation. Post-mortem examination: much sero-sanguineous subcutaneous effusion extending forward to sternum under skin of abdomen. Muscles pale, with traces of hæmorrhage. Small quantity (few ounces) of peritoneal and of thoracic effusion. Pericardium distended with clear effusion: abomasum slight congestion of mucosa; no ingesta; spleen normal; liver and kidneys congested. Microscopical examination showed typical bacilli chiefly in muscles, few in subcutaneous œdema, none in blood, spleen, thoracic fluid, and mixed bacilli in peritoneal fluid. The blood showed no development of bacteria even after prolonged incubation at 37°C.

APPENDIX B.

Victorian Disease.

I.—Natural Cases Examined Post-mortem.

Case I.—Two-year-old wether, fat.—No evidence of struggling. Body cold, except in groins and axilla, and rigor mortis well established (the night had been cold, with slight frost at daybreak). Subcutaneous tissues: patches of hæmorrhage and semi-gelatinous œdema, especially marked around the shoulders and along the neck. Pre-scapular lymph glands swollen, œdematous and hæmorrhagic. Abdomen: cavity contains about a pint of somewhat granular sero-sanguineous exudate. Liver mottled with circumscribed, irregular greyish areas of necrosis; a few distoma present in pile ducts, but no biliary cirrhosis; lymphatic glands of liver enlarged and œdematous. Kidneys congested. Spleen soft and dark coloured, but not enlarged. Rumen tympanitic. Abomasum: mucous membrane congested; small quantity of normal ingesta. Small intestines empty; little ingesta in large intestines, and rectal contents showing flakes of mucoid material. Thorax: 8-10 oz. of fluid, clear and but slightly blood-tinged. Lungs: œdematous and more voluminous than normal, but not congested. Mediastinal and bronchial glands enlarged and congested. Pericardium contains 3-4 oz. clear, semi-gelatinous effusion. Heart normal, but for ecchymoses in left ventricle. The peritoneal fat flaccid, mottled and watery. Evidence of commencing putrefaction was present on opening the abdominal cavity, but elsewhere there was none.

Case II.—Two-year-old wether, fat.—Still warm when found. No evidence of struggling. In subcutaneous tissues, especially of neck, irregular patches of sero-sanguineous, semi-gelatinous effusion. Pre-scapular glands enlarged, deeply hæmorrhagic and œdematous. Abdomen: about a pint of serous exudate, slightly blood-tinged. Peritonitis with flaky deposits on posterior surface of liver, and at border, also on gastro-hepatic mesentery. Liver mottled with areas of necrosis; organs smaller than normal; biliary cirrhosis marked; a few distoma present in gall-bladder; hepatic glands enlarged, but not hæmorrhagic. Rumen, tympanitic. Abomasum: mucosa deeply congested but no ulceration or visible necrosis; submucosa slightly œdematous. Intestines empty but for small quantity of clear, glairy fluid in small bowel. Kidneys congested; urine in bladder albuminous and cloudy. Spleen enlarged and diffluent. Thorax: 8-10 oz. of sero-sanguineous fluid. Lungs voluminous and œdematous; mediastinal glands enlarged and hæmorrhagic. Pericardium: several ounces of clear, semi-gelatinous effusion. Heart normal. No evidence of putrefaction throughout the carcase.

Case III.—Two-year-old wether, fat.—Carcase cold, but for faint warmth in armpit. Abdomen much distended with gas, causing abduction of limbs from body. (This animal had not been observed ill twelve hours previously when the flock had been placed in paddock. The night had been cold, hoar frost covering the ground in the morning.) Much sero-sanguineous effusion in subcutaneous tissues, especially along inferior aspect of thorax and abdomen, particularly about the pubis and anterior part of the sternum. Lymphatic glands of limbs not enlarged or hæmorrhagic. Abdomen: quantity of sero-sanguineous effusion. Liver: commencing putrefaction, with gas bubbles, but no necrosis; no distoma observed. Abomasum empty but for small quantity of sandy soil; mucosa slightly congested. Spleen slightly enlarged, dark and soft. Kidneys: slight congestion. Thorax: about a pint of sero-sanguineous effusion. Lungs normal; mediastinal glands congested. Pericardium: small quantity of serous effusion. Heart normal. It should be observed that the owner had noticed the most prominent of these lesions in the majority of the animals which he had examined post-mortem, so that the above may be taken as presenting a fair indication of the usual picture.

Examination of Specimens Secured.—Smears were secured and pipettes filled from various fluids and tissues of the first two cases, time not permitting this in regard to the third. The smears from the first case showed in the subcutaneous fluid the pre-scapular glands, the pleural fluid and blood, few organisms, chiefly large bacilli, generally in pairs, varying somewhat in length, and some sporulating terminally. The spleen showed similar bacilli, some in chains of four; the liver the same bacilli and longer and broader bacilli, probably putrefactive, the peritoneal fluid similar bacilli, also much narrower bacteria, some cocci, etc. The smears from the second case showed no organisms except those from the liver, which contained a few bacilli in pairs similar to those described.

II.—Isolation of Pathogenic Organism by Passage through Sheep and Guineapigs.

SHEEP.

Sheep 6 (two years old) was inoculated with 0·25 cc. mixture of blood and pleural fluid from Case I., and *Sheep* 7 (same age) with the same dose of similar materia (apparently sterile) from Case II. Sheep 7 developed no symptoms of illness as result of inoculation. Sheep 6 the following morning was ill, lying down, and with no appetite. The subcutaneous tissue of the inoculated region was distended with œdema, but skin not discoloured, Temperature, 102°. At noon, 24 hours after inoculation, swelling increased. and extending to coronet, with slightly livid tint of skin. Continued increase of swelling throughout day. Following morning, 44 hours after inoculation, animal found dead. Post-mortem examination: carcase cold, except at axillæ and groins. Skin over region of inoculation livid, but not gangrenous. Subcutaneous tissues of inoculated (hind) limb and along floor of abdomen for 6-8 inches distended with semi-gelatinous œdema, which at site of inoculation was blood-tinged, showed some gas and had a slightly putrefactive odour. Abdominal cavity contained about 10-12 oz. of sero-sanguineous effusion. Some fibrinous adhesions between anterior portion of bowels and liver and between cæcum and peritoneal wall with injected peritoneum underneath. Rumen tympanitic. Abomasum deeply congested from cardiac orifice to near pylorus, where congestion becomes patchy; submucous tissue of folds œdematous; contents fluid, small in quantity and containing sandy material. Small intestines practically empty of ingesta, but catarrhal mucoid fluid present; cæcum and anterior portion of large colon show mucous hæmorrhages; kidneys congested; spleen softened, but otherwise normal; liver:

small areas of hæmorrhage, with one large patch of necrosis ; hepatic glands hæmorrhagic. Thorax : no pleural exudate. Lungs œdematous and enlarged. Pericardium : about 2 oz. sero-sanguineous effusion. Petechial epicardium, especially around grooves. Mediastinal glands œdematous and hæmorrhagic. No odour internally of putrefaction. Microscopical examination of fluids and tissues showed numbers of double bacilli, also larger, at times filamentous organisms, and a few cocco-bacilli. Only one ærobic organism was present, a motile short bacillus, which had also been isolated from the original sheep. That this was not pathogenic was proved by inoculation of guineapigs and rabbits, each with 0·5 cc., and a sheep (8) with 1 cc., all of which, but for transient swellings, remained normal.

Sheep 7 (which had resisted inoculation with fluids of Case II.) was reinoculated with 4 drops of clear effusion that had been pipetted from the subcutaneous tissue of sheep 6 the day before death. The material had been placed at 37° for 24 hours, emitted a slight odour of putrefaction and contained a few anærobic bacilli in pairs, sometimes in chains of four, with few spores. The following day the animal was dull, the leg dragging, but little swelling, temperature 104°. Some improvement was observed during the day, but next day dullness and lameness had increased, the fæces were slightly bloodstained ; there was grinding of teeth and restlessness. Next day, symptoms aggravated, temperature 105·5. Slight discharge from vagina ; but swelling of limb not increased—no discolouration. Animal in extremis and killed 72 hours after inoculation. Post-mortem : little subcutaneous œdema. Peritoneal cavity about 10 oz. cloudy, slightly blood-tinged fluid. Stomachs normal. Intestines, especially cæcum, congested, and hæmorrhagic, with small blood extravasations ; liver, pale, shrunken ; kidneys, normal ; uterus, congested with much sero-sanguineous fluid infiltrating wall and fœtal membranes—two fœti about a month old being present. Thorax : about 6 oz. of deeply blood-tinged pleural fluid, pericardium distended with similar effusion. Left ventricle : many subendocardial hæmorrhages. Examination of fluids, spleen, etc., showed a number of bacilli, those in pairs predominating, but other bacilli morphologically different were also present.

Sheep 9 (2 years old), crossbred merino.—Inoculated in shoulder with 0·25 cc. pericardial fluid from sheep 6, after incubation, showing chiefly bacilli in pairs, some sporulating. The following day the animal was slightly lame, but otherwise normal. Next day, dull, lame, and with considerable swelling, temperature 105·6. Animal killed 70 hours after inoculation when moribund. Post-mortem : much swelling of subcutaneous tissues, but no skin discolouration ; œdema clear, but little blood-tinged, semi-gelatinous and with no odour, beyond a marked "muttony" odour. Peritoneal cavity : no effusion ; abomasum practically empty ; intestines normal. Spleen : dark, softened but not enlarged ; kidneys normal ; about 10 oz. straw-coloured effusion in pleural cavity ; lungs œdematous ; pericardium distended with clear effusion ; heart normal. Microscopical examination failed to detect any organisms in the pleural, and pericardial fluids, blood and spleen, but the subcutaneous œdema contained the paired bacilli, some sporulating, and some short cocco-bacilli. The subcutaneous œdema at some distance from the point of inoculation showed a few bacilli, generally in pairs, apparently pure, and similar to those found in greatest numbers in the fluids of Case I and liver of Case II.

Sheep 11 (3 years old).—Inoculated with 0·30 cc. clear subcutaneous fluid from sheep 6, removed 12 hours before death. This material had been incubated for several days, and remained clear, with no odour and apparently sterile. The animal remained normal. (See sheep 7.)

Sheep 12 (2 years old), merino cross ewe.—Inoculated with 0·25 cc. subcutaneous clear serosity from sheep 9 : 24 hours later the limb was carried, there was distinct subcutaneous swelling and temperature 104·6. The condition became aggravated throughout the day, respirations increased to 110 per minute, the temperature gradually rose to 106·5, the swelling increased, and the fœces became slightly blood-stained. Death occurred about 44 hours after inoculation ; post-mortem examination being made two hours later. Post-mortem : bloody froth from nostrils, a little blood oozing from mouth and vagina ; intense subcutaneous œdema of limb, oozing through skin of hock ; some gas formation, but no odour of putrefaction ; skin of thigh slightly discoloured but not necrosed ; muscles dark and serum infiltrated ; subcutaneous tissues show marked hæmorrhages here and there. Abdomen : uterus congested and œdematous ; peritoneum contained a small quantity of sero-sanguineous effusion. Abomasum : submucosa slightly œdematous, large hæmorrhagic patch on serous surface. Mucosa catarrhal but not injected or congested ; spleen normal ; kidneys congested ; liver congested, here and there on posterior surface some gas formation. Thorax : about 6 oz. of blood-stained effusion. Lungs congested and œdematous ; bronchi and trachea congested with hæmorrhages ; pericardium distended with clear semi-gelatinous effusions ; petechiæ on epicardium and left endocardium. Microscopical examination of fluids showed bacilli often in pairs, apparently pure, but for a few longer organisms of same thickness ; in congested and hæmorrhagic muscle numbers of bacilli sporulating and no long organisms. The blood showed no organisms, but after incubation in pipettes numerous bacilli morphologically similar to those described were found.

Sheep 17 (3 years old merino, in good condition).—Inoculated with 0·25 cc. sub-culture from muscle of sheep 12. As controls, guineapig 113 was inoculated with 0·1 cc., guineapig 120 with 0·3 cc., and rabbit 34 with 0·5 cc. of the same culture, all of which died within 20 hours. 16 hours after inoculation sheep 17 was found not eating, the leg lame, and slightly swollen and micturating freely. Temperature 101.5. The animal remained in this condition throughout the day and was found dead 38 hours after inoculation, death having apparently occurred some hours previously. Post-mortem : inoculated region swollen, puffy, and livid ; subcutaneous œdema extended forward to the xyphoid, sanguineous at the point of inoculation, but clear elsewhere ; muscles of limb dark in patches, elsewhere pale and friable; no definite odour. Peritoneum : small quantity of cloudy sero-sanguineous effusion ; spleen pulpy, dark and somewhat enlarged ; liver mottled, especially near gall-bladder with areas of necrosis, varying in size from 1 to 2 c.m. Abomasum : mucosa deeply congested, with surface covered by a thin diphtheritic membrane ; here and there small areas of superficial necrosis and patches of hæmorrhage. Kidneys normal. A few ounces of pleural effusion ; lungs œdematous, with many sub-pleural petechiæ. A little pericardial clear effusion ; many epicardial petechiæ. Microscopical examination : many bacilli at region of inoculation and in muscle ; a number in necrosed liver areas, none visible in smears from elsewhere.

Sheep 18 (4 year old crossbred ewe).—Inoculated with 0·5 cc. culture from liver of guineapig 102. In four hours the animal showed uneasiness. Temperature 103.5. The following morning, 19 hours after inoculation, found dead. Post-mortem : inoculated limb showed much œdematous swelling, with some gas, extending from coronet up limb, and forward to sternum, no skin discolouration. On incising skin, very slight odour, which disappeared almost immediately. Muscles variegated with greyish and dark areas. Uterus congested, swollen and œdematous. About 6 oz. of peritoneal fluid, but slightly blood-stained ; spleen enlarged and pulpy; liver pale and shrunken ; stomach normal ; pleura and pericardium contained a small quantity of clear effusion. Heart showed large blood extravasations under epicardium, especially of auricles and appendages ; and many petechiæ in left endocardium. Microscopical examination of fluids showed typical bacilli in subcutaneous œdema and muscles ; similar bacilli, but also long undulating filaments in peritoneal fluid. The pleura and blood also contained typical bacilli.

GUINEAPIGS.

Guineapigs 64 *and* 65 were inoculated with a small quantity of blood from Case I. and guineapigs 66 and 67 with blood from Case II. Guineapig 65 succumbed in 40 hours, examination showing a large œdematous swelling at the region of inoculation and extending forward to the shoulder. Few organisms were present in the œdema, these being chiefly short bacilli. The other guineapigs developed only slight and passing swelling of the inoculated limb.

Guineapig 69.—Inoculated with 0·05 cc. spleen pulp from sheep 6. On incubation at 37° this spleen pulp developed a putrefactive odour, and besides the double bacilli which sporulated, large double sporulating bacilli also developed. This animal developed slowly a swelling at the seat of inoculation and died in five days. Post-mortem examination: a mass of necrosed material at site of inoculation; œdematous effusion extending forward to thorax in subcutaneous tissue; small quantity of semi-gelatinous effusion in peritoneum; intestines congested, and small bowel œdematous; spleen enlarged; liver pale; otherwise normal. Smears showed mixed bacilli, with some polymorphs in the necrosed tissue. The œdema contained chiefly the double bacillus of braxy type. Similar bacilli were present in the liver, spleen, etc., but the blood was apparently sterile.

Guineapig 73.—Inoculated with 0·25 cc. anærobic culture in glucose serum broth from uterus of sheep 7 showing deposit with little cloudiness and little gas formation. Bacilli apparently of braxy type morphologically, but a large number do not stain by method of Gram. Animal found dead 20 hours later. Post-mortem examination: sero-sanguineous fluid in subcutaneous tissues of inoculated limb, and a little peritoneal fluid; a putrid odour present. Smears show mixed bacilli—some Gram positive, others not; a number of long bacilli also present.

Guineapig 74.—Inoculated with 0·05 cc. peritoneal fluid from sheep 7, showing numbers of typical braxy-like bacilli, many sporulating. Found dead 18 hours later; body cold. Post-mortem examination: sero-sanguineous effusion into subcutaneous tissues of inoculated limb; slight clear peritoneal effusion; otherwise normal. Examination of subcutaneous effusion showed many typical bacilli, which were also present in peritoneal fluid and spleen, but along with these were many long filaments.

Guineapig 75.—Inoculated with 0·05 cc. pericardial fluid from sheep 6 (as used for sheep 9). Animal died 20 hours after inoculation. Post-mortem examination: much subcutaneous œdema extending along inferior portion of body to point of thorax; no gas and no odour; muscles slightly pale at region of inoculation; liver mottled with necrosed areas; spleen enlarged and dark; little peritoneal fluid; sero-sanguineous pleural effusion; clear effusion in pericardium. Many typical braxy-like bacilli were found in fluid of subcutaneous tissues and a few in spleen. The liver necrosed areas contained besides these many long filaments. The heart blood was apparently sterile.

Guineapig 76.—Inoculated with 0·1 cc. heart blood of sheep 7, which after incubation showed many sporulating bacilli with putrefactive odour. Animal found dead 18 hours afterwards. Post-mortem examination: gangrene of skin and tissues at region of inoculation; little sero-sanguineous subcutaneous effusion; no effusions in serous membranes; intestines deeply congested; liver pale. Smears from subcutaneous fluid, peritoneum, spleen, and liver showed bacilli irregular in length with many long filaments, the general appearance being that of malignant œdema organisms. (Compare guineapig 75.)

Guineapig 77.—Inoculated with 0·2 cc. subcutaneous œdema of sheep 9 (as used for sheep 12).

Guineapig 78.—Inoculated at same time with 0·1 cc. blood from sheep 9, after incubation, and showing bacilli of braxy type, some sporulating; also a few longer bacilli.

Animals found dead in 20 hours.

Post-mortem examination on these animals showed a similar picture:—infiltration of subcutaneous tissues of limb and abdomen, with clear œdema; no discolouration, no odour and no gas; small quantity of somewhat cloudy peritoneal fluid; spleen dark, but not enlarged; small intestines distended with œdematous effusion into lumen. Liver of 78 showed patch of greyish-yellow necrosis. Smears showed typical braxy-like bacilli in subcutaneous effusions. In peritoneal effusion, similar bacilli, but also long filamentous organisms.

Guineapig 81.—Inoculated with 0·25 cc. second subculture in serum broth under oil from blood of guineapig 77, which, after incubation, showed typical bacilli. Animal dead in 20 hours. Post-mortem examination : subcutaneous œdema, peritoneal fluid, intestinal effusion, etc., as in guineapig 77.

Guineapig 98. Inoculated with 0·1 cc. third subculture in serum broth under oil from blood of sheep 12 after incubation. Animal found dead in 20 hours. Post-mortem examination typical with patches of necrosis in liver, effusions, etc.

Guineapig 102.—Inoculated with 0·75 cc. blood of sheep 12 after incubation (as control of guineapig 98). Animal found dead 20 hours later. Post-mortem examination : as in guineapig 98, but no liver necrosis.

Guineapig 107.—Inoculated subcutaneously with 0·25 cc. subculture from blood pipette of sheep 18. Death in less than 20 hours. Usual post-mortem picture.

Guineapigs 113 and 120.—Inoculated with 0·1 cc. and 0·3 cc. respectively with second broth subculture of muscle of sheep 12, being control to sheep 17 and rabbit 34. Result, death in 16 hours. Post-mortem examination : much œdema and some gas formation, with hæmorrhage in muscles ; small intestines œdematous ; spleen enlarged and congested ; liver congested.

III.—Experiments on Other Animals.

Calf.—A calf six months old, in good condition, was inoculated behind the shoulder with 0·5 cc. 24 hours' old first culture from sheep 12. The following day a very slight swelling, with no lameness, was visible ; temperature, 102°. This swelling rapidly disappeared, the animal continuing normal. (Compare calf 5, Tasmania.)

Rabbits.—Rabbit 26, inoculated with 0·1 cc. œdema from leg of guineapig 102 (which succumbed in 20 hours with 0·1 cc. blood of sheep 12 after incubation) ; remained normal.

Rabbit 29, inoculated with 0·25 cc. same culture as used for guineapig 107 ; remained normal.

Rabbit 34, inoculated with 0·5 cc. second broth culture as used for guineapigs 113 and 120 ; dead in 16 hours. Post-mortem examination : much subcutaneous œdema, with little gas and no definite odour, extending forward to the shoulder, clear and semi-gelatinous ; a small quantity of peritoneal effusion ; spleen enlarged and dark, otherwise normal.

Rabbit 40, inoculated with 0·2 cc. first culture (muscle), remained normal. Guineapig 171 inoculated with 0·1 cc. same culture dead in less than 20 hours.

Pigeons.—Two pigeons inoculated with 0·05 and 0·1 cc. respectively were found dead 18 hours later. Post-mortem examination: beyond an œdematous infiltration, with hæmorrhage of the muscles at the seat of inoculation, no pathological change.

Fowls.—Two fowls inoculated with similar doses remained normal.

IV.—Cultures in Glucose Serum Broth—Rapid Loss of Virulence—Immunity Produced.

Guineapigs 130 and 131.—Inoculated with 0·1 cc. first subculture in glucose serum broth, 24 hours old, from sheep 12 ; both found dead in 20 hours. Post-mortem examination : typical picture, with much subcutaneous œdema, little gas, a little effusion into small intestines and in peritoneal cavity, one showing a few necrotic patches of liver, the other none. Seven days later this culture was again employed in a similar dose on *Guineapig* 135. In this case, however, no change was observed till the third day, when a slight swelling was noticed, but the animal was otherwise normal. Death occurred six hours later, when post-mortem examination showed the usual picture.

Sheep 20 *and* 25 (2 years old).—Sheep 20 inoculated with 0·25 cc. fourth subculture from muscle of sheep 12. No swelling or other abnormality was observed the following day. The sheep was then inoculated with 0.25 cc. first subculture, seven days old, from sheep 12 (as employed originally for guineapigs 130 and 131). (See also guineapig 135.) Four days later, the sheep having remained normal, it was again inoculated with 3 cc. fourth subculture, eight days old ; the sheep remained normal. Fifteen days later re-inoculated with 0·25 cc. two-days' old second subculture, sheep 25, of same age and breed, receiving a similar dose, and guineapig 144 receiving 0·1 cc. as controls. Sheep 20 remained normal. Sheep 25, the following morning, 17 hours after inoculation, was very lame, with considerable subcutaneous œdema of the inoculated limb ; temp., 106.8° (temp. of sheep 20, 103.7°). The guineapig was prostrate and died about 26 hours after inoculation, the post-mortem examination showing a typical condition. Sheep 25 gradually developed graver symptoms and died about 50 hours after inoculation. Post-mortem examination showed the usual condition ; much œdema of inoculated limb, which implicated the subcutaneous tissues of abdomen forward to the xyphoid ; intestines injected, especially small intestines, which contained some extravasated serous fluid ; abomasum, submucosa œdematous, mucosa deeply congested with patches of surface necrosis ; little effusion in peritoneum and pleura ; liver small, very pale and waxy ; spleen not enlarged, but dark ; lungs œdematous, ecchymoses under pleura, especially posterior portion ; pericardium distended, with deeply blood-tinged effusion ; petechiæ of epicardium and of left endocardium.

Sheep 31 (2 years old).—Inoculated with 3 cc. eight days old third subculture from sheep 12 in glucose serum broth, and guineapig 149 inoculated with 1 cc. of same culture. Result : sheep developed no lameness or swelling, and the temperature did not rise above 103°. The guineapig developed a slight swelling, from which it rapidly recovered. Twenty days later sheep 31 re-inoculated with 0·25 cc. first culture 24 hours old from muscle of sheep 12 in *ordinary* serum broth. Guineapig 149 was re-inoculated with 0·15 cc. of same culture, and guineapig 161 was inoculated with 0·15 cc as control. Both guineapigs died in less than 20 hours. Post-mortem examination typical. Sheep 31 the following day showed no swelling and but slight lameness. The temperature was 104.5, which next day dropped to 102.8. (Further inoculations are recorded in text.)

Sheep 30 (3 years old).—Inoculated with 5 cc. seven days' old first subculture (which when one day old had proved fatal for guineapig 151 with a dose of 0.1 cc.). Guineapig 153 inoculated with 1 cc. of same culture. Guineapig 153 was found dead in 18 hours ; typical post-mortem. Sheep 30, following day, showed considerable swelling of region of inoculation, extending down the limb, accompanied by definite lameness. Temperature 104·2. Animal, however, had fair appetite. The following day the lameness and swelling had disappeared. Temperature 103·2. Fifteen days later sheep 30 re-inoculated with 0·25 cc. 24 hours' old first culture in serum broth from muscle. The sheep the following day was slightly lame, but there was little swelling. Temperature 104·6. The lameness increased somewhat, but appetite remained. Next day the normal was resumed. Temperature 102·5. For further inoculations, including cross experiments, see text.)

V.—Filtered Cultures.

A five days' old culture containing many bacilli (some degenerating) from muscle of sheep 18, and which proved fatal for guineapig 111 in 20 hours, was filtered through a Chamberland B filter. Of the filtrate 5 cc. was injected intraperitoneally into guineapig 113. The animal remained normal. Twenty-four days later it received subcutaneously 0·1 cc. first broth culture from muscle of sheep 18, as used for guineapig 120 and rabbit 34. Death occurred in 16 hours. Post-mortem examination typical.

EXPLANATION OF PLATES.

PLATE XLIII.

Fig. 1.—Section through wall of abomasum showing necrosis of surface and congestion of blood vessels of mucous membrane, from a natural case of the Tasmanian disease.—x275.

Fig. 2.—Section through wall of abomasum showing necrosis of surface and congestion of blood vessels of mucous membrane. Experimental case.—x275.

PLATE XLIV.

Fig. 1.—Smear preparation showing bacilli in œdema.—x680.

Fig. 2.—Section through fold of abomasum of sheep naturally infected with the Tasmanian disease. Showing necrosis of mucous membrane, congestion, etc.—x18.

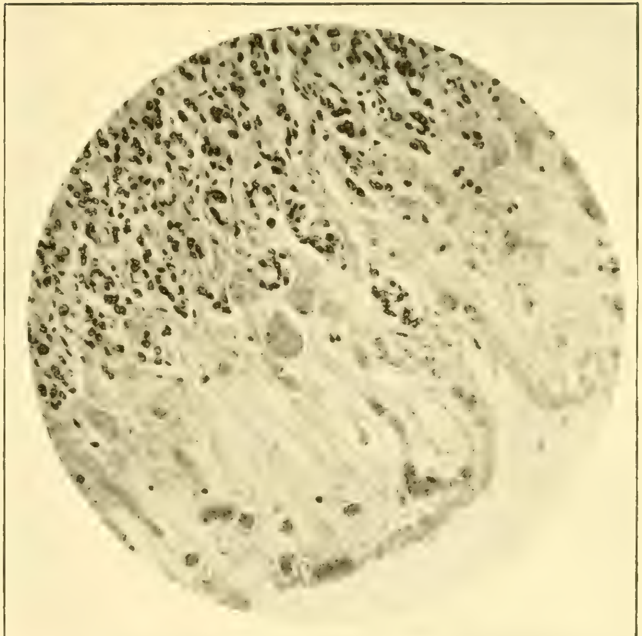


Fig. 1.

Fig 2.

Braxy Type of Sheep Disease.

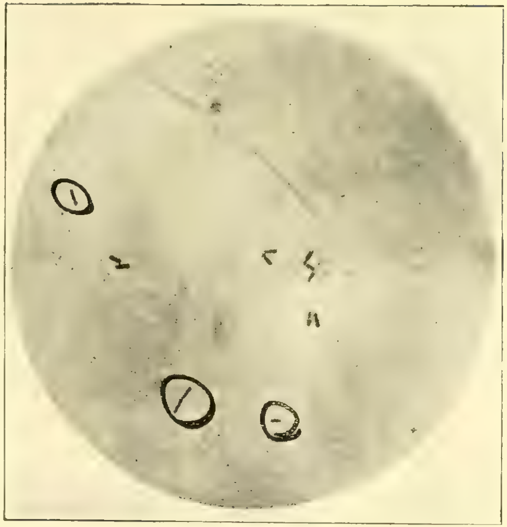


Fig. 1

Fig. 2

Braxy Type of Sheep Disease.

Section H

ENGINEERING AND ARCHITECTURE.

ADDRESS BY THE PRESIDENT:

ELLWOOD MEAD,

Chairman of the State Rivers and Water Supply Commission, Melbourne.

CONSERVATION OF WATER IN AUSTRALIA.

In choosing a subject for this address it was desirable that it be one about which I knew something, and also one in which others had an interest. I chose the conservation of our water supplies as coming nearest to meeting both requirements.

I regard the right management of public water resources as the most important economic problem of this continent. Water is the one raw material which is indispensable to the use of all others. Without an adequate supply of pure water the conduct of an orderly household is unthinkable; without it, mines are unworkable and land is worthless for either mining or grazing. In about two-thirds of this continent the average annual rainfall is less than 20 inches. In all this area it is doubtful whether with the most economical use enough can be conserved to permit of all the land being occupied or all the mines worked, and it is certain that with improvident or wasteful use large areas of fertile and fruitful soil must for ever remain barren.

To have a right ending this work must have a right beginning. The first laws and the first works have an immense importance because of their influence on what is to follow. What is done at the outset affects not simply the present generation, but all the unnumbered generations which are to live here in the future.

The portion of the continent where the limited rainfall makes water conservation necessary is about half as large as all Europe. Here nature must be supplemented by the work of man to secure an adequate water supply to meet the requirements of civilised life. To provide for this so as to safeguard all dependent thereon from loss or suffering in recurring dry seasons is a monumental task in engineering, legislation and economics.

The first requirement in formulating policies for this work is accurate knowledge. We must know how much water is available, or can be made available. We must know how much is needed to supply any particular use before we can safely make plans. Until we have this information all that is done has no safer basis than individual judgment or opinion. If those who direct development guess right, the country is fortunate, but such guesses are rare and should not be risked. To secure the facts there should be an early and comprehensive investigation of both artesian and surface water supplies to determine their origin and extent and the manner in which they should be controlled and used. This should be carried out under the direction of the Commonwealth Government, or, if this is not feasible, by concerted action of the States.

Among the questions with which this investigation would deal are the source, the extent, and the probable permanency of the underground water supplies. In Queensland alone the wells which tap this underground reservoir have a total length of over 310 miles, and have cost over £2,000,000. They are the sole or principal reliance for domestic supplies for a large number of towns, and for the watering of millions of live stock ; to a limited extent they are used for irrigation, and in two or three instances provide power to operate electric light works and flour mills. These bores in Queensland are found in an area of over 376,000 square miles. This is an area about equal in size to the United Kingdom and France, and the only reason why it will not support as many people as the combined population of these countries is that it has an inadequate water supply. The industries of this present scanty population are chiefly wheat-growing and the raising of cattle and sheep. To provide water for this the underground reservoir has been tapped by nearly 2,000 bores. The exact number is not known, because there is no official record in Queensland of the private bores. The drain on this reservoir for the limited population is enormous. Professor Gregory in his work, "The Dead Heart of Australia," estimates that in 1903 the wells of New South Wales discharged about 22,000,000 cubic feet a day and those of Queensland 63,000,000 cubic feet. Since that time the number of wells and the total discharge have largely increased. The 1910 report of the Hydraulic Engineer of Queensland gives 39 wells, out of the 1585 recorded, as having discharges varying from 2,500,000 to 4,000,000 gallons a day. Much of this is wasted, the prevailing practice being to allow all the water forced to the surface to escape. In many cases the water flows for miles month after month before it sinks into the soil or is taken up by the air. All told the volume wasted is many times the volume used.

Australia needs to consider whether it is wise or prudent to permit this enormous waste to continue. The water which is lost in evaporation and seepage does no good ; in fact, the salts which it leaves in the soil do harm. May not this wasted water be needed in the not distant future ? Discussion shows widely varying views. Mr. J. B. Henderson, the Hydraulic Engineer of Queensland, has for many years urged putting valves on bores and regulating the discharge to actual needs ; but he has been a voice crying in the wilderness. The pastoralists, who have most at stake, have as a class opposed all regulation or any laws looking to a conservation of the supply. With many the position is the selfish one that there is enough to last their lifetime, and they have no interest beyond that ; others believe that the supply is practically unlimited, and that restricting the discharge is unnecessary, and in some cases impossible owing to the injury to the bores which would result if it were attempted.

That the supply is not unlimited need not be argued. Not only is it limited, but it is less than will be needed for domestic and stock purposes alone. Invaluable as is irrigation, artesian supplies cannot be expected to provide for it. Just how limited this supply is and how long the flow will continue are the vital questions. If it is a true artesian supply coming from rain falling on elevated districts the prospect of permanency is far more reassuring than if much of it is plutonic water, as Professor Gregory believes. Should Professor Gregory's conclusions prove correct, the ultimate and complete exhaustion of this reservoir is inevitable, and it will go out without warning, like a snuffed candle, or like the exhausted oil and gas wells of other lands. Whatever is the origin of this supply, there are need of public control over its use and rigid regulation of waste, and the best means of determining how this control and regulation should be exercised is to first gather the facts.

The management and use of surface water supplies present questions even more complex and important. This is illustrated by problems of the Murray River and its tributaries, which drain a large part of Queensland, New South Wales, South Australia and Victoria.

Steamboats ply along the lower course of this river, furnishing a cheap and convenient means of transport to immense and remote pastoral areas ; pumping plants lift its waters to supply irrigation districts, which rival in the perfection and value of their products the century-old districts of other lands ; it furnishes water for drinking and domestic purposes for numerous cities and towns, and products of irrigation supply the greater part of the traffic for important railway lines. The fortunes of individuals, of municipalities, and even of different States are inseparably interwoven with the management of this stream and the right use of its waters. These rights of widely separated districts are apt to be considered rival and conflicting. They are already of immense importance, and will, in time, come to be of immeasurably greater magnitude. This renders it highly desirable that there be an agreement as to plans and policies which are to control diversions and use in order that development may be systematic and continuous, and that the people who live within this territory may have confidence as to the future.

The solution of these questions should not be influenced by considerations as to what will be to the selfish interests of a particular State. It is not so much how much land will be irrigated in New South Wales, Victoria and South Australia, as where the water can be used to the least waste and made available at the least expense, and where land is most productive, so that the least irrigated acreage will support a family in comfort. In other words, we wish this resource to contribute to the wellbeing of the largest number of people, regardless of the portion of the Commonwealth in which they may live.

At present there is a wide divergence of opinion both as to where this water should be used and what it should be used for. Much has been made of the navigable features of the Murray and Darling Rivers—far too much, in my opinion. Many believe that the preservation and improvement of navigation must be first assured ; what water remains after this has been cared for may be used for irrigation and drinking purposes. Others, with a happy optimism, scarcely warranted by the stream gaugings of 1902 and 1907, insist that there is water enough for all purposes ; but to believe this one has to ignore the experience of other lands and the controlling facts as to the flow of the river and the needs of the thirsty soil of its valley.

Meanwhile the use of the water of this river for irrigation is being largely extended in each of the three States most concerned. The settlement of the land under the schemes already undertaken, and on which large expenditures are made, will so increase the absorption of water as to create conditions entirely different from those of the past. In 1902 the demands on the Murray showed that there was little margin for expansion so long as dependence is wholly on the natural flow. Since that time New South Wales and Victoria have constructed large storage works on tributaries. But there is need of immediate and large storage provision on the main stream to safeguard the settlements under the schemes already inaugurated, as well as to make safe provision for further expansion.

The movement of settlement towards Australia makes it additionally desirable that there should be early and intelligent action in this matter. There is also need of additional legislation. The fundamental water laws of the States are admirable, but they do not provide for an extensive and complete use of the water of the stream, and they should only be regarded as preliminary steps. One important feature of the best water laws of other countries is not found in any of the Australian statutes, and that is the recognition of the doctrine of priority of right under which the older settlements are protected from the encroachments of unwise or imprudent expansions. It is only through a study of the economics of irrigation that the importance and necessity of this additional legislation will become apparent ; hence the economics of irrigation should be made a distinct and important feature of the investigation.

Before there should be any large expansion of existing works, there should be a wholly disinterested study of the river to determine how much water enters it, where and how much of the water is lost by seepage and evaporation, how much water is needed to irrigate an acre of land, and how wide is the variation in need between different crops and different methods of distribution. There is need to consider the present and ultimate requirements of cities and towns for domestic purposes, and of the dry-farming districts which must be supplied through artificial channels with water for household and stock purposes. A knowledge of all these is essential to the making of proper plans for the utilisation of this river's flow, and without this comprehensive understanding disappointment and loss of money and time must inevitably be the outcome of some important undertakings.

Here is a scientific problem worthy of the knowledge and wisdom of the greatest minds of this Association, and whose early investigation will, I hope, have the approval and support of its members.

PAPERS READ IN SECTION H.

1.—THE AREA OF WATERWAYS.

By JAMES VICARS, M.C.E.

The question of area of waterway to be provided for carrying off stormwater from a catchment is one bristling with difficulties of no ordinary character. It must, however, be apparent at the outset that the area of waterway to be provided cannot be determined until the flood discharge is known. This latter depends upon so many unknown quantities—quantities which in general practice cannot be approximately determined or even guessed—that it is well to concede at once the futility of assigning definite coefficients or factors for them in estimating flood discharges.

The elements referred to are the effective average values for the whole catchment area to be assigned to rainfall, absorbing power of the soil, evaporation, slope of surface, and nature of surface, such as forest growth or grass or plain country.

Monsoonal rains may be of less intensity than that of the recorded maximum fall at individual stations, yet may be more generally distributed, last longer, and produce the maximum flood flow. In another case it may be a cyclonic or anticyclonic storm which produces this result. Or it may be a storm of high maximum and great variation which causes maximum discharge. The steeper the slope and the harder and barer the surface, the less the evaporation and absorption; the more the vegetation and forest growth or sandy or open character of soil, the greater the absorption, and the less the velocity of flow on even steep slopes, while high winds increase evaporation.

Thus the question seems at first impossible of rational treatment in a manner to be at all useful for practical purposes. Under such circumstances, as in so many other problems, the average values of the effects of all these elements may be ascertained as a whole, and only in this way is the problem rationally capable of practical solution.

The history of failure is one of the best means, as it frequently discloses inaccuracy of assigned values or fundamental errors in previously accepted formulæ, or makes known exceptional circumstances. Then, the gaugings and records of flood discharges from well-known catchments for water supplies should be of equal, if not greater importance, being more numerous, and the volume of flow being more accurately determined.

Working from such data various formulæ have been devised by various authors according to their conception of the elements to be taken directly into consideration, and of the values to be assigned to them. It is generally assumed that a maximum rate of rainfall should be a factor ; but whether the hourly rate, a certain percentage of it, or a five minute, ten minute, or twenty-four hours maximum, or other rate has not been universally conceded, although the maximum hourly rate is the more generally favoured. The area must also be taken into consideration. These two elements, rainfall and area, are of cardinal importance, and should be the basis of any such formula. The effect of slope of surface, and ratio of length to breadth of catchment have been incorporated in the formulæ of several well-known authors, but they are not by any means generally conceded as essential, or if so the relative values assigned to them are not considered of general applicability. Some even go so far as to assign a constant value to rainfall, but evidently their authors generally intended them for local application only.

The following is a list of some of the better known formulæ :—

TABLE I.

Author.	Formula.
Col. Dickens . .	$Q=100\ CM^{\frac{3}{4}}=825\ M^{\frac{3}{4}}$
" . .	$Q=27\ CM^{\frac{1}{2}}\quad C=8{\cdot}25$
Ryves	$Q=CM^{\frac{2}{3}}\quad C=400$ to 650
Fanning . .	$Q=200\ M^{\frac{5}{6}}$
Burge	$Q=\dfrac{1300\ M}{(\text{Length in Miles})^{\frac{2}{3}}}$
Dredge	$Q=$ "
Jackson	$Q=\dfrac{C\times\text{Breadth}}{\text{Length}}A^{\frac{3}{4}}$
Steane	$Q=\dfrac{181\times\text{Area in sq. chains}}{1800\ (\text{length in chains})^{1{\cdot}23}}$
Craig	$Q=440\ BN\ \text{hyp log}\ \dfrac{8\ L^2}{B}\quad N=1{\cdot}16$
O'Connell . .	$Q=-45{\cdot}796+(2097.28\times 457.96A)^{\frac{1}{2}}$
McComb . .	$Q=5{\cdot}29375\ A^{\frac{3}{4}}$
Burkli Ziegler	$Q=CRS^{\frac{1}{4}}\ A^{\frac{3}{4}}$ S=slope in ft. per 1000 C=.75 to ·31
McMath . .	$Q=CRS^{\frac{1}{5}}\ A^{\frac{4}{5}}$
" . .	$Q=2{\cdot}448\ RS^{\frac{1}{5}}\ A^{\frac{4}{5}}$
Adams	$Q=ACR\left(\dfrac{S}{A^2\ R^2}\right)^{\frac{1}{12}}=CR^{\frac{5}{6}}\ A^{\frac{5}{6}}\ S^{\frac{1}{12}}\quad C=1{\cdot}035$
Hawksley . .	$Q=ACR\left(\dfrac{S}{AR}\right)^{\frac{1}{4}}=CR^{\frac{3}{4}}\ A^{\frac{3}{4}}\ S^{\frac{1}{4}}\quad C=3{\cdot}946$
Chamier . .	$Q=ACR\left(\dfrac{M^{\frac{3}{4}}}{M}\right)=5{\cdot}03\ CRA^{\frac{3}{4}}$

Table I, *Continued.*

Author.	Formula.
Kernot	$a = CM^{\frac{3}{4}}$ $C = 40$ to 80
Myers	$a = CA^{\frac{1}{2}}$ $C = 1$ to 4
Talbot	$a = CA^{\frac{3}{4}}$ $C = \frac{1}{3}$ to 1
Peck	$a = \frac{A}{C}$ $C = 4$ to 6
Cleeman ..	$a = CA^{\frac{1}{2}}$ $C = 1$ to $1 \cdot 6$
Steane	$a = A^{0 \cdot 62}$

Q=Cubic ft. per sec.
R=Rainfall in inches per hr.
a=Area of waterway in sq. ft.
M=Area of catchment in sq. miles.
A=Area of catchment in acres.
C=Variable co-efficient.

Those formulae which do not take into consideration the variation of rainfall for different catchments will not be considered, as they are evidently of local value only. Of the above list only five remain, four of which directly take into consideration the slope of surface, and of these, two adopt $S^{\frac{1}{4}}$, one $S^{\frac{1}{5}}$, and one $S^{\frac{1}{12}}$. When S varies between ·0001 and ·04 the $S^{\frac{1}{4}}$ makes the discharge vary from 1 to nearly 4·5 times ; while $S^{\frac{1}{12}}$ makes the variation range from 1 to 1·65 time. Manifestly both cannot be reliable for general application. Again one assigns to the rainfall a value of $R^{\frac{5}{6}}$, one $R^{\frac{3}{4}}$, and the three others simply R. The values of R determined for the most generally occurring maximum rainfalls show the absurdity of these factors :—

R ..	3	4	5	6	inches
$R^{\frac{3}{4}}$ ..	2·28	2·83	3·33	3·83	„
$R^{\frac{5}{6}}$ ..	2·5	3.18	3·82	4·45	„
·7R ..	2·1	2·8	3·5	4·2	„
·75R ..	2·25	3·0	3·75	4·5	„

The above shows that by assigning a suitable co-efficient to R the result can be made to differ only about 5 per cent. up to 5 inches of rainfall nnd 10 per cent. for 6 inches of rainfall, and on the safe side. There can therefore be no practical advantage in adopting the more cumbersome factor. The Burkli Ziegler formula is probably the best, but the adoption of a definite value for S for the slope makes its application difficult or indeed impossible in the many cases in which the average slope cannot even be approximated.

It is thought improbable that variations of average slope from ·0001 to ·04 should give four times the discharge, in many cases exceeding the possible volume due to actual rainfall, and is contrary to the author's gaugings of flood flow from catchments, including areas of 1 to 300 acres and one of 180 square miles. The values assigned to the area A in the formulæ vary from $A^{\frac{3}{4}}$ to $A^{\frac{4}{5}}$ to $A^{\frac{5}{6}}$, which give results for a catchment of 100,000 acres from 5600 to 10,000 to 14,700 respectively. Such results surely indicate some fundamental error. In spite of this great diversity of values of individual factors the resulting volume determined by either one of the best four formulæ—Burkli Ziegler, McMath, Adams, Hawksley—give fairly uniform results for a rainfall up to four inches and areas up to 10,000 acres.

The uncertainty of the results obtained by these formulæ induced the author to systematise his practice during the past 20 years, with the object of securing rational results; and while shrinking from increasing the already long list of formulæ, feels justified in doing so for the reasons given and in the hope that those who may have the opportunity of checking it will do so to the benefit not only of engineers, but the country and community at large.

Firstly, inclusion of direct values for length and breadth of catchment had to be considered, and it was decided to omit them after making many calculations, and also for the following reason. Assume a uniform rainfall and a strip of catchment one chain wide and 100 chains long, and assume that the rain continues during time taken by flood water in travelling from top of catchment to outlet, then the discharge becomes equivalent to 100 times the average rainfall over one square chain, i.*e*., is directly proportional to R $\times$ A. The same result is obtained if the storm is assumed to travel with the flow and at the same rate, perhaps a rare occurrence, but nevertheless a result which may be approximated in large areas and certainly attained in small ones.

The maximum volume of flood flow may then be accepted as depending directly on the rainfall —r, the area—A, and probably as the velocity of flow of water off catchment, which is inversely as the square root of the average length or radius of the catchment, and may be represented by $\frac{1}{A^{\frac{1}{4}}}$; and as the velocity of flow is directly governed by the average rainfall over the catchment, this factor is assumed to indicate the percentage of run-off to maximum fall.

It has been found that maximum flood flow is chiefly associated with a heavy general rain—not of maximum intensity—over the catchment after the surface soil has become saturated by previous rain. Some have accordingly suggested a reduced value for r; but to do so, whilst eliminating a co-efficient for absorption in small areas would give too small results for large areas; and it must be borne in mind that the rain previously absorbed may be considered as an equivalent increase in amount of actual rainfall causing maximum flood flow, *i.e.*, the value to be assigned to r becomes practically equal to the maximum record.

Adopt=Maximum rate of rainfall, in inches per hour.
A=Area of catchment in acres.
Q=Maximum flood discharge in cubic feet per sec.

a = Area of waterway to be provided, in sq. feet.
c = Co-efficient for nature of catchment.
v = Velocity of flow in outlet waterway in feet per second.

$$\text{Then } Q = \frac{c\ r\ A}{A^{\frac{1}{4}}} = c\ r\ A^{\frac{3}{4}}$$

$$A = \frac{Q}{V} = \frac{c\ r\ A^{\frac{3}{4}}}{V}$$

To avoid the necessity for selecting values for c it was sought to modify the formula so as to embrace large as well as small catchments while maintaining the value of c constant. Curves were accordingly plotted for values of Q when c=1,0·8, 0·6, and 0·4, and a mean curve was determined, which at every point gave full values, but not excessive values, for all areas generally met with in practice. The curve corresponded to the formula $Q = 1{\cdot}57\ c\ r\ A^{\frac{2}{3}}$, giving results equivalent (in original formula) to c=1·0 up to 1,000 acres, c=0·6 up to 100,000 acres, c=0·4 up to 10,000,000 acres.

The value of 1·57 c when C=1 gives volumes of flow equivalent to full maximum intensity of rainfall up to 10 acres, volumes 50 per cent. above the possible for one acre, and above 10 acres the results are generally about 25 per cent. above the author's records and are believed to be full to that extent. Instead of r it is considered preferable to use $\left(\frac{R}{2}\right)^{\frac{1}{2}}$ where R represents the average annual rainfall in inches.

The formula thus modified becomes $Q = 1{\cdot}11\ C\ R^{\frac{1}{2}}\ A^{\frac{2}{3}}$. But as it has been established that not more than 80 per cent. of the rainfall flows off even paved surfaces during the time the storm continues, the volume of flow becomes $Q = {\cdot}888\ C\ R^{\frac{1}{2}}\ A^{\frac{2}{3}}$. The author, however, adopts for preference $Q = c\ R^{\frac{1}{2}}\ A^{\frac{2}{3}}$ which gives results at least 10 per cent. higher than have proved sufficient, so far as has come within his knowledge. In this formula C is a coefficient, never less than unity, varying with the nature of rainfall in the locality. Its value has not been determined for tropical (monsoonal) conditions; but for temperate zone unit value is believed to be ample.

Adopting then $Q = c\ R^{\frac{1}{2}}\ A^{\frac{2}{3}}$
When C is given a value equal to unity

$Q = R^{\frac{1}{2}}\ A^{\frac{2}{3}}$	$Q = 1{\cdot}414\ r\ A^{\frac{2}{3}}$
$a = \frac{R^{\frac{1}{2}}\ A^{\frac{2}{3}}}{V}$	$a = \frac{1.414\ r\ A^{\frac{2}{3}}}{V}$
$D = \frac{1{\cdot}13\ R^{\frac{1}{4}}\ A^{\frac{1}{3}}}{V^{\frac{1}{2}}}$	$D = \frac{1{\cdot}342\ r^{\frac{1}{2}}\ A^{\frac{1}{3}}}{V^{\frac{1}{2}}}$

D = diameter of pipe or culvert in feet.
But with the customary value of C=0·9.

TABLE II. AREA OF WATERWAYS—JAMES VICARS, M.C.E.

Locality.	Character.	Average Annual Rainfall. R inches	Area of Catchment. A Acres.	Area of Waterway: Provided. Sq. Feet.	Area of Waterway: Kernot's Formula.	Area of Waterway: Formula $a = R^{\frac{1}{2}} A^{\frac{3}{4}} \div v$.	Area of Waterway: Formula $a = .9\, R^{\frac{1}{2}} A^{\frac{3}{4}} \div v$.	Remarks.
Bridgewater, Tasmania	Steep and rocky	20	1,500	13				Failed
				170	75	98 v—6	88 v—6	Ample
Bendigo Creek, Sandhurst, Vic.	Undulating			190				Failed
	Lightly timbered	25	10,240	370	320	393 v—6	354 v—6	Ample
Cootamundra N.S.W.	1/3rd hilly. 2/3rds Undulating or Flat. Moderately timbered	20	12,800	53	380	408 v—6	367 v—6	Failed
Moonee Ponds, Victoria	Slightly undulating Very little timber	25	32,000	1,000	752	840 v—6	756 v—6	Ample
Plenty River, Victoria	Small portions steep and densely timbered, remainder Undulating and open	30	38,400	440	864	1,040 v—6	936 v—6	Failed
Merri Creek Victoria	Undulating and lightly timbered	25	83,200	1,500	1,540	1,585 v—6	1,427 v—6	Ample
Saltwater River, Victoria	Generally open and lightly timbered	30	358,400	4,500	4,600	4,606 v—6	4,145 v—6	Ample
Yarra River, Victoria	All timbered, mountainous	35	960,000	8,000	9,640	9,595 v—6	8,636 v—6	Ample
Barwon River, Geelong, Vic.	Lightly timbered, undulating	25	1,062,400	8,000	10,400	8,676 v—6	7,809 v—6	Small
Ditto Railway Bridge	Lightly timbered,	25	1,075,200	4,000	10,496	8,730 v—6	7,857 v—6	Failed
Sturt Street, Adelaide, S.A.	Paved surface and buildings	20	16	1.75				Too small
	Slope, 1%			4.5 1% Grade	2·7	4·7 v—6	4·3 v—6	Ample
Morphett Street, Adelaide, S.A.	Ditto	20	35	3				Too small
	Slope 1% to 3%			5.3 1.5% Grade	4·8	4.9 v—10	4·4 v—10	Ample
Symonds Place Adelaide, S.A.	Ditto	20	56	7				Too small
	Slope 1%			10.8 Grade 1%	6·8	10·9 v—6	9·8 v—6	Ample
East Terrace, Adelaide, S.A.	Ditto Slope 1% to 2%	20	50	4.9 1.4% Grade	6·3	5·1 v—12	4·6 v—12	Ample
Victoria Park, Adelaide, S.A.	2/3rd Park Lands 1/3rd Residential suburban	20	300	36 ½% Grade	24	28·7 v—7	25·8 v—7	Ample
Torrens River, South Australia	Very hilly, lightly timbered	30	115,200	1,550	1,900	2,161 v—6	1,945 v—6	Actual section of flood at 6 ft. per sec.
Marrickville, N.S.W.	Open suburban, undulating	49	2,000	125 Grade, 1 in 2,000	114	139 v—8	125 v—8	Ample

$$Q = \cdot 9 \ R^{\frac{1}{2}} A^{\frac{2}{3}} \qquad Q = 1\cdot 26 \ r \ A^{\frac{2}{3}}$$

$$a = \frac{\cdot 9 \ R^{\frac{1}{2}} A^{\frac{2}{3}}}{V} \qquad a = \frac{1\cdot 26 \ r \ A^{\frac{2}{3}}}{V}$$

$$D = \frac{1\cdot 07 \ R^{\frac{1}{4}} A^{\frac{1}{3}}}{V^{\frac{1}{2}}} \qquad D = \frac{1\cdot 27 \ r^{\frac{1}{2}} A^{\frac{1}{3}}}{V^{\frac{1}{2}}}$$

The following Table No. 2 will serve to indicate the application of the formula in actual practice ; but for this purpose, as the slope of waterway and hydraulic radius are not known in the majority of cases, a velocity of 6 feet per second (which is generally attained in all waterways) has been adopted for them. The particulars for all cases cited except those for Adelaide are taken from the late Prof. Kernot's paper on Waterways of Bridges and Culverts ; those for Adelaide are from the author's practice.

In the case of the Torrens River catchment the flood flow was accurately measured. At top flood the water flowed over the crest of the weir 8 ft. deep, the crest being 132 feet long and 9 feet wide ; at the same time six sluices each 3 ft. diameter and 26 ft. long were also carrying off water under a head of 18 ft.

In presenting the above formula it is not pretended that it represents the last word on the subject. It is, however, believed to embody the primary essentials governing flood discharge, and is in such a form that it can be applied intelligently to any locality. It also is of such simple form that it can be modified without difficulty as further data and experience may prove desirable, either by assigning special values to c or otherwise. For instance, the coefficient c may have unit value in the temperate zone, and higher in sub-tropical and tropical countries subject to monsoonal rains both heavy, prolonged, and extensive ; but this refinement has not been attempted for lack of data.

Indeed, while it is believed that the formula is at least as reliable as any other and lends itself to more rational and general use with equal facility, and probably gives better results for very large catchments, the chief object of the author has not been the perpetration of another formula on the already long list, but to direct the attention of the Government, civic and shire authorities to the necessity of keeping and publishing frequent and comprehensive records of rainfall and flood discharge in connection with catchments for water supply, etc., throughout the States. And to this end it was necessary to demonstrate the inadequacy of existing formulæ and the grave risk in their indiscriminate use.

Every day culverts and waterways are being built too small or of very excessive size through the want of proper data, thereby entailing serious loss on the community, damaging property, interfering with business, and causing great waste of public money and inconvenience. To prevent this great annual loss and hardship should warrant considerable expenditure in time and money to collect reliable data so as to establish this branch of knowledge on a proper and scientific basis ; and it is felt that this Association is the proper and national medium through which to approach and prevail upon the authorities to initiate the work.

2.—THE SAND BLAST TEST APPARATUS FOR TESTING THE WEARING QUALITIES OF TIMBERS WHEN USED IN FLOORS OR FOR STREET PAVING.

By PROFESSOR WARREN and Mr. J. MacD. ROYLE, B.E., Demonstrator in Engineering.

(ABSTRACT)

THE experiments described in this paper consist of a special apparatus designed to produce a jet of sand by means of steam pressure at 42 pounds per square inch. The sand was of standard quality, having grains of uniform size regulated by passing it through sieves of a definite mesh. The apparatus is so arranged that no particle of sand is used more than once, and after impinging on the specimen it collects in a vessel and is thrown away. The specimen of timber is fixed in the apparatus, and the sand is allowed to impinge upon it for a definite time, generally from two to five minutes, according to the hardness of the timber, the results being afterwards reduced to the equivalent effect produced in two minutes.

The specimens were prepared of uniform dimensions, and were tested in three directions as follows :—

A.—Parallel to the axis of the tree on the end grain, as in street paving.
B.—Perpendicular to the annual rings.
C.—Tangential to the annual rings.

The hardness of the timber in regard to resistance to wear is greatest when tested as in A, and least when tested as in C. In the case of blackbutt from the North Coast the hardness in the direction A, as used in street paving, is three times as great as in the direction B, as used in flooring boards, and 4.7 times as great as in the direction C. This ratio differs slightly with other timbers, and the order of hardness compared in each of the three directions is not the same, but the table giving the order of combined hardness in the three directions A, B and C places woollybutt (South Coast) at the top, followed by turpentine, spotted gum and grey box—all from the South Coast. Grey ironbark from the North Coast comes fifth, South Coast blackbutt sixth, and North Coast blackbutt thirteenth ; North Coast tallow-wood is fourteenth, and colonial teak (North Coast) sixteenth.

Tests of exceptionally well-seasoned blocks tested as in A showed that spotted gum would wear better than blackbutt in street paving, and that either were superior to tallow-wood ; whereas jarrah was not even as good as tallow-wood. The exhibit of tested specimens and the numerous diagrams and tables show very clearly the resisting power of New South Wales timbers to wear and abrasion.

3.—THE HOLDING POWER OF NAILS AND RAILWAY DOG SPIKES IN NEW SOUTH WALES HARDWOOD.

By PROFESSOR WARREN and MR. H. A ROBERTS, B.E., Assistant Lecturer and Demonstrator in Engineering.

(ABSTRACT)

THE holding power of nails or spikes in timber depends upon the friction that can be developed between the fibres of the timber and the surface of the driven nail or spike. The friction increases with the pressure exerted by the fibres, and this latter is influenced by the elastic properties and strength of the timber. In all the New South Wales hardwoods it is necessary to bore a hole slightly less than the nail or spike to be driven, otherwise they would probably bend or buckle. In soft woods, on the other hand, it is not necessary to bore a hole.

The nail was withdrawn in a testing machine, using the ordinary steel wedge grips, as in the tests of flat specimens.

The tables of results show that grey ironbark is the best timber for holding power, and that blackbutt, tallow-wood and grey box are each about 20 per cent. below ironbark. The holding power differs in the same timber in the three directions relatively to the annual rings, being greatest when driven parallel to the layers of fibre, and slightly less when driven perpendicular to the layers of fibre, as in sleepers and flooring boards.

It was found that the ordinary round and square spike used on railways and tramways respectively was much inferior to a special twisted square spike, known as the "Floessell spike," the latter having 35 per cent. greater holding power.

This paper included many tables of results, and it was illustrated by numerous diagrams.

4.—HARDNESS OF NEW SOUTH WALES TIMBERS.

By PROFESSOR WARREN and MR. G. E. COWDERY, B.E., formerly Demonstrator in Engineering.

(ABSTRACT)

IT is well known that what we call the hardness of material is a quality difficult to define in an exact manner, as there is no absolute standard of hardness. In this investigation the hardness of the timbers has been compared with reference to the three planes as follows :—

A.—Parallel to the fibre.

B.—Perpendicular to the annual rings.

C.—Parallel to the annual rings.

Three methods were used :—

The cross-compression test, or the sleeper test, as it is sometimes called, because it is almost identical with the indentation produced by the bottom of the rail pressing on the sleeper.

The Brinell ball test, at present very largely used for testing the hardness of metals, consisting of measuring the diameter of a circular impression made under a definite pressure, and dividing the pressure by the area of the indentation. In this case the diameters were measured by a special micrometer ; the pressure was 1,000 kilogrammes applied for two minutes, and the ball was of hard steel, 20 m.m. diameter.

The cone pressure test, carried out by means of the Brinell apparatus, substituting for the steel ball a right-angled cone, which latter is forced into the timber with a definite pressure, and the depth of penetration measured by means of a special apparatus made for these tests by Messrs. Amsler Laffon & Son, Schaffhausen, Switzerland.

The cross-compression test showed that grey gum from the South Coast was the hardest, and white stringy bark the softest. No one timber showed a decided advantage over another. Ironbark did not give the results expected, whereas turpentine exceeded all expectations.

In the other tests grey gum and ironbark were the best, followed by turpentine ; South Coast tallow-wood was tenth, South Coast blackbutt eleventh, North Coast blackbutt sixteenth, and white stringy bark last.

The hardness of New South Wales timbers can be best realised by a careful study of the numerous tables and diagrams contained in this paper.

5.—MODERN LIGHTHOUSE ILLUMINATION.

By JAMES SHIRRA, Engineer Surveyor, Department of Navigation, Sydney.

(ABSTRACT)

In these days, or rather nights, of artificial illumination we are apt to forget how very modern all such amenities of civilisation are. Oil lamps are of unknown antiquity, but only in very recent times have they been scientifically constructed ; but a large Doty Argand lamp, or its modification by Douglass, which may burn a gallon and a-half oil per hour, gives a very great heat as well as a fair light, and is difficult to manage. Gas or electricity, where available, are more manageable, but require much machinery. The incandescent petroleum-vapour lamp, where kerosene vapour is burnt under a Welsbach mantle, is the real modern lighthouse illuminant, and nearly all new—and many old—lighthouses are being fitted with it. Acetylene gas, made by the action of carbide of calcium on water, is a promising lighthouse illuminant, but is not without disadvantages. When compressed into receivers filled

with loose asbestos saturated with acetone, it may be safely handled, and in this form is much used for buoys and beacons. Or a buoy or beacon may contain a store of carbide to which water is admitted, the supply being governed by the pressure of the gas in the receiver. Wi k lamps burning a month or more without attention are much used for similar work, the wicks being either carefully carbonised in a manner that allows them to retain their capillarity for oil ; or made to burn, not at the end, but at the bight, where it travels slowly over a small roller in the burner, the motion being produced by the end of the wick being attached to a float in a cistern of oil that slowly leaks away.

Powerful lights are necessary to maintain the visibility in hazy weather, but there is no evident proportion between the candle-power and the range of visibility. The latter is really more affected by the height of the light above the sea level. In a perfectly transparent atmosphere every light would be visible to its geographical limit, but a slight haze soon renders weak lights invisible. To increase the range in such an atmosphere by a given factor we have to increase the candle-power by approximately the tenth power of that factor ; or to double the range we must increase the power a thousand times ; but the problem is not capable of being solved by a mathematical formula, the data are so uncertain.

To render the lights distinctive they may be made flashing, occulting, or coloured, or all or any of these in combination. Coloured glasses stop much of the light, and are only proper for harbour work. Occultations may be produced either by turning up and down the gas or by rotating round the light a discontinuous opaque screen. Flashes are produced by rotating the optical apparatus itself, which then consists of spherical or bulls-eye lenses surrounded by curved glass prisms, arranged as a series of panels. The faster the optic revolves, the fewer the panels needed to produce the sequence of flashes ; to enable the heavy mass of the optic to revolve frictionlessly it is supported in modern instances by being floated in a bath of mercury in a circular castiron tank, seven or eight hundredweight of mercury suitably disposed buoying up five tons or more of the cut-glass and gun-metal forming the optic.

Cape Byron light thus rotating on mercury revolves once in ten seconds, while Macquarie (the South Head light) takes 16 minutes to go round on its chariot of rollers. But the duration of the flash is much reduced by this quick speed, and Cape Byron only shows for one-fifth of a second every five seconds. When these *feux éclairs*, or lightning flashes, were first introduced, one-tenth second was thought enough, but it was found too short for the eye to fully appreciate. One-fourth second is enough, however, and if the flashes succeed each other often enough this *feu éclair* system is the most powerful, economical and effective system of lighting, especially when the flashes are arranged in groups, as they may be even with less rapid speeds of rotation. Thus at Jervis Bay light, which is a fairly modern one, the optic revolves on rollers every minute, and gives three groups of three flashes each in that time.

The metallic reflection, or catoptric system, is practically obsolete, except for secondary purposes, but has been revived at the new first-order German light at Heligoland, erected in 1904. Here three parabolic reflectors of silvered glass, 30 inches in diameter, each with an arc electric light of 34 amperes in its focus, revolve round a vertical axis and give a flash every five seconds, said to be of 30 million candle-power.

There is evidently a great variety of choice in lighthouse illumination, and the subject demands the careful co-operation —in its practical application—of the engineer, the student of optics, and the seaman.

6.—NOTES ON SOME EXPERIMENTS WITH MODELS OF BUILT-UP COLUMNS.

By G. HIGGINS, M.C.E. (Melbourne), M.Inst. C.E., M.Am. Soc. C.E., etc.

[PLATES XLV-XLVII.]

THE object of making the experiments referred to in the following notes was to ascertain the possibility, or otherwise, of determining by a series of tests suitable proportions and spacing for the side-lacing of columns of a certain type. The aim, in the first place, was to ascertain if possible how thick and wide lacing pieces must be if they are not to fail before the longitudinal members fail ; and, in the second place, to find how closely the lacing points—*i.e.*, the points of connection between longitudinals and lacing bars—must be spaced, if the longitudinal members are not to fail by flexure between the said lacing points, *i.e.*, by secondary flexure.

The workmanship in the models which were tested may be taken to be of the same character as ordinary girder work, if anything, a little inferior ; but the fairly consistent results obtained show that there cannot have been very much wrong with the building of the columns. Only one of the nine tests need be discarded.

During the application of load, each column was closely watched by several persons, with the object of detecting any local yielding, such as might result from imperfect workmanship ; but, as usual in such cases, none was revealed ; all failed so suddenly that it was impossible to say which part was the first to give way. Undulations moved along some of the longitudinals shortly before collapse, and the stress in certain of the lacing members changed sign ; for example, it was observed that a piece of the lacing buckled, as in compression, at one stage and straightened out tightly afterwards. But the collapse occurred with suddenness in each case. Inferences may, however, be drawn, as to the order in which failure occurred in the various parts.

The columns experimented with were all 48 inches long by 4.8 inches square, this transverse dimension being measured outside the four longitudinal L bars placed at the corners. The material was mild steel. That in the longitudinals showed a not very well defined yield point at 38,000 lb. per square inch, and the specimen tested, one inch in length, failed by the L opening out when the stress was 57,100 lb. per square inch. The sectional areas of the L bars were ascertained by calculation from the weights of known lengths, taking 4·533 ounces as the weight of a cubic inch. The area of cross section of the L bar which was used in the longitudinals of all the columns and in the flanges at their ends was found in this way to be 0.145 square inch, so that the four longitudinal L bars, which supported the load, had a joint area of 0·58 square inch. The rivets were of diameters roughly proportioned to those that would be used in real girder work of similar design. Those used for attaching the flanges at the ends of the columns were 3-16 in diameter. This size was also employed for attaching the lacing members to the longitudinals in columns 5 and 6. The lacing in columns 2, 3, 4, 2A, 3A and 4A was attached with rivets 0·12in. in diameter, and in column No. 1 the diameter was 0·08 in.

All the lacing pieces were steel L bars. As will be seen from the photographs, the columns numbered 1 to 6 had a single system of lacing on each of their sides, each piece making an angle of about 45 degrees with the longitudinals. One rivet at each end formed the attachment for each piece of lacing to the longitudinals. Naturally those lacing bars which failed in tension tore at the rivet holes ; but those that failed in compression did so, in most cases, by deflecting laterally before damage was done at the riveted ends. The fact that so many lacing L bars failed in compression shows that flat bars are quite unsuited for lacing columns. The lacing was lightest in No. 1 and heaviest in No. 6, the variation in Nos. 2, 3, 4 and 5 being gradual.

The photographs taken of column No. 1 after failure show how the lacing was practically all destroyed, being unable to hold the four longitudinals together. Two of the longitudinal bars diagonally opposite each other bulged apart, while the other two became bowed towards each other. The load at collapse was 9150 lb.

In column No. 2 the lacing failed mainly in compression and the longitudinals became bowed, but not to the same extent as in No. 1. This column failed at 17,320 lb. Inspection of Table A makes it clear that neither 1 nor 2 were sufficiently strongly laced to enable the full strength of the longitudinals to be developed. By strength of longitudinals in this case is meant the strength of those portions of them between lacing points, for, as will be seen, the lacing points in the first six columns were not close enough to each other to prevent secondary flexure. The ratio of length to least radius of gyration was smaller for each entire column than for each section of it between lacing points.

Columns Nos 3 to 6 all failed by secondary flexure at about 19,000 lb., nothing being gained by having the lacing in 4, 5 and 6 heavier than in No. 3. In other words, the lacing bars in No.3, which had an area equivalent to 18·4 per cent. of that in the longitudinals, were sufficiently strong to develop the strength of the longitudinals when these had lacing points about 9½ in. apart.

Having got these results, which, under the circumstances, were as satisfactory and consistent as could have been expected, the next step taken was to try the effect of placing extra pieces of lacing in columns resembling Nos. 2, 3 and 4, so as to reduce the distance between lacing points. The new columns were numbered 2A, 3A, and 4A. Their lacing bars had about the same weight as those in 2, 3, and 4, but extra pieces were placed transversely, extending from each apex in the former system of lacing to midway between the lacing points on the opposite longitudinal bar. The effect of introducing these extra pieces was to prevent secondary flexure in the longitudinals.

Column 2A was 17·1 per cent. stronger than 2.

Column 3A was less than 1 per cent. stronger than 3.

Column 4A was 21·3 per cent. stronger than 4.

The added metal, in each case, was 14·7 per cent. of that previously there. The result in the case of column 3A may evidently be discarded, because some defect, which observation failed to discover, may have existed; or, as subsequent investigation made to appear probable, the lacing bars in 3A may possibly have been 6 per cent. lighter than those in 3. The writer had not time to confirm this.

The result, then, of the three last tests is to show that the system of lacing adopted in them is sufficient for developing the strength of the longitudinal portions of the columns, for each of the columns failed by primary flexure—*i.e.*, they bent sideways, each as a whole, without secondary flexure. So that the experiments, few in number and small in scale as they are, serve to demonstrate that, with the particular longitudinals here made use of and with these dimensions for the columns, L lacing bars, whose weight per yard is about 18 or 20 per cent. of that of the longitudinal bars, and arranged as in these columns, are able to prevent secondary flexure and are strong enough to hold the parts of the column together.

Further experiments, on a different scale, would be needed to show whether or not similar proportions would hold in the case of square built-up columns, with other sizes of longitudinal angle bars, or with different proportions of length to width.

It is true that some of the lacing members in the last three columns were broken or crumpled in the testing machine, but this may be taken to be the result, not the cause, of the collapse. We may take it that the column bent as a whole, failing virtually, and then, when the lateral deflection reached a certain amount, the lacing yielded. This seems a reasonable inference, because these three columns, 2A, 3A and 4A, failed in a manner quite different from 2, 3 and 4. In the case of 3A, as mentioned, there probably was some defect causing the premature yielding which there occurred.

The table of results (A) shows that the ultimate stress in the longitudinal L bars in column 4A was 38,276 lb. per square inch, which is approximately the yield point for the mild steel from which the bars were rolled. It is not likely that any considerably higher figure for the ultimate strength of a column can be obtained with these longitudinal L bars, whatever system of dimensions of lacing be adopted, for the yield point in compression tests of this nature is virtually the ultimate strength.

It may be that columns with longitudinal members, more massive in proportion to the transverse dimension of the column than those experimented with here, might have their stength developed with lacing bars lighter in proportion than those in the present case ; but it must be remembered that the question is often one of stability. Many columns have channels instead of L bars. The Quebec bridge had four channels as longitudinal members in the strut which caused failure. The lacing bars there had a section 0·32 per cent. of that of the column itself, a vastly lower figure than the $4\frac{1}{2}$ or 5 per cent. which we found necessary here. The Quebec bridge lacing, moreover, consisted of a double system of braces, connected by transverse pieces. The existence of these transverse pieces, which acted in tension, really weakened the structure, because they compelled the diagonals to share largely in the load on the strut which they were supposed merely to brace.

The writer is of opinion that systematic tests, comparing different sizes of lacing bars, and different systems of lacing, on columns of various sections, would afford much better guidance for the proportioning of struts than any formulæ he has seen. In any case, we should recognise that there is great uncertainty as to eccentricity of a column's axis, or of loading, also that there are unknown variations in the strength and elasticity of the material of which a column is built, and, further, that accidental lateral blows may be given, which may be cumulative with considerable wind pressure ; besides all which, if the strut is not vertical, the column's own weight tends to deflect it The attachment of a cross beam in a bridge may deflect a strut. For all these reasons it is urged that lacing bars should be used liberally and not cut down for economy's sake. Extra dimensions in the parts forming columns may be made to give great increase of strength, and the cost is comparatively small.

For several years past, and especially since the collapse of the Quebec Bridge, scores of formulæ for columns have been brought forward, and much excellent experimental work has been done. The researches of Lilley, Burr, Buchanan and of Talbot and Moore on steel struts has supplemented what Hodgkinson did with cast-iron and Christie with wrought iron. Lilley's work has thrown much light on the subject of secondary flexure, mainly in the case of hollow cylinders. Buchanan has given the results of actual tests to destruction of full-sized bridge struts. Burr tested a large model of the strut whose failure wrecked the Quebec Bridge. Talbot's and Moore's researches are especially valuable, inasmuch as they show how unexpectedly and how seriously stresses vary from place to place in a column. They applied numerous extensometers to longitudinal and lacing members of actual bridge struts and deduced the corresponding stresses. A very important finding of theirs was that the actual stresses were very much greater than the measured deflections would account for. They ascertained that, in the particular columns which they tested, the maximum stresses in the lacing bars were such as would be produced by transverse loads varying from 2 to 6 per cent. of the central compressive load.

Painstaking work has been done by Moncrieff, who analysed the experiments of others in the endeavour to find what deflection it would be safe to assume for the calculation of bending moments and shearing forces.

The well-known formulæ of Rankine, Gordon and Euler, as well as the straight-line formula, so popular in America, have been examined and criticised by numerous writers to the technical press. One writer points out that, if Rankine's formula be put in a certain form, it will be found to be based upon a certain assumed eccentricity of loading, this eccentricity varying as $\frac{l^2}{b}$ where l is the length of the column and b its least transverse, dimension. Again, if the straight-line formula be looked at in a similar manner, it also will be found to be based upon an assumed eccentricity, the eccentricity in this case, however, varying as the length of the column simply.

Claxton Fidler bases his formula upon the assumption that the modulus of elasticity of the material on one side of a column differs from that on the other side by an amount equal to the greatest known difference in the values of the said modulus ; in other words, he goes back and deals with the causes of the deflections which others assume.

Keelhoff derives a formula by calculating the bending moment and shear corresponding to an indefinitely small deflection.

A number of investigators appear to apply Euler's method of reasoning to determine a critical load, which corresponds to any deflection, and then proceed in a way which is tantamount to giving the said indefinite deflection a definite value.

In the majority of cases the procedure followed in the preparation of a formula is to find a value for a bending moment and calculate the corresponding shear, which is, of course, a maximum at the ends and zero at the middle of the strut. Now, as Carl Jensen points out, lacing designed on these principles might prove dangerously weak, for the shear may be quite large at the middle of a column's length ; for example, when the centres of pressure on the two ends of a column are on opposite sides of the column's geometrical axis, then the column will tend to fail by bending in an S curve, causing heavy shear at mid-length.

Burr's large model column failed in this manner. Instead, then, of basing our calculations upon some assumed deflection of a column as a whole—*i.e.*, a bending such that the maximum deflection is at the middle, we should remember that it may bend in an S curve ; and, if for purposes of approximation, we employ one of the many formulæ, deduced as above-mentioned, we should certainly not reduce the dimensions of the lacing near the middle of the column, but maintain throughout the dimensions found for the lacing at the ends.

But, rather than trust to any formula or to any factor of safety, which may be guessed to be sufficiently large to cover unknown possibilities, the writer would recommend that those concerned with the design of important compression members should ascertain experimentally what would be safe dimensions to employ for the lacing components of their columns.

The results of a series of such tests might be used to base designs upon in much the same way that the results of tests of timber columns are employed.

Addendum.

Since writing the foregoing notes the writer has had the benefit of the opinions of those who took part in the vigorous and able discussion which followed the reading of the paper. Prompted by the remarks made by engineers having different points of view, he thinks that the following facts and explanations may add to the clearness of the original paper.

(1) All the L bars employed for longitudinals, heads of columns and lacing had sides of equal width. The columns were thus not unlike those used in poppet-heads for important mines.

(2) The ratio of length to least radius of gyration was, in the case of the complete column $\frac{48}{2{\cdot}2} = 22$ to 1. The corresponding ratio for the portion of each longitudinal member of a column, contained between adjacent lacing points was, for columns Nos. 1 to 6, about 55 to 1.

In columns 2A, 3A and 4A, this ratio was 28 to 1.

The ratio in the case of the lacing bars was, in general, greater still. That for column 2A, for instance, was 78 to 1; and yet this lacing proved sufficient to develop the strength of the column as a whole—*i.e.*, the column failed as a unit, without appreciable distortion such as would result from the yielding of parts.

The common rule, and a good one to follow, is to make the ratio of length to least radius of gyration, for each portion between lacing points of a longitudinal component of a column, the same as for the whole column. The present experiments support the rule—*e.g.*, secondary flexure was observed when the ratio was about 55 to 1, and the lacing bars strong enough, while the columns proved to be satisfactorily braced against secondary flexure when the lacing points were so spaced as to make the ratio 28 to 1.

On the other hand, it must be borne in mind that experiments, such as those carried out by Talbot and Moore, show that any lacing bar may act in compression. Now, if the same stress per unit of area be allowed in lacing bars as in the principal components of a column, it would follow that the ratio of length to least radius of gyration should be the same for lacing bars as for the other portions of the column. The practice is to make this ratio far greater for the lacing than for the principal bars, and the present experiments seem to show that the practice is to some extent warranted. This leads to—

(3) The object of lacing. In the writer's opinion the object is to hold the longitudinal members together and so prevent them from yielding singly, by lateral deflection, as long columns. This is not the same thing as providing against deflection of the column as a whole. It seems incorrect to design a column as a beam subjected to bending, because the column, under working loads, should not deflect as a whole, nor, with proper workmanship, should there be any perceptible initial deflection. Moreover, it is only in exceptional cases that loads are applied eccentrically. Nor is it sufficient to consider each longitudinal component separately, designing the lacing to resist bending in two planes, for it must be remembered that the lacing bars fixed to one longitudinal are merely attached to other longitudinals, which may tend to bend in the same direction as the first. This is not the same thing as staying an upright post from an immovable wall.

There appears to be no method of deducing a rational formula for determining the dimensions of lacing-bars, connecting longitudinal column components with each other. Their *raison d'etre* is (1) to prevent flexure of individual longitudinal components, and (2) to transmit any equality of loading from one such component to the other. What appears to be needed is a series of tests, covering built-up columns of all good designs. Nothing but actual tests can enable us to make satisfactory allowance for the accidental imperfections in workmanship, the variation in elasticity of the materials used in construction, and unintentional eccentricity of loading.

(4) The failure of column No. 1 would suggest the usefulness, in certain cases, of bracing diagonally opposite longitudinal column components together.

(5) The columns tested were placed horizontally in the testing machine. It might, therefore, be expected that their own weights would cause slight initial downward bending, great enough to influence the direction in which final collapse would occur. But, curiously enough, none of the columns bent downwards at collapse ; most of them bent upwards, and the remainder bent sideways.

(6) The following are a few quotations from the paper by Talbot and Moore, referred to in the foregoing notes. (University of Illinois Bulletin, No. 44. "An Investigation of Built-up Columns under load." Also Proc. A.M. Soc., C.E., June, 1909.)

P. 63.—" It seems futile to attempt to determine the stresses which may be expected in column lacing for central loading by analysis based on theoretical considerations or on data now available."

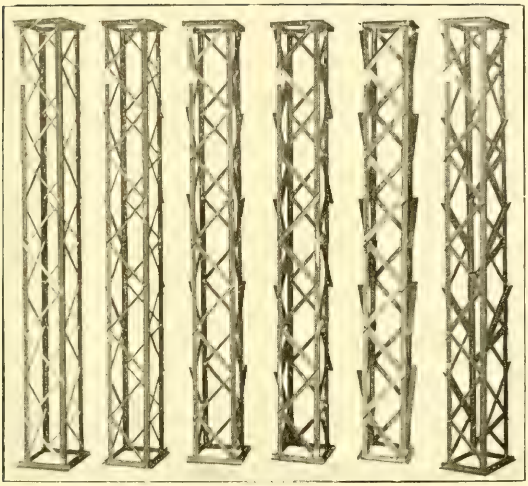
" No relation has been found between the stresses actually observed and the stresses computed by column formulæ. The stresses do not increase towards the middle of the length of the column, as may be expected from the Rankine form of analysis, but are quite irregular in their location and distribution."

P. 61.—" For the strength of the component angle, channel, or other structural shape used in a built-up compression piece, many engineers have been satisfied with the provision that the slenderness ratio " (*i.e.*, the ratio, length to least radius of gyration) " of the component member shall be less for the length between the points of attachment of lacing than the slenderness ratio for the column as a whole, and have given little attention to the possible non-integrity of the section or to the probable effect of imperfections of manufacture. Fortunately, the large influence of the slenderness ratio in column formulæ has given sections with which failures have not occurred. Whether a column formula should include a factor depending on the form of the section and the relative thickness of the metal, or whether the allowable stresses for any form of column should be based on experimental data for the section used, will depend on future developments."

P. 60.—" Within the critical length at which Euler's formula governs, the general flexure of the column as a whole under load has less influence upon the strength of the column than is ordinarily assigned to it, and therefore the influence of $\frac{1}{r}$ (length to least radius of gyr.) is not as great as is represented in the usual column formula."

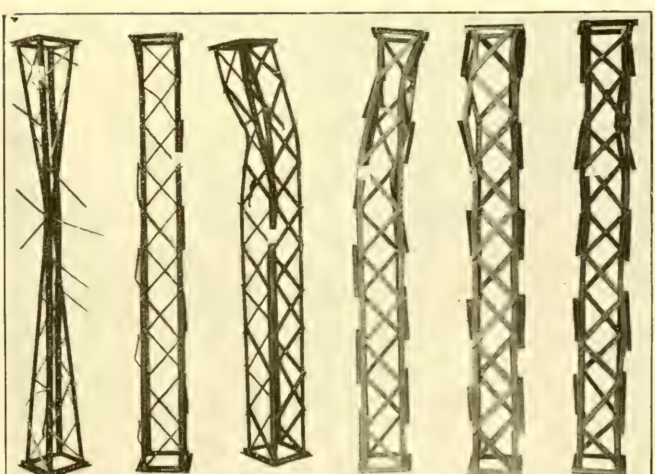
(7) A few small alterations and one or two additions have been made to the text since the original paper was read.

1 2 3 4 5 6



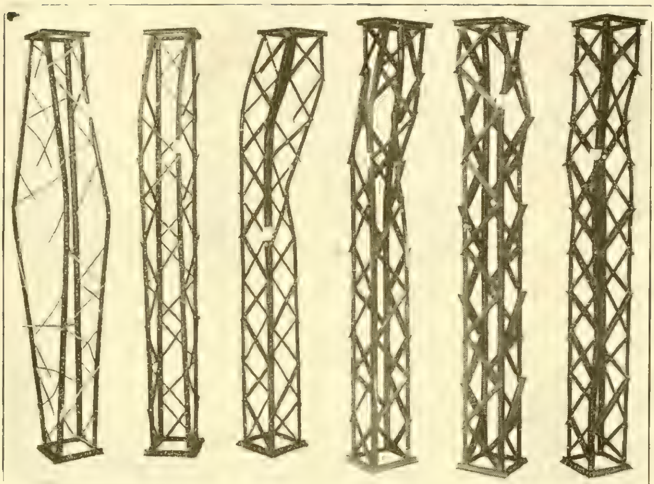
Columns 1 to 6 before Testing

1 2 3 4 5 6



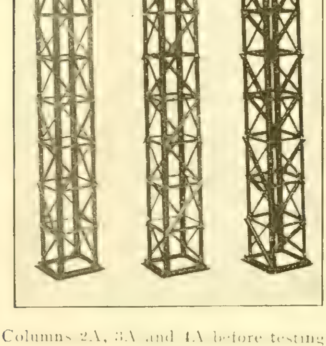
Columns 1 to 6 after Testing

1 2 3 4 5 6



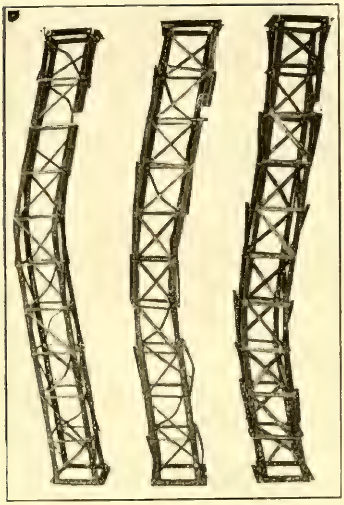
Columns 1 to 6 after Testing—Another view.

2A 3A 4A



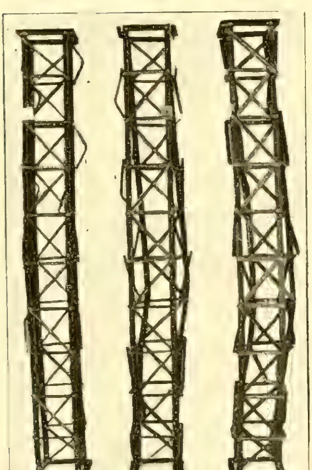
Columns 2A, 3A and 4A before testing.

2A 3A 4A



Columns 2A, 3A and 4A after Testing.

2A 3A 4A



Columns 2A, 3A and 4A after Testing—View at right angles to previous view.

TABLE A.

Steel L Bars used for longitudinal and end flanges, weighed 23·635 oz. per yard and measured 0·6 in x 0·6 in.; Section area, 0 145 sq. in.

Column No.	Dimensions of L lacing bars.	Weight of lacing bars per yard.	Section of lacing bar compared with longitudinals.	Collapsing load.	Stress in longitudinals at collapse of column.	Remarks on Appearance at Failure.
	in. in.	oz.	p.c.	lbs.	lbs. per sq. in.	
1	7/32 × 7/32	1·25	5·28	9,150	15,776	Lacing nearly all destroyed; some torn at rivet holes, others buckled. Longitudinals bowed.
2	19/64 × 19/64	2·67	11·31	17,320	29,862	Lacing buckled; one piece torn at rivet hole. Longitudinals bowed.
3	13/32 × 13/32	4·36	18·40	19,110	32,948	2 diagonals torn at rivet holes; one buckled. Secondary flexure in longitudinals.
4	1/2 × 1/2	5·00	21·16	18,300	31,552	3 diagonals buckled. Secondary flexure in longitudinals.
5	5/8 × 5/8	6·60	27·90	19,500	33,621	No lacing damaged. Secondary flexure in longitudinals.
6	9/16 × 9/16	8·78	37·10	18,900	32,586	No buckling of lacing. One sheared rivet. Secondary flexure in longitudinals.
2A	1/4 × 1/4	2·67	11·31	20,280	34,966	Column bent bodily. Some diagonals buckled; 3 torn at rivet holes.
3A	11/32 × 11/32	4·36	18·40	19,245	33,181	Column bent bodily. 14 diagonals torn at rivet holes; many buckled.
4A	15/32 × 15/32	5·00	21·16	22,200	38,276	Column bent bodily. Many diagonals torn and buckled.

EXPLANATION OF PLATES XLV-XLVII.

Models of Columns under stress.

7.—NOTES ON A FEW EXPERIMENTS WITH GYROPLANES AND HYDROPLANES.

Paper by GEO. HIGGINS, M.C.E. (Melbourne Univ.), M. Inst. C.E., M.Am. Soc. C.E., M. German Soc. Engineers, etc.

So many lives have been lost within the last few months in connection with the use of flying machines that it seems quite time to enquire seriously whether it is not useless to continue working on the lines hitherto followed. It appears that all that is necessary to wreck any aeroplane is that a sufficiently strong gust of wind shall be encountered. If an aeroplane is to be safe from the effects of gusts of wind, which may have a velocity of 60 miles an hour, the aeroplane must be able to travel at a speed still higher than 60 miles an hour. And if this is so, what is to happen if a gust strikes an aeroplane before it attains that speed at starting, or while it is slowing down to effect a landing ?

It seems almost certain that no mere modification of the present type of aeroplanes will avoid more than a fraction of the great risk which is met with. It seems almost certain, too, that unless some substitute is found for the aeroplane the use of the heavier-than-air machine will have to be abandoned.

It is desirable, therefore, that any invention which has for its object the substitution of some body less liable to be " driven with the wind and tossed " than the curved or flat-plate now so much used should be carefully looked into.

One scheme, having this for its object, has recently been brought under the writer's notice. The suggestion is that of Ernest Sadleir, of Boulder, W.A. He made some four-armed boomerangs, which he called " gyroplanes," the under-surfaces of which were flat, and in one plane. These he found to behave very much as the boomerangs do which are used by the aborigines, and their wonderful steadiness, in spite of gusts of wind, impressed him. He tried the effect of adding weights of varying heaviness to them, until he reached a limit, beyond which his gyroplanes would not rise when thrown. The idea that his gyroplanes would be much steadier in the air than the curved or flat plates called " aeroplanes " has long been present with him. He aims at trying whether rotating gyroplanes will not answer better than plates, curved or flat, when the gyroplanes are set at the necessary upward inclination and suitably propelled—*i.e.*, the whole gyroplane is given the inclination, but the arms have their undersides in one plane, and any number of gyroplanes can be attached to one machine.

To ascertain whether or not this contrivance is likely to be successful practically it is necessary to determine two things—(1) whether or not a rotating gyroplane is capable of sustaining as great a weight as a disc whose diameter is the same as that of the gyroplane ; and (2) whether the gyroplane will remain sufficiently steady in gusts of wind to avoid being wrecked by them. The few experiments about to be mentioned throw a little light upon the first question, and they, together with a few results with hydroplanes, may possibly indicate an answer to the second.

(1) *Gyroplane Experiments.*—Several gyroplanes of various sizes, a few of which are exhibited, were caused to rotate with their axes vertical, or nearly so, and while rotating they were allowed to drop through 42 feet from a bridge to water in a river. Discs, of the same diameters, were dropped at the same place, and the times occupied in falling were compared. Also, for purposes of comparison, two gyroplanes were thrown horizontally from a height of about 46 feet. These, after first falling slightly and then rising—boomerang fashion—fell in the water some 150 feet from the bridge. The effect of spinning a helix was also compared with that of spinning the gyroplanes. The arms of the helix were shaped like those of the gyroplanes, and, like them, were about 2½ inches wide, but they were tilted upwards slightly in the direction of their rotation, their inclination being about 1 in 10. The times of falling were ascertained by means of a stop-watch. The following are the results :—

TIMES OCCUPIED BY GYROPLANES, DISCS, AND A HELIX, DROPPING FROM A HEIGHT. DATE OF TRIAL, 3RD JANUARY, 1911.

No. of Test.	Description.	Weight. lb.	Description of Under Surface.	Manipulation.	Height of Drop. feet.	Time of Falling. seconds.
1	Gyroplane, 18″ diam. ..	$\frac{1}{2}$ (full)	Monoplane	Thrown	46	5
2	,, ,, ..	,,	,,	,,	46	$5\frac{1}{2}$
3	Helix, 24″ diam. ..	$\frac{3}{4}$	Tilt of arms about 1 in 10	Spun at 450 revs. a min. and dropped	42	$4\frac{1}{2}$
4	Gyroplane, 24″ diam. ..	1	In one plane	Spun at 480 revs. a min. and dropped	42	$3\frac{1}{4}$
5	Gyroplane, 36″ diam. ..	$1\frac{3}{4}$	,, ,,	Spun at 432 revs. a min. and dropped	42	4
6	Disc., 24″ diam. ..	$\frac{3}{4}$	Flat	Dropped flat (It turned over several times in falling)	43	4
7	,, ,, ..	1	,,	,, ,, ,,	43	$3\frac{3}{4}$
8	Disc, 36″ diam. ..	$1\frac{1}{2}$ (full)	,,	,, ,, ,,	43	$4\frac{1}{4}$
9	Helix, 24″ diam. ..	$\frac{3}{4}$	Tilt as in 3	Angular rev. as in 3	42	5
10	Gyroplane, 24″ diam. ..	1	In one plane	As in 4	42	3
11	,, 36″ ,, ..	$1\frac{3}{4}$	,, ,,	As in 5	42	4
12	Gyroplane, 18″ diam. ..	$\frac{1}{2}$ (full)	In one plane	Thrown	46	5
13	Helix, 72″ diam. ..	4 (full)	Tilt of arms about 1 in 10	Spun at abt. 30 revs. a min. and dropped	42	3
14	,, ,, ..	,,	,, ,,	(Not satisfactorily spun)		
15	Helix 24″ diam. ..	$\frac{3}{4}$	Tilt of arms about 1 in 10	Dropped without spinning	43	2
16	Gyroplane, 24″ diam. ..	1	In one plane	,, ,,	43	2
17	Gyroplane, 36″ diam. ..	$1\frac{3}{4}$	,, ,,	,, ,,	43	$2\frac{1}{6}$

Tests Nos. 3, 6, 9 and 15 to be compared. Tests Nos. 4, 7, 10 and 16 to be compared. Tests Nos. 5, 8, 11 and 17 to be compared.

Tests Nos. 13 and 14 may be discarded ; the primitive mechanism for spinning the gyroplanes, etc., was not strong enough for the comparatively heavy arms, which were 3 feet in length.

The experiments showed that the sustenance afforded by the air to a rotating gyroplane is nearly as great as that afforded to a disc whose area is the swept area of the gyroplane arms.

But the distinction which was most strongly marked was the steadiness of the gyroplane as compared with that of the disc. The gyroplanes fell with their axes of rotation vertical, and when they reached the water they did so gently, and continued rotating, the arms skimming on the surface quite prettily ; whereas the discs of equal weight and diameter turned over and over while falling.

These experiments, and others not here described, have given the writer reason for supposing that increase of speed of revolution beyond a certain amount will not be accompanied by any increased sustenance.

Further experiments are needed to ascertain what particular angular velocity corresponds to the best sustenance effect.

Of course, merely dropping these objects does not afford a complete comparative test. If propelled through the air the centre of air pressure, both in the case of the disc and the gyroplane, would be in advance of the centre of gravity, increasing the lifting effect.

The blades cleave the waves of air much as the blades in the hydroplane experiments, next to be mentioned, cut through waves of water.

(2) *Hydroplane Experiments.*—The photographs which accompanied the paper showed the type of hydroplane used. Sadleir discovered, independently, what Horatio Phillips had discovered years before, viz., that narrow blades are much more efficient than wide ones, both in water and air. The eddies formed in contact with the surfaces are quickly dropped when the blades are narrow ; there is not the frictional loss that there would be if the eddies were dragged along the rear portions of wider surfaces ; moreover, the eddying water quickly restores itself and becomes ready for the next blade to operate on, if the blades be not placed too near each other. Sadleir supports his boat upon a number of transverse blades, flat on the underside, which are tilted upwards in the direction of progress at a slight angle. The blades he used with the boat were 3 ft. 6 in. long by 2 in. wide by about $\frac{1}{4}$ in. thick at the middle of their width, the blades having knife edges on either side. Sadleir's hydroplane differs from Phillips's in three respects. 1. Phillips hollowed out the underside of his blades slightly, while Sadleir keeps his quite flat. 2. Phillips made them wider at the middle than at the ends, whereas Sadleir's planes were of the same width throughout. 3. Sadleir's hydroplane differed from Phillips' in regard to the number of blades employed. Phillips had one fairly large blade, taking nearly all the weight of the boat. It was placed just abaft the centre of gravity of the boat. Then, to steady the boat, he placed a smaller blade near the bow. Both recognised the necessity for

keeping the tips of the blades turned slightly upwards. Phillips did this by actually curving his steel blades upwards near the tips. Sadleir let his wooden and somewhat flexible blades overhang their supports, so that when the boat would roll the lower projecting ends of the blades would take an upward turn, and this, he found, helped the boat to right itself. He found that a rigid blade tended to sink further beneath the surface when the boat rolled to one side. While Phillips, then, employed one blade to carry practically the whole weight of his boat, Sadleir employs several, the number depending upon the weight to be carried, and they are all of the same size. In some of his hydroplanes he places his blades in tiers, one above the other, so that as the speed increases the boat rises and certain of the blades are lifted quite out of the water and thus put out of action.

In Sadleir's experiments his narrow blades kept at about the same level, cutting through minor waves. On larger waves, such as followed in the wake of the motor launch, which towed the hydroplane, the latter simply adapted itself to the slope of the wave. The pull on the towline was, however, heavier when the hydroplane was travelling uphill than when travelling downhill. The following are the results of some of the experiments. The speeds were ascertained by one of Walker's patent logs. The pulls were measured by spring balances.

The craft kept remarkably steady. Small as it was, the lads who were on board could stand up, sit down, or move about without affecting the stability of the vessel.

Weight of Boat and Contents.	No. of Blades.	Angle of Tilt	Blade Area.	Weight per sq. ft. of Blade Area.	Speed at which Skimming Commenced.	Pull just before Skimming.	Pull when Skimming.	
lbs.			sq. ft.	lbs.	knots.	lbs.	lbs.	
112	6	1 in 15	3·5	32	About 5	22	16	With 75 lbs. more weight, the boat would not skim, the speed not being great enough.
112	7	1 in 12	4·1	27·3	,,	—	14 to 20	On waves: 14 down hill; 20 up.
226	7	,,	,,	55·1	,,	—	37 to 41	In these three cases the greatest speed attained was 8 knots.
270	7	,,	,,	65·8	,,	—	44	The pull then was about the same as at 5 knots.
278	8	1 in 6	4·7	59·2	not recrd.	—	50	
112	8	1 in 6	4·7	24	,,	—	26	At a reduced speed of about 3 knots the pull was 23, the boat skimming.
112	4	1 in 20	2·3	48·7	,,	—	9	
240	4	,,	2·3	104·4	,,	—	28 to 31	Did not skim properly at 6 knots.

Of course, a great many more experiments are needed before it can be determined with certainty what the best number of blades is, and what their tilt should be to carry a given weight.

Piecing the information together in a rough way, I estimate that a hydroplane on Sadleir's principle, weighing in all one ton, could be driven at 40 knots with about 30 or 35 actual horse-power. Thorneycroft gets this speed with about 58 h.p., and skimming does not commence until about 17 knots. He has a nearly flat bottom to his boat (an ordinary craft), and a skimmer of the same weight would require perhaps 200 h.p. for this speed.

It still remains to be seen whether the gyroplane will cut through gusts of wind as the blades of the hydroplanes cut through waves of water. Boomerang experiments seem to show that they will.

Dr. Harvey Sutton gave an exhibition of boomerang throwing in illustration of this paper, using some of Sadleir's gyroplanes for comparison with ordinary boomerangs.

LECTURES

A LECTURE on "Irrigation in India" was delivered before the Section by Professor Warren. Following is a brief abstract. The lecture was profusely illustrated by lantern slides.

The lecturer traced briefly the progress of irrigation from ancient times to the present day, and stated that, according to an ancient inscription, it appears that the perennial systems of irrigation so successfully operated in India and elsewhere were introduced by the hydraulic engineers of ancient Chaldea and Babylonia about 2000 B.C.

The basin system on the Nile in Egypt, and the various systems of inundation canals in Egypt and India are also of ancient origin; the perennial systems derived from the large rivers in India are, however, the work of the British engineer. The various mechanical contrivances, such as the Persian wheel, were illustrated and explained by means of lantern slides, which method was freely used in the lecture to describe the weirs, anicuts, under-sluices and canal headworks in connection with the irrigation of the Punjab, the United Provinces, and in Madras.

These magnificent works in India were explained in considerable detail, and it was shown that they were all most remunerative Government investments, and a source of inestimable benefit to the natives of India, in whose behalf they were constructed. The works dealt with more especially in the lecture were the Bari-Doab, the Chenab, and the Sidhnai irrigation colonies in the Punjab; the Upper and Lower Ganges canals and the most important structures situated in the Ganges-Jumna Doab ; the great delta systems in the Madras Province, including the Godavari weir and headworks at Dowlaishwaram, and the Kistna weir and headworks at Bezwada ; also some more modern undersluices and anicuts at Shahatope. The construction of these works and the extent of the areas irrigated by the various canals and distributaries were fully considered. The lecture concluded with a description of the Periyar project in Madura and the diversion of the waters of the Periyar to the River Vaigai by means of a dam in the course of the former, and a tunnel through the hills separating the valleys of the two rivers.

Section I

SANITARY SCIENCE AND HYGIENE.

ADDRESS BY THE PRESIDENT:

W. PERRIN NORRIS, M.D., D.P.H.,

Commonwealth Director of Quarantine, Melbourne.

[THE text of the President's Address was not available when we went to press.]

PAPERS READ IN SECTION I.

1.—THE BIOCHEMICAL METHOD OF BACTERIOLOGICAL ANALYSIS.

(WITH ESPECIAL REFERENCE TO THE COLON BACILLI AND THE DIPHTHEROIDES)

By BURTON BRADLEY, M.B., Ch.M. (Syd.), M.R.C.S. (Eng.), L.R.C.P. (Lond.), D.P.H. (Lond.), Assistant Microbiologist, Bureau of Microbiology, Sydney.

IT was once said of bacteriologists by a scientific man of another branch, " Oh, *they* simply make cultures and look at them, and there it is finished."

As a matter of fact the truth is very far from this. With a few exceptions the bacteria—and by this term I include all the members of the class Schizomycetes (bacilli, cocci, vibrios streptothrices)—are so morphologically similar that, armed with the best of microscopes, we should make but slight headway in our attempt to differentiate them into classes, far less to isolate individuals. Cultures also are only available in certain cases, and our methods of culture must be modified by the data given us by numerous other methods of investigation.

It is difficult to enumerate all the means that have been tried—some successfully, some unsucessfully—to aid in the classification of the huge group of bacteria.

In all cases the *morphology* must be considered, and here we get a first separation into three more or less distinct groups —bacilli, cocci, vibrios (rod, round and curved forms respectively), and by considering their arrangement some further separation is obtained, especially amongst the cocci, into staphylococci (bunched forms), streptococci (chain forms), diplococci (twin forms). There are also streptobacilli (streptothrices) and diplobacilli.

But having arrived this far we are met by difficulties, inasmuch as there are bridging forms between all three main groups, and an organism may frequently grow as a coccus one time and later on as a bacillus. Also, if we accept the three groups as being on the whole constant, yet each group contains a vast number of classes and types indistinguishable from each other. A few types can be more or less weeded out by considerations of size, shape, presence and, if present, position and shape of spores, presence, and, if present, number and situation of flagella, arrangement of individual elements to each other ; but this is all.

The reactions to various methods of staining have proved of great value, and Gram's method holds the place of honour, enabling us to classify all bacteria into two classes—those which do and those which do not stain by Gram. This reaction has enabled us to sharply separate a number of types similar in other ways, and being most likely the indication of a physiological peculiarity of the organism, probably leads towards a *natural* classification. Zeill Neillsen's method, originally used for the tubercle bacillus, enables us not only to demonstrate bacilli which other stains fail to show, but again gives us *another* means of classifying into two groups. Other staining methods—Neisser's, Loeffler's, and a number of less important ones—have enabled us to get a much greater insight into the characteristics of different bacteria, and so to separate and classify.

Cultural Methods.—It is to the method of culture that bacteriologists probably owe most. Unfortunately, cultures are not available in all cases, and numerous bacteria grow identically, though quite obviously of different type ; still, by the study of the nature of growth, rate of growth on different media, much has been done, and for other practical purposes cultures are of utmost importance ; and, lastly, the method of culture is the direct progenitor of the biochemical method.

The Biochemical Method.—I take it that the biochemical method attempts to find out what a bacterium *does* in contradistinction to what it *looks like*, each way of investigation of course leading up to the question, what a bacterium *is* in relation to other bacteria. This aspect of inquiry has been criticised. It has been said that it is fallacious to attempt to classify by the *action* of an organism, and has been likened to attempting to classify individual men not on appearance, etc., but by their actions. I cannot help thinking that this was a bad analogy, for we most assuredly do get a more useful idea of a person if we know what he does. It is usual to classify people by their features, shape, or size, but I am sure if we could find out everything that each of us is capable of *doing* we should be nearer truth in our classification than by any method depending on length of moustache, shape of head, etc.

How much of what we *see* in nature outside of the bacteria altogether is fallacious. In the cunjevoi, familiar member of ascidia adhering to the wharf, it is hard to *see* the vertebrate ; it is only when we find out what it *does*, watch the free-swimming vertebrate become attached and vegetate, that we realise its place in nature. How much of the *appearance* of the bacterium is not the top hat and frock coat of plenty or the dungaree of adverse circumstances. But I imagine someone thinking of the contrast between himself and the slant-eyed Chinaman. Here is morphology vindicated! But granting, as we must, that appearances in some cases are useful enough, could not anyone of us with his eyes shut tell the Chinaman by what he *does?* Admittedly the most certain way will be to use both methods.

The biochemical method attempts, by the inquiry into the chemical, physical and biological properties of organisms, to help in the separation into types or units. In this laboratory the general method is as follows :—

After having noted the usual morphological and staining properties, the organism is grown generally for a week on—

1. *Gelatin*: To test for liquefaction.
2. *Litmus Milk*: To note peptonisation or acid production or clotting.
3. *Various Carbohydrates*: To note formation of acid, or acid and gas, or no action.
4. *Peptone Water*: To test for indol.

According to circumstances fuller tests are added if they are useful—*e.g.*, agglutination reactions, immunity experiments, Vosges and Proskauer's reaction, and test for nitrates or nitrites.

Technique.—There is little to be said on this account. Gelatine is inoculated in the usual way and kept under observation for varying periods, depending on the type of organism in question. With colon bacilli the test should last a week for general purposes, but for more complete separating a month is necessary, as some colon bacilli, though roughly speaking not gelatine liquifers, are able to do so after a long while (*B. cloacæ, B. coscoroba*). The inoculation of litmus milk needs no comment, but it should be stated that though for general purposes a few days' observation is sufficient, in some cases 15 days are necessary. The observer notes acidity, alkalinity, decolorisation, peptonisation, or clotting, or any combination of these.

The carbohydrate tests form the principal part—the very backbone, so to speak, of the biochemical method. They are put up in solution or suspension in litmus-peptone water, and in each tube is a little inverted tube (Durham's) to catch any gas formed. The points noted are acid formation, or acid and gas formation. The carbohydrates, familiarly known as sugars, most frequently used can be seen by reference to tables. The most important are what we know at the laboratory as "the first five sugars"—glucose, mannit, dulcit, lactose, and cane sugar; while for special cases adonit, inosit, sorbit, and raffinose are of prime importance. This will be referred to further later on.

Of the remaining tests, the indol reaction should be tested by the benzaldehyde method, seven days being the most useful time in most cases.

There is no need to dilate on the value of the agglutination reaction in certain cases where a stock standard immune serum can be used to test a culture, or of immunity experiments on animals, seen best in the usual critical test for a suspected diphtheria culture.

Vosges and Proskauer's reaction is seldom used, and is manifested by a red colour on the addition of potash to a glucose broth culture of certain organisms.

The test for nitrites and nitrates need not be further referred to; they have as yet found slight application in this method, though it is likely further experience will show them to be useful in certain cases.

The cholera red reaction is merely the test for indol and nitrites, and is performed by the addition of sulphuric acid to a culture which, if it contains both indol and nitrites, will give a red colouration.

The Biochemical Method and the Colon Bacilli.—The biochemical method is especially useful in certain branches of bacteriology. It is the only way, for instance, of separating the vast army of colon bacilli, by which term I include all non-gelatine liquefying in seven days, Gram-negative bacilli, which grow well on agar at 37° C. in 20 hours, do not peptonise milk. This group includes such widely divergent types as *B. lactis ærogenes* (Emmerich), *B. coli communis* (Escherich), *B. pneumoniæ* (Friedlander), *B. acidi lactici* (Hueppe), *B. enteritidis* (Gaertner), *B. paratyphosus*, A and B (Schottmuller), *B. suipestifer* (Salmon), *B. enteritidis* (Morgan), *B. hog cholera* (McFadyean), *B. typhosus* (Eberth Gaffky), *B. dysenteriæ* (Flexner), *B. dysenteriæ* (Shiga), and a vast number of other types. It will be simplest if I demonstrate the biochemical method first of all on these organisms, for it is here universally admitted to be most useful.

By referring to Table I (general classification of the colon organisms) it will be seen that the first step after assuring ourselves of the morphology, staining reactions, and absence of liquefying action on gelatine of the bacillus, is to find if it is a gas-former or not. Straight away it may be said that the vast majority of the colon bacilli are gas-formers, and by some the term colon bacilli is restricted to these. I think it is a mistake to thus restrict the name colon bacilli, preferring to apply this to all the organisms as above described. The name ærogenes is a better term to apply to those which form gas as well as acid, and anærogenes to those which do not form gas. Tubes of glucose litmus peptone water in which are gas-collecting Durham's tubes are the means of testing this property (no organism yet isolated belonging to the colon group failing to give gas on glucose, gives gas on any other sugar).

Having divided the colon gro p into these two main headings we can follow McConkey's classification of the ærogenes, first splitting into those giving acid and gas on lactose (lactose ærogenes) and those which do not affect lactose (non-lactose ærogenes). The lactose ærogenes can theoretically be sp'it according to their action on mannit, but non-mannit-lactose-ærogenes are rare, if occurring at all, o we usually regard the lactose ærogenes as mannit fermenters, and classify them first of a'l into McConkey's four groups, accord'ng to their action on dulcit and saccharose, and further, if necessary (as shewn in Table III), by their action on adonit, inosit, and gelatin, an l by the Vosges and Proskauer's reaction, indol formation, and according to whether they are motile or not. This is more clearly shown on the tables.

Turning now to the non lactose ærogenes (Table II), work at present done does not enable us to draw up so clear a scheme of separation. It is convenient and practically useful to first split the groups according to the action on mannit into mannit non-lactose ærogenes and non-mannit non-lactose ærogenes. Further than this my own experience tells me that dulcit is not to be relied on as a means of differentiating this type, and Twort has stated that some of this group, usually not fermenting saccharose, can be made to ferment it. Still it can, I think, be definitely stated that if an organism does give acid and gas on saccharose under four days it is not a true Gaertner type. Therefore at present I think the scheme in the table good enough for practical purposes. It at any rate gives very useful results in my hands, and is comparable to the scheme used with the lactose ærogenes. All the non-lactose-mannit-ærogenes are classified according to this scheme by their action on saccharose into saccharose-mannit-non-lactose-ærogenes and non-saccharose-mannit-non-lactose ærogenes. Further splitting may be made by considering the action on dulcit, but, as I have suggested before, I think these organisms show inconstant reactions towards this sugar.

The other great group of the colon bacilli is the anærogene group, which do not produce gas on sugars (glucose being used as the test) (Table I). It may be divided into the oxygenes and anoxygenes, according to whether acid is produced or not, a very small number being known which produce no action on any sugar. Here, however, we will consider only the oxygene anærogenes. All these organisms produce acid on glucose (Table IB).

At present it is impossible to classify this group properly, as very little work seems to have been done on it. Its great interest lies in the fact that three of the most pathogenic organisms of the colon group lie in its confines—*B. typhosus* (Eberth Gaffky), *B. dysenteriæ* (Flexner), *B. dysenteriæ* (Shiga). For the purpose of separating these organisms mannit is the most important sugar. *B. shiga* Eyre, Kruse, etc., are all non-mannit anærogenes, whereas *B. typhosus* and *B. flexner* are mannit anærogenes.

The key to the separation of Bacillus typhosus and Bacillus dysenteriæ Flexner, are the sugars raffinose and sorbit, and the observation of the effect on litmus milk—the production or not of the indol reaction, and whether motile or not.

It will be advantageous here to briefly refer to a few practical applications of the biochemical method.

The Isolation of the Colon-like Organisms of Food Poisoning.—A large number of the cases of food poisoning are associated with the presence of colon organisms of the Gaertner type. This is a general name including a number of closely allied organisms believed to be responsible for certain acute "ptomaine" poisonings, with diarrhœa or pseudo-typhoid symptoms, which cases are sharply marked off from botulism cases, where the symptoms are mainly referable to the higher nerve centres. The first isolated of these organisms was the *Bacillus enteritidis* of Gaertner, but now the cases are known to be caused by several members of a group of organisms with very similar attributes, mostly differing only in their agglutination and immunity reactions. Such organisms as *B. enteritidis* Gaertner, *B. paratyphosus* A (Schottmuller), *B. paratyphosus* B (Schottmuller), *B. ærtrych*, *B. breslaviensis*, *B. suipestifer*, are included in this group. As shown by the inclusion of B. paratyphosus A and B, which organisms, besides being the apparent causes of cases of food-poisoning, are also associated with that elusive entity paratyphoid fever, and B. suipestifer, the second factor in the causation of the filter-passer-cum-bacillus disease, swine fever, which organism on the score of probability is almost certainly the type found in some food-poisoning cases, the group is one of wide interest, and the means of distinguishing its members from other colon bacilli becomes vitally important.

Faced with the problem of telling whether certain organisms, say isolated from a brawn, the supposed cause of some food-poisoning epidemic, are of this group, how do we proceed? First, referring to the table, we find they are ærogenes, and then rapidly we can see they are non-lactose-mannit-non-saccharose ærogenes, and as far as definitely known dulcit is fermented. However, some (suipestifer) members of this group which I possess, ferment dulcit very erratically, sometimes doing so, sometimes not. Here also the litmus milk observation is very useful, probably the most useful single test of all. All the Gaertner group produce a very slight acidity on milk, and generally, usually after the third day, become progressively more and more alkaline. B. paratyphosus A is said to give permanent acidity on milk, but it is questionable whether it does not after some weeks gradually give rise to an alkaline reaction.

With these data it is easy enough to settle the question as to whether our suspected organism is or is not of the Gaertner group. If we wish further details we may employ the agglutination and absorption methods, and determine its immunity reactions.

As a practical method of separating food-poisoning organisms of the colon type plate on bile salt lactose agar or ordinary agar, and if bile salt lactose agar be used pick off white colonies (non-lactose fermenters), or if ordinary agar pick off a dozen or so colonies at random. Sow these on lactose peptone water and throw out all acid or acid and gas formers on lactose, and investigate only the non-lactose fermenters by testing on glucose, mannit, dulcit, and cane sugar and litmus milk ; agar cultures are made and stained for morphology.

Isolation of Bacillus typhosus.—The bacillus typhosus is a mannit-oxygene anærogene. Here the procedure is first to exclude all gas formers, then to prove that the bacillus (1) gives acid on mannit ; (2) nil on dulcit, lactose, cane sugar or raffinose ; (3) acid on sorbit ; (4) slight and permanent acidity on litmus milk ;[1] (5) is motile, and (6) gives no indol reaction, and (7) of course conforms to the general characteristics of the colon group ; (8) the agglutination reaction is the final criterion as to the specific nature of the bacillus. The actual technique of plating, picking off and testing is similar, with obvious modifications, to that described for food poisoning organisms.

Isolation of Bacillus dysenteriæ (Flexner).—The procedure here is similar to that employed for the isolation of *B. typhosus*, but while *B. dysenteriæ* (Flexner) agrees exactly with *B. typhosus* on the first five sugars, glucose, mannit, dulcit, lactose and cane sugar (at any rate up to 48 hours) (1) some varieties may give some acidity on lactose and cane sugar after a more or less long period of incubation ; (2) it ferments raffinose ; (3) does not ferment sorbit ; (4) gives transient acidity followed by alkalinity on litmus milk ; (5) is non-motile ; (6) gives a positive indol reaction ; and (7) the agglutination and immunity reactions may link it to one of the standard types of the Flexner group, but there seem to be a considerable number of strains with different powers of agglutinability.

Isolation of Bacillus dysenteriæ (Shiga).—This organism belongs to the non-mannit oxygene anærogenes, and is thus sharply marked off from the typhosus Flexner group. There are several varieties whose biochemical reactions have been more or less worked out. The Shiga Kruse strain (1) gives acid on glucose ; (2) no action on mannit, dulcit, lactose, cane sugar, raffinose or sorbit ; (3) slight acid is said to be produced on erythrit, which should therefore be an important acid in differentiating it, as so few organisms affect this sugar ; (4) maltose is not fermented by the true Shiga Kruse strain, but is affected by another variety ; (5) litmus milk is turned faintly acid and later becomes alkaline ; (6) indol is not produced ; (7) the organism is non-motile.

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1 B. typhosus is, I have found, able to blue litmus milk after a long period of incubation two months about .

General Considerations as to the Usefulness of the Sugar Tests as applied to the Colon Bacilli.—The experience of observers who have had most experience in the use of the sugar tests in the way I have indicated tells in no uncertain voice in its favour ; but critics have sprung up an l objected on more or less theoretical grounds against its employment, without, I think, quite understanding the question. They say—

1. The reactions are not constant, and the number of varieties is too large, being in fact only limited by the number of sugars used.

2. The method is slow.

1. The first objection is mainly based on such theoretical work as has been done by Klotz, Twort, Penfold and myself, which undoubtedly goes to show that the fermentative properties of an organism are not constant hard and fast attributes, that, in fact, one can educate organisms and increase their capacity for fermenting carbohydrates. Working with cultures of typhoid it is quite easy to produce several different strains from the same original culture, strains that will ferment new sugars according to their education, which shortly consists in growing them for longer or shorter periods in such sugars. But, firstly, opportunity for these variations do not seem very likely to occur in nature, and in the most important cases they do not occur on points vital to the identification of these types. It seems quite certain that if we place two *identical* organisms *in identical conditions*, say upon five sugars, we will get the same results. If the reactions are different the organism is different. Whether or not the difference is permanent or great can be arrived at by more extended tests. It is only as we would expect amongst so pleomorphic a group as are the bacteria, that we find intermediate linking varieties between more stable types. The sugar reaction should be taken as a whole, and their results considered along with the data arrived at from other sources ; and although we cannot rely too much on any hard and fast tabulated scheme of separation, and although we must be prepared to find varieties of well known organisms, yet it is obvious, I take it, that a rational use of the "sugar" method, coupled when necessary with the other tests indicated, has cleared the way amidst the maze of colon bacilli, more than all the other work had since the first of the tribe was discovered.

2. As regards the time taken. After a little practice this is very small, and it is in many cases virtually impossible to identify the organisms any other way, and, moreover, the time actually occupied in working is small, and all the inoculating can be done by a reliable assistant.

TABLE I.

COLON BACILLI

- Anærogenes (No gas produced)
  - Anoxygenes — Non acid formers rarely found.
  - Oxygenes — See Table IB.
- Ærogenes (Acid gas produced) (on glucose)
  - Non-lactose ærogenes (nil on lactose) — See Table II.
  - Lactose ærogenes (Acid and gas on lactose) — See Table III.

TABLE IB.

OXYGENE ANÆROGENES

(Acid but no gas on glucose)

- Non mannit anærogenes (Nil on mannit)
  - *e.g.* Shiga, Kruse, Eyre
- Mannit anærogenes (Acid on mannit)
  - Typhosus
  - Flexner

	Typhosus	Flexner
Sorbit	Acid	Nil
Raffinose.. ..	Nil	Acid
Litmus milk ..	Slight acid ..	do. but followed by alkalinity,
Indol	Nil	Present
	Motile	Non motile

TABLE II.

Non Lactose Ærogenes

(Nil on lactose, but acid and gas on glucose)

- Non mannit non lactose
  - *e.g.*
  - Morgan's No. 1 (AG, —. —. —. —)*
- Mannit non lactose
  - Non saccharose mannit non lactose
    - *e.g.*
    - B. enteritidis Gaertner), B. paratyphosus A & B, B. suipestifer (Salmon) } (AG, AG, AG, —, —)*
    - Morgan No. 14 (AG, AG, —. —, —)*
  - Saccharose mannit non lactose
    - *e.g.*
    - Morgan No. 10 (AG, AG, AG,–, AG)*
    - Morgan No. 11

AG=Acid and Gas.

* = On glucose, mannit, dulcit, lactose, saccharose.

TABLE III.

Colon Bacilli.

Table of Lactose Fermenting Type.

	Glucose	Mannit	Dulcit	Lactose	Cane Sugar		Inosit	Adonit	Indol	V.P.	Motility	Liquefaction
Group I. ..	AG	AG	—	AG	—	Acidi Lactici Huppe		AG	+	—	+	—
						Grunthal, Vesiculosus Gasoformans, Castellus, Sulcatus		—	+	—	+	—
						Levans	—	—	—	+	+	+
						Coli mutabilis..	—	—	—	?	—	—
Group II. ..	AG	AG	AG	AG	—	Coli communis Cavicida	—	—	+	—	+	—
						Mustelæ septicus No. 36 McConkey	—	—	—	—	+	+
Group III. ..	AG	AG	AG	AG	AG	Neapolitanus		—	+	—	—	—
						Rhinoscleroma, Friedlander ..	AG	AG	—	—	—	—
						Oxytocus perniciosus	AG	AG	+	+		+
Group IV. ..	AG	AG	—	AG	AG	Lactis ærogenes	AG	AG	—?	+		—
						Capsulatus	AG	AG	—	+	—	—
						Cloacæ..	?	—	—	+	+	+
						Coscoroba	—	—	+	—	—	—

This table is not complete: only a few of the better-known types are given.

It is a shortened rearrangement of McConkey's long table in *Journ. of Hyg.*, 1909, No. 1, p. 94.

I have previously used this table to illustrate a paper, *A.M.Gaz.* In course of transcribing, several errors crept in, which are now remedied.

The Classification of Diphtheroides.—The biochemical method here should include immunity tests with a standard antitoxin. This is the surest test of the specific nature of a suspected diphtheroid organism. Opinion is divided as to the extent value of the sugar reactions for the differentiation, but from the writings of Arkwright, Graham Smith, Hiss and Zissner, and from observations in this laboratory, I am convinced of the great value of these tests. Glucose, mannit, lactose and cane sugar solutions in peptone water are used, as we find these quite satisfactory and infinitely more easy to prepare than the serum water media of Hiss. The typical reaction for true diphtheria is to produce acid on glucose and *nil* on mannit, lactose, or cane sugar. In two of our cases there was no appearance of acidity on glucose with cultures believed to be diphtheria. Hoffman's bacillus gives no acidity on any of the sugars. Various other diphtheroids ferment mannit or saccharose, and thus can be excluded with certainty. In several cases Dr. Cleland informs me he has found the sugar reactions of great value in differentiating diphtheroids from the true diphtheria bacillus. The following case illustrates the value well. Five cultures were taken from children believed to be suffering from wound diphtheria, and one from a child in the same hospital with true throat diphtheria. Diphtheroid bacilli were found in all cases. These cultures were tested on the sugars; one only gave the reactions of *B. diphtheriæ.* The others all agreed, having diphtheroid reactions, fermenting saccharose as well as glucose. The culture giving the reactions of true diphtheria was pathogenic to guineapigs and was protected against by antitoxin. One of the "diphtheroid" cultures was tested and was non-pathogenic to guineapigs.

The Biochemical Method Applied to the Classification of Other Organisms.—I had intended to refer somewhat fully to the possibility of the application of the biochemical method to the classification of other organisms, but on considering the matter I determined to conclude this paper at this point.

If I have fulfilled my intended object, which was to show how valuable are the "sugar" tests as applied to two great groups of organisms, and especially how absolutely necessary they are in the identification of members of the colon family, I am well satisfied. The amount of systematic work done in the application of the above methods to other groups of organisms, notably the streptococci, certain of the diplococci, is considerable, but hardly of such a nature as to condense into a paper of this nature. Later I hope to group together this work, together with work done by myself and my colleague, Dr. Cleland; at present I will simply conclude by saying that I believe that it will be demonstrated that the sugar reactions will prove almost, if not equally useful on several other groups of bacteria, and that in the method lies one of the greatest aids to systematic bacteriology.

2.—THE DESTRUCTION OF MOSQUITOES, FLEAS, FLIES, PEDICULI, AND OTHER INSECT CARRIERS OF DISEASE.

By J. S. PURDY, M.D., C.M. (Aberd.), D.P.H. (Camb.), F.R.S.E., F.R.G.S., Chief Health Officer for Tasmania.

THE results following crusades for the wholesale destruction of mosquitoes and the extermination of malaria at Ismailia, Khartoum, Sierra Leone, Hong Kong, Saigon, and Port Swettenham, organised by British sanatarians, have been actually excelled by the remarkable success achieved by the enthusiastic and brilliant work of members of the United States Marine and Hospital Service at Habanah, Laredo, New Orleans, and the zone of the Panama Canal. The initial campaign on a wholesale scale was that suggested by Major Ronald Ross at Ismailia in 1903, and carried out to an absolutely successful conclusion under the supervision and personal direction of Dr. Pressat, of the Suez Canal Company.

On entering the Egyptian Quarantine Service in July, 1905, one was not only interested in the problem of mosquito extermination at Ismailia, but having to do duty by night in a mosquito infested office at Port Said, was impelled for one's own comfort to attempt ridding the quarantine quarters of mosquitoes. By merely pouring petroleum on the fosse or cesspool in the rear of the offices, recognising from observation that mosquitoes, like chickens, come home, if not to roost, to breed, one speedily disproved the contention of one's continental colleagues that it was futile to destroy the larvæ of mosquitos in the basement or garden of one building unless all other persons in the neighbouring premises did likewise. After a few weeks whilst on night duty one was not troubled except by an occasional visitant from the fosse of the adjoining British Consulate, and even the Arab attendants admitted an improvement by remarking " quice kateer " (very good), instead of the somewhat philosophical ejaculation of " malish " (never mind), with which they at first heralded any suggestion to kill the " namal," a general term for all insects.

About this time Colonel H. Hamilton, I.M.S., repeated in the British Medical Journal a statement originally made in the Indian Medical Gazette :—" I know that Ismailia will at once rise to the lips of champions of mosquito brigade operations. But the chief measures were drainage and filling up pools, and if it is claimed that the improvement effected is the result of destruction of mosquitoes, then I must say that my experience going through the Suez Canal last December (1904) leads me to doubt it. Mosquitoes abounded everywhere, and particularly in the neighbourhood of Ismailia, and I was much struck by their aggressiveness during the day—no doubt Stegomyiæ—whilst at night they made sleep impossible." Major Ronald Ross was easily able to show that Colonel Hamilton's remarks were absolutely incorrect with reference to Ismailia, which as a matter of fact is a mile distant from the Suez Canal.

The official statistics of the Suez Canal Company showed that whereas in 1902 there were 1990 cases of malaria at Ismailia, the incidence fell to 37 in 1905 as a direct result of the crusade (*par une surveillance constante*) in destroying mosquitoes as soon as their presence was recognised, and by the methodical labours of the sanitary corps.

In 1906 there was not a single new case of malaria at Ismailia, and on visiting the town the Sanitary Inspector of Port Said, who was anxious to obtain some anophiles for examination, was unable to secure a single specimen.

During the controversy I pointed out in the British Medical Journal that if Colonel Hamilton had substituted " Port Said " for Ismailia his indictment would have been correct. After some private correspondence (to which I was indebted for the suggestion of utilising petroleum in mitigating the nuisance from flies in the Hedjaz Pilgrimage Quarantine Camp at El Tor in the Sinai Peninsula, where I had observed flies feeding on the fæces during an epidemic of bacillary dysentery) I met Col. Hamilton on his return from India, and was able to show him then that by similar measures to those undertaken at Ismailia, mosquitoes had also been practically abolished from the European quarter of Port Said.

To Dr. E. J. Ross, a younger brother of the distinguished Director of the Liverpool School of Tropical Medicine, is due the credit of having removed the mosquito pest from the city at the entrance to the Canal. Shortly after taking up the appointment of local Health Officer at Port Said in the Egyptian Public Health Department, this enthusiast commenced a crusade for the extermination of mosquitoes.

It was recognised that the first requisite was to arouse public interest in the project and enlist the co-operation of the officials and other residents.

Dr. Pressat delivered in French an oration at the El Dorado Theatre to the different nationalities, illustrating the scheme by the success which had followed the Ismailian campaign. At Dr. Ross's request, through the courtesy of the Editor of the Egyptian Gazette, I published in that journal a series of papers and leading articles on " The Extermination of the Mosquito." A careful survey was made of the town, a house to house inspection being carried out with a view to locating the breeding places of mosquitoes, and financial assistance to the amount of £600 was obtained from the Suez Canal Company and the Government. In a short time there was added to the many interesting sights at Port Said the procession of a native sanitary gang with their donkey cart and petroleum barrel. Every house was visited once a week and petroleum poured down the W.C., sufficient in quantity to spread over the fosse.

Stagnant pools were drained, wet cellars filled in with sand, and refuse regularly removed. Within a few months even the most sceptical were convinced, and the only people who suffered as a result of Dr. Ross's campaign were a few drapers who had no longer any sale for their stock of mosquito netting.

Equal success attended the crusade in Khartoum. The first of those model reports issued from the Wellcome Research Laboratories of the Gordon Memorial College recording the splendid work of Dr. Andrew Balfour, the Director, contains an account of the organisation of a mosquito brigade towards the end of 1903. Dr. Balfour, having classified the species of mosquitoes found in Khartoum and made a general survey of their breeding haunts, suggested to Colonel Talbot, R.E., the formation of a mosquito brigade on the lines laid down by Major Ross. Two intelligent natives were trained to recognise under the laboratory assistant mosquitoes, their eggs, larvæ and pupæ. Captain Rivers, the acting S.M.O., provided the equipment with which the mosquitoes were attacked in their larval stage. This was easily accomplished, owing to the nature of their breeding places, classed as follows :—

1. Wells, by far the most numerous and most largely infected.
2. Sakia pits, both along the river bank and in certain gardens.
3. Garden tanks, practically confined to the river front.
4. Bath waste pits.
5. Permanent garden pools, practically only found in the Palace Gardens.
6. Zeers (native water filters).
7. River pools—*i.e.*, pools left in the banks by the falling Nile.
8. Steamer holds, tanks, water-closet cisterns, and engine-rooms, also the holds of wood and other barges.
9. Chance water collections as in old "sardals" or barges drawn up on the river bank, and from which speedy evaporation was prevented.

Fortunately, in Khartoum they had not to deal with any swamps, ditches, permanent pools in the streets or near the houses, empty cans, old bottles, broken crockery, or other receptacles containing water for any length of time ; at least there were none such in the season of 1903, when the rainfall during the summer was trifling. Crude petroleum was used, not only because it was cheaper, but because comparatively little of the well water is used for drinking purposes, the native portion of the population preferring to use water direct from the Blue Nile.

Latterly, as a considerable quantity of refined petroleum had been stocked, a mixture of crude and refined was employed. The former was found to be the more efficacious (as was the case also in Port Said), as it formed a denser film and one which lasted longer.

The men constituting the brigade began every morning to visit systematically all the water collections in the town, beginning on the river front and working backwards day by day until the whole town had been explored. They were provided with wide-mouthed bottles for taking samples, and instructed how to proceed. In the afternoons, under the charge of Mr. Newlove, the men again went their rounds, the water collections were re-inspected, and any found to be infected were thoroughly oiled. In the case of wells with an average surface area of 12 to 13 square feet about one pint of crude petroleum was employed per well.

This amount was probably in excess of that actually required, but by using it a reliable film was obtained. Syringes, though good in the case of pools, were no use for wells, and it was found best to simply pour the oil straight down upon the water, which, as a rule, was found at a depth of from 25 to 30 feet.

The sheiks of the various districts had orders to see that such "trained" water was not disturbed for forty-eight hours, after which time the users were allowed to remove the oil and take the water. This length of time amply sufficed, all the larvæ and pupæ present being killed, as shown by repeated investigations.

As a matter of fact, the real lethal period was probably from about four to six hours, or even less, but it was deemed advisable to let the oil remain for a time, as it has been shown that although mosquito eggs may be laid on such oiled waters they will not undergo further development.

More recently efforts have been directed to the closing of all unused wells, while, wherever possible, covers have been fixed on those in use and pumps introduced.

For the sake of argument, Dr. Balfour, to show the benefits of treatment, takes the average number of larvæ and pupæ in infected water at one thousand, believed to err on the small side. According to the results obtained there is indicated a total destruction of 222,000 mosquitoes, granting that if left alone all the larvæ and pupæ would have reached maturity. Nor does that represent in any way the eggs which were checked in their development.

Again, say that half of the above were females capable of laying from 200 to 400 eggs apiece—a moderate computation—and it will be apparent that the ranks of the winged host have suffered enormous depletion. From Kassala, Captain Ensor, D.S.O., with whom I travelled in South Africa, reports a great improvement both as regards mosquitoes and other noxious and annoying insects which pass their larval stages in water. The introduction of sunflower cultivation is suggested at stations in the swamp regions of the White Nile. Apart from its water-absorbing capacities, the sunflower is of great value as an economic product, the oil, seeds and fibre all being useful. It has been successfully cultivated in the previously malarial stretches of the Mississippi Valley, and is known to grow well and rapidly in the Sudan. Whilst on duty on the Suez Canal I had the opportunity of meeting the medical officers accompanying the flotilla taking out the American floating dock to the Philippines, and with them, as well as their colleagues attached to the American fleet during its visit to Auckland, discussed the procedure as to mosquito extermination in Central America as contrasted with the Egyptian methods.

During the last half of the last century over 40,000 people died in Havannah from yellow fever, or one out of every ten. Colonel Gorgas stamped out the disease there in a ninety days' campaign. In America the destruction of mosquitoes was chiefly accomplished by the drainage of all areas with stagnant water, or by putting small-fry fish into pools to eat the larvæ and pupæ. The American crusade is summed up thus :—" A slap at the mosquito for the moment, kerosene for the week, ditching for a season, but reclamation for all time."

Since leaving the Egyptian service one has not had much opportunity in New Zealand or Tasmania to attempt any wholesale crusade for the extermination of mosquitoes. Fortunately in these countries, as far as I can learn, both Anophiles and Stegomyia calopus are non-existant, and no mosquito-borne diseases have to be combated. Other species, however, and their name is legion, are sufficiently objectionable and suggestive of possible danger, to encourage the adoption of any means calculated to get rid of such a pest. In the north of New Zealand and Tasmania, and in those places where mosquitoes are prevalent, the problem of mosquito extermination is not only a difficult one, owing to the rainfall being greater and more distributed throughout the year than in Egypt and the Sudan, but also the benefit to be derived from their extermination will not warrant the cost, so comparatively small is the population concerned.

One has been able, however, occasionally to rid premises for a time of mosquitoes, to recommend preparations such as citronella oil for smearing the hands and faces of those who have to sleep or work near swamps, and in other ways to mitigate the pest for individuals.

As far as Australia is concerned, now that a Laboratory for Tropical Research has been established at Townsville, it is probable that a complete classification will be made of all mosquitoes found on the Continent. It is probable also that in the future, as the great benefits of instruction in tropical medicine become more extensively appreciated, we will have lectureships on tropical medicine at each of the Medical Schools. In the meantime, in order to encourage an interest in the problem of mosquito extermination, I would suggest that the experiment of freeing each quarantine station in Australia from mosquitoes might be carried out as a means of interesting the sanitary staffs of the different States in the subject, and demonstrating the ease with which a locality can be rid of the pest when a systematic and constant crusade is made against it.

Another point which is worthy of consideration is that at the next International Quarantine Conference, Australia and New

Zealand, together with South Africa and Canada, should ask for separate official representation. It has always appeared to me as out of all proportion to the maritime interests at stake that countries like Greece, with a comparatively small tonnage as to ships, should have the same number of delegates as Great Britain and the Overseas Dominions. The great shipping interests of the Oversea Dominions, and the special requirements as to quarantine, seem to justify their having some direct say in the formulation of what are now almost universal quarantine stipulations.

One point worth discussing would be that means be taken to prevent the introduction of disease-carrying mosquitoes from centres where malaria, yellow fever and other diseases are endemic. The future opening of the Panama Canal need not necessarily increase the danger of yellow fever reaching Australia, as it has recently been shown that in certain places where Stegomyia calopus is present and yellow fever has actually been introduced, it has not spread, but it certainly justifies attention being given to such problems as mosquito extermination.

It will be necessary, by teaching hygiene in schools and creating a better appreciation of sanitary measures in those who will be our future householders, to arouse a better public sanitary conscience before any regulation such as that enforced in some American centres will be possible of adoption and application in any Australian community, unless the outbreak of an epidemic should cause an awakening to immediate action.

Thus the City Council of Laredo, Texas, in April, 1904, was forced to adopt the following, among other resolutions, before the crusade for the extermination of mosquitoes and yellow fever was successful :—" That all wells, cisterns, tanks, reservoirs, barrels, tubs, vats, pools, lakes, ponds, puddles, and other water containers holding and containing water therein, within the corporated limits of the City of Laredo, other than those in which the water therein contained is either coated and kept coated with oil or such water container screened in such manner as to prevent mosquitoes from getting therein or escaping therefrom is hereby declared a public nuisance."

Until, however, people realise that to make the tropical parts of Australia habitable with comfort for a white population, the people themselves must appreciate and apply the teachings of tropical hygiene, not only in dress, diet, clothing, temperance, and habitation, but also in protecting themselves against preventable disease and discomfort, there will be little temptation other than that which induces the more adventurous in search of fortune in fresh fields, to make a permanent home in some of the most productive parts of the northern part of the continent of Australia.

The experience of Khartoum, where even typhoid fever has been reduced to 10 cases per 50,000 of population, abundantly proves what can be accomplished by good sanitary supervision and organisation among a native population, disciplined to obedience by an efficient central and local government following the direction of a sanitarian with initiative enthusiasm and resource. It ought not, therefore, to be beyond the genius of a people, one of whose watchwords is a " White Australia," to make the settlements of its fruitful north habitable with comfort and health, and even more capable than at present of rearing a vigorous race.

With regard to fleas, which, since the report of the Indian Commission, have been definitely proved to be the intermediary in the spread of plague from rat to rat and from rat to man, the use of petroleum suggests possibilities of preventing the carriage of infection. Experience shows that even in San Francisco and Sydney, where attempts at the wholesale extermination of rats have been carried out, owing to their prolific breeding propensities, how difficult it is to extirpate rodents. Having whilst in Egypt found that kerosene was the best application to keep ants out of a kitchen, to remove bugs from old houses, and that it was effectual in killing fleas, I made enquiries as to its sphere of usefulness in combating the inroad of infected fleas into houses. Dr. Turner, Executive Medical Officer, Bombay Municipality, in a letter dated June, 1907, referring to the use on the floors of native huts of crude petroleum, to which the name of " Pesterine " has been given, says :—" We are using ' Pesterine ' freely in Bombay and killing rats. Whether it is the ' Pesterine,' the rat killing, or both, I cannot say, but this is the mildest epidemic we have had. We use ' Pesterine ' in the places after infected rats are found and plague cases occur, and also in collections of water and privies and stables."

When in May, 1907, we had two fatal cases of plague in one building in Auckland, N.Z., six tins of kerosene were used in swabbing the floors and other woodwork.

Although three years ago, when I circularised the different State Health Departments in Australia drawing attention to the use of kerosene in the destruction of fleas and other insects, it was probably merely regarded as a fad ; I was pleased on meeting Dr. Ashburton Thompson last June to learn that the properties in this respect of blue oil had been recognised by the New South Wales Health Department, more especially in connection with conservancy systems.

In Australia and New Zealand, apart from rats, the presence of fleas in houses is due to the keeping of flea-invested dogs, and in some cases, cats. With regard more especially to the former, a night spent in a Maori whare would convince anyone of this. Fleas naturally live upon the animals which they infest, or upon man, special varieties being found on different animals. The eggs laid by the fleas may fall on the floor or the carpets of houses, and, after hatching, live for an indefinite period upon the dust which accumulates under carpets, and in crevices and joints in the flooring. Thus, to rid a house of fleas, attention should first be directed to any domestic pets which should be treated by rubbing them either with kerosene mixed with three parts of some ordinary oil, such as linseed oil, to reduce the strength, or by some other pulicide. Recently Messrs. Newton Chambers & Co., of Birmingham, forwarded me two consignments of twenty gallons each of Izal and Izo-izal with the idea that I might carry out experiments on a wholesale scale for the destruction of fleas, flies and other insects, similar to some which I carried out at the Quarantine Island of Motuhihi and Rangitoto, Auckland, N.Z.[1]

Mr. Wynter Blyth, writing of fleas and disinfectants in the Indian Medical Gazette, March, 1908, speaking of the need for a reliable substance which will combine good disinfecting properties with a high insecticidal value, states that Dr. Hossack claims that phenyle in the strength of 1 in 500 fulfils all the requisites of a good pulicide in that it paralyses the flea in a few seconds. Dr. H. M. Crake, in "Plague in Calcutta," 1906, claims that the best solution for practical use appears to be izal. In my opinion petroleum is the best.

Mr. Wynter Blyth's series of experiments showed that petroleum both light and crude, purisine, crephol and izo-izal were the best pulicides, and that the last named also had a carbolic acid coefficient of ten. In a report issued by the United States Marine Hospital Service, July, 1910, Maurice Mitzmain makes a classification of the potency of the different substances suggested for destroying fleas. With kerosene (full strength) applied to fleas there was no movement in 10 to 20 seconds ; dead in 30 seconds. No other substance gave such rapid and certain results. This has been my experience since I first in Egypt used to demonstrate, by pouring kerosene into a test tube, pouring it out, and then dropping in a flea or fly, the almost instantaneously lethal effect of kerosene.

I have found, however, that for ridding animals, such as dogs, from fleas, izo-izal is almost equally efficacious, and being also a disinfectant and not liable to lose its virtue so rapidly by evaporation, has a sphere of usefulness where kerosene has its limitations for practical use. Where it is not advisable to prolong the use of kerosene in houses after carpets and furniture have been replaced, owing to the odour, one can use a ten per cent. solution of creolin, cyllin, izal, cofectant, phenyle, kerol, or in fact any of the now well-known disinfectants of the higher phenol series. Although all these disinfectants are boomed as the "one and only efficient," as a matter of fact the firms with established reputations, such as Little, McDougall, Quibell, Cook, Jeyes, and Cooper, all put such effective preparations on the market that it is unfair, or savours of commercialism, to single one out for special mention.

Schools can be kept free of fleas by using sawdust saturated with such disinfectants sprinkled on the floors, and a weekly scrubbing, using water in which a disinfectant has been dissolved. Sprinkling animals with pyrethrum powder will also keep fleas away from them. The most rational means, however, of keeping fleas from houses is to flood them with sunlight.

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[1] Recorded in *Journ. Royal Sanitary Inst.*, 1909.

Mr. H. Nicholls of Hobart, who has made a special study of fleas, tells me that even fleas, which have no visible eyes, are extremely sensitive to light. The two fleas which in temperate climates cause the most annoyance are the human flea, *Pulex irritans*, and the dog flea, *Ctenocephalus canis*. *Pulex cheopis*, which is the flea which has generally carried the Bacillus pestis, has well developed eyes and shuns the light. Thus we see that sunlight is not only Nature's most powerful germicide, but also pulicide. Surely in sunny Australia more advantage might be taken of this in as far as possible insisting that there be no narrow culs de sac or dark flea-breeding haunts, more especially in the vicinity of the wharves of our chief ports.

With regard to bugs, which are of interest in so far as that the bed-bug at least has come under the ban of the epidemiologist as the carrier of the spirillium of relapsing fever ; at the Mt. Eden Gaol, Auckland, N.Z., at one of the receiving cells we were able to get rid of these pests by swabbing out with kerosene. An interesting observation with regard to these insects was made in a house in Auckland, where I had occasion to cut through seven layers of wall paper, namely, that between the fourth and fifth layer there were numbers of bugs.

This habit of living behind old wall papers may account for the failure which recently attended an attempt to kill these insects by fumigation with cyanide in a house in Hobart. Stripping and spraying with izo-izal, however, was successful.

Another interesting point which came under our notice was that on the successful extermination of cockroaches by a preparation made by Mr. Pruden of Tauranga, N.Z., on some old ships, bugs came more into evidence. As a matter of fact, Inspector Franklin of the New Zealand Health Department, after exterminating cockroaches at the Tararua Old Men's Home at the Thames had to reintroduce cockroaches to keep down the bugs. In any effort to exterminate a pest by introducing some other natural enemy of the pest, one must consider not only the immediate effect, but also the remote contingency of the natural enemy also changing its habits as a result of change of environment.

Thus although starlings were introduced into Tasmania to keep down various pests, they are now one of the biggest fruit pests we have. I have noticed, however, that possibly owing to the existence of insectivorous birds, such as swallows and martins in Tasmania, it is possible here to grow cabbage, cauliflower, and other vegetables without their becoming fly-infected or blown, an experience which one could only avoid by special treatment in Auckland, N.Z.

In this respect I recommended the experiment of introducing swallows and sand martins into New Zealand at Tauranga Experimental Farm. Certainly the multiplication and encouragement of fly catchers is of special benefit, as experience showed at Motuihi.

With regard to flies, after trying various means of destroying *Mus. domestica*, the common house-fly, and other varieties, I have come to the conclusion that the best and most rational means to prevent this pest is the observance of cleanliness, both inside and outside all places of habitation. The prompt removal and cremation of all organic refuse from kitchens, together with the regular removal, more especially of stable manure, their favourite breeding habitat, would greatly mitigate the fly nuisance in the summer months.

Experiments we carried out in 1908 in Auckland, N.Z., on the breeding habits of flies by placing pieces of meat, which had been exposed to flies, in fine meshed cages, showed that although maggots prefer earth as a congenial media for the larval or pupal stage of development, still it is possible whenever the temperature reaches 60°F. actually to breed flies in the meat itself, which ultimately has the appearance of being honeycombed. Although it has been shown that flies as carriers of typhoid more especially may transfer pathogenic germs on their feet, mandibles, and other parts of their bodies, yet it is now recognised that the chief danger from flies is due to their method of feeding. The fly defaecates on an average twice a day, but as Dr. Grahame, in a report to the L.G.B., England, shows, it vomits much more frequently. Before taking food, of which it can imbibe sufficient in a few seconds to last almost as many days, it exudes a fluid, dissolves the food, and then fills its crop or stomach. It is in this way that food becomes infected by flies which have had access to typhoid stools or tubercular sputum, the organisms having actually been recovered from the fæces and stomach within two to seven days after contact.

As a matter of fact, the fly is really cleanly in its person, because it has to be clean, and to remove at once foreign matter from its body, as otherwise the breeding apertures in its body become clogged and it dies. Often the cleaning of the fly's body is at our expense, as also is its method of walking with filthy feet over food after feeding on fæces. The ease with which its breathing mechanism is deranged, however, is illustrated by the almost instantaneous effect of the slightest film of kerosene applied to the fly's body, an effect resulting perhaps as much from the closing of the pores of the skin to the escape of the vitiated air, as to the closing of the breathing tubes to inspiration.

In 1908 my attention was drawn to a plague of flies which congregated so thickly on the Rangitoto wharf, Auckland, as to make the lower surface of the structure black. Advantage was taken of a visit of some Parliamentarians to Motuihi to demonstrate the effects of kerosene as a fly exterminator. Inspector Grieve, of the Health Department, spent an hour syringing the wharf with kerosene. The bottom of the boat from which he operated was over an inch deep with dead flies, and except in places where the kerosene had not reached, the flies disappeared. Last year by invitation I attempted the wholesale destruction of flies at the saleyards at Otahuhu. First we tried fumigation with formalin of the kitchen attached to the restaurant, and after two hours found that fumigation had practically no effect. We certainly found that spraying with kerosene of places where flies congregated, and later of heaps of offal and manure at the public abattoirs was fatal to flies, but speedily realised that petroleum for practical purposes, due to the fact that its effect only lasts for twelve hours owing to evaporation, had its limitations. There is one sphere of usefulness, however, for petroleum, and that is that the sprinkling of earth over which kerosene had been poured was shown by Mr. Symons, of the N.Z. Health Department, to act perfectly in keeping flies away from nightsoil pans. Even in this respect, however, I have found that it is better to have all privies made either fly-proof or to see that each pan accurately fits beneath the seat, and that the latter has an automatically self-closing lid.

It is interesting to note, however, that the United States Marine Hospital Service, in their special reports on privies and hookworm disease, advocate the use of water with petroleum in pans as being superior to the use of disinfectants, lime, and all other substances recommended.

Another point which I have abundantly proved is that the keeping of fowls where stable manure is stored is one of the best means of keeping down fiies, as the fowls feed on the larvæ. Six fowls to each horse is now recommended as a means of preventing the nuisance from flies wherever there are stables. Formalin in solution 1 in 10 one finds absolutely useless in houses unless one prevents the flies having access to all other liquids and also adds sugar, when it is very effective. As a matter of fact the mere closing of a room for three days in the absence of any water is sufficient to kill flies.

Powdered petroleum shale we have not found to be fatal to flies like the powder of pyrethrium or the ground pollen of plants of the composite class, or cofectant powder, which kills them by preventing them walking on a glass pane or other smooth surface. The sticky papers, such as tanglefoot, are perhaps as effective as any other means for keeping down the nuisance in houses, short of screening, and may be recommended as a prescription with shotgun effects.

They are especially useful for making records as to numbers to show, as we demonstrated in Auckland, that when the mean temperature reaches 60° F. flies begin to become more plentiful, and as records in Auckland and more recent experiences in Tasmania show, it is when flies are most numerous that typhoid and intestinal diseases are most prevalent.

The protection of food from flies is a new demand of modern civilisation, and comes within the regulations under the more recent Food and Drugs Acts of the Australian States. The following letter from the Secretary of the largest butchering firm in Auckland in answer to a communication *re* the effect of introducing screening from flies is of interest, in showing how an enterprising firm recognises that it pays to protect their produce from flies :—

Sir,—" In reply to your favour of the 15th instant *re* the screening of our shop, Dominion Road. We find that it has turned out a great success, the public have appreciated the change, and in consequence the cash trade has considerably increased. We found the meat kept better, also a great saving in handling, not nearly so much trimming being required, as the "blows" from flies were fewer. We also found a great saving in ice, as under the old system of keeping meat in the ice chest during the summer months made the constant opening to take out joints as required very expensive. As regards ventilation, we do not find that the screens interfere to any great extent, but at the same time, as the electric system extends here, we shall instal fans ; at present it would be too expensive. We are so satisfied that the idea is a good one, that we are screening all our suburban shops, and already have ten shops finished in the same style as the one you remember in the Dominion Road.

" We are, etc.,

Auckland, N.Z., " R. & W. Hellaby, Ltd.

29th Nov., 1910. " F. Wing, Secretary."

I have also found in Launceston, Tasmania, that not only the public, but also the butchers, appreciate the improvement.

With regard to *Pediculi capitis*, everyone is familiar with the fact that petroleum is now recognised as an efficient remedy for the removal of nits.

It is interesting to note that Dr. Isabel Ormiston, Medical Inspector of Schools, Tasmania, finds that every case of impetigo contagiosa which she has investigated has had this condition of pediculi associated therewith.

A recent report from Dr. Hamer, Medical Officer to the London County Council, shows that there has been some association between outbreaks of scarlet fever in common lodging houses with the occupation of beds infested with vermin.

Although we have no " Cleansing of Persons Act " in Australia or New Zealand, yet we cannot claim after the reports of the examination of school children to be free from the disgusting infection of children with vermin.

In an examination of the children attending one of the schools in the city of Auckland, the worst case of scabies (itch) I came across was in a child living almost next door to the Health Department.

The provision of school nurses and women health visitors, as is intended in Tasmania, if adopted in the other parts of Australasia ought to remove the conditions which occasionally, although fortunately rarely, allow the continuance of the spread of vermin among children. Some people, unfortunately, look upon a bath as a form of torture, but magistrates might inflict this punishment on some of the casual occupants of receiving cells, and if at the same time the clothing was sterilised there would be fewer vermin to start a fresh cycle among that small class in our cities " who toil not, neither do they spin," yet being human carriers of insect carriers of disease are not only a drag economically on the community, but also occasionally if not actually a source of danger, and always a nuisance.

3.—SOME NOTES ON SCHOOL CONSTRUCTION.

Dr. REUTER E. ROTH, D.S.O.

During the last few years, in my capacity as Chief Medical Inspector to the Department of Public Instruction, I have had many opportunities of visiting schools. It is easy to criticise; it is difficult to originate.

The school site should be most carefully chosen. It can never be too large, as later it may be used as a recreation reserve for children. It should be situated opposite a public reserve or park, in order that it can have plenty of light and air and be free from dust and noise. If the above is not possible, it is better to have the site surrounded by back streets in preference to a frontage on a main street or road, where a nuisance will be caused by noise and dust as the result of traffic, besides the danger to the children from trams and other vehicles. It should be levelled, otherwise it is not a playground. Many schools have sloping grounds, which are a constant source of danger. It speaks well for the care taken by the teachers that so few accidents happen. I am of opinion that the asphalted playground is the most suitable of all. It can be readily kept clean, and, if properly levelled, dries very rapidly. It allows of the playing of lawn tennis, basket ball, hockey, and other suitable games. The turfed, gravelled or clay grounds are always unsuitable. They are never clean, and are always most unsatisfactory after wet weather; wounds caused by falling on the asphalt are less troublesome than those caused on gravel; in the former case little foreign matter gets in. Instead of the usual shelter-shed, which is generally improperly used as a class-room, it would be better to have an 8 ft. verandah on two sides of the playground; this would provide shelter from rain and sun during playtime, and would also during wet weather shelter those going to the out offices. In front of these covered verandahs flower beds could be established. I would also advocate the planting of good shade trees, *e.g.*, plane trees, especially in front of the school building, to help to strain off the street dust and minimise noise. To prevent accidents, all corners of the school building should have a 3 or 4 ft. trellis projecting about 4 ft. outwards.

I am of opinion that the buildings so far erected are not always suitable; they are very expensive, and there always appears a difficulty in expanding the building to meet a larger enrolment of children. Sometimes we find three separate buildings, one for infants, one for girls, and a third for boys. This causes a difficulty where it is necessary only to increase the accommodation for one, two or three departments. At other times one department is wedged in between the two other, so that it is impossible to increase the accommodation of one department without interfering with the others. This is modified to a certain extent by co-education, where there is one department common to boys and girls, with a separate one for infants. There is no doubt that this latter system is the better. The infants' department should always be connected with a primary school. This arrangement allows of the infants having the protection of their bigger brothers and sisters in going to school. Such separate buildings must materially add to the cost of construction. In other cases we find a big frontage to the street and the premises are increased by building wings at right angles; this encroaches on and decreases the size of the playground, and there is always a waste of space. In order to make allowance for good light to the classrooms in the new wings, it is necessary that they are built some distance away from the sides of the school boundary. It would be impossible to build up to the alignment unless there is a street or lane, in which case there would be a nuisance caused by dust and the noise of traffic.

The building should be as far as possible from the street, and so constructed that the departments in the school and in the playgrounds can be made quite distinct. Allowance should be made that the building can be started in the shape of the letter "I" running parallel with the street some distance away; then it can be expanded by converting the "I" into a "T," and later on into an "H." This would safeguard the light and minimise the encroachment on the playground, besides separating the boys and girls in the playground. Such additions will not interfere with the lighting and ventilation of the existing class rooms. The planning of the room should be simple. It should be oblong in shape, with the sides in the proportion of 6-5. Every child should have an allowance of 15 square feet; the average in this State is 10 square feet. This is much too little, considering the very mild climate. The number in the class should be limited to 30. It is the opinion of up-to-date educationalists that it is impossible to teach and supervise more than 30 children; such a number would require a superficial area of 450 square feet, the teacher would require another 15 feet, and 15 feet could be allowed for the space taken up by the furniture; this would total 480 square feet, and remembering the proportion of 6-5, would represent a room 24 feet in length and 20 feet in breadth. As every child requires 200 cubic feet of air space, this will give the height of the room as 13 feet. The above proportions are most suitable for light and sound.

Great attention is now given to the cleaning of the classrooms. Elsewhere I have pointed out that more stress should be laid on the prevention of dust entering and collecting in the school. Most of the dust is introduced by the children in wet weather when they enter with the feet and footwear covered with mud. It is pitiable to see outside every school entrance a mud-scraper; it looks so lonely and neglected. There is no reason why the main and other entrances should not be grated over for about 12 feet with movable gratings in handy sections, and have shallow trays underneath. The youngsters would enjoy the noise of scraping the feet over the grating, and much mud and dust would be collected in the underlying trays and would form a very suitable fertiliser for the school garden. I would also recommend that the first four or five steps on every staircase near an entrance should have a grating for the tread, and a tray underneath to pull out. The ordinary fibre and wire mats are utterly useless; the former soon become saturated with the mud and decompose, whilst the latter clog and wear out rapidly.

For the prevention of dust accumulating and to facilitate its removal the flooring boards should be tongued and grooved. In many of the older schools there are crevices between the floorboards, in which great quantities of dust collect. Although the floors are well washed and swept, clouds of dust arise, being displaced as the result of the vibration caused by the children's movements in marching in and out, etc. A rounded insertion should form the junction between the wainscot and the floor. All presses, doors and window frames should be built well into the walls, so that there will be no ledges projecting for the collection of dust. The walls should be smooth; plaster of Paris appears very suitable for the purpose. All maps and diagrams should be mounted on spring rollers under a sloping roof; wood picture rails for the insertion of nails could be let into the plaster. Fireplaces are not necessary; they are useless, unpractical and expensive. The ordinary school fireplace roasts those in the vicinity and causes currents of cold air. It is said that 89 per cent. of the heat is lost in an open fireplace. They cause unnecessary dirt, consume fuel extravagantly, and are a source of danger to the skirts of women and girls. It would be more economical and effective to have stoves with a long flue. Placed in a corner they would be out of danger and would take up a minimum of space. The ventilation of the classroom must be thorough; to be so it must be a system of thorough through or cross ventilation, and this is only possible where there are windows on both sides. There is much doubt as to the efficiency of the ventilators adopted at present. I have tested many of the ceiling and wall ventilators and found them not working. Sometimes one believes they are simply made to please the eye. Many people because they see a ventilator are quite satisfied, however stuffy and smelly the room may be. Where windows are on one side it is impossible to think that air currents will be so obliging as to come in by one window and curl round out of the adjoining one. By diffusion and change of temperature a certain amount of ventilation can be effected, but it is very limited in its results. The most satisfactory is cross ventilation and that can only be brought about by having windows facing each other. It would be necessary to have the building so constructed, either with a series of rooms with a corridor having a lower elevation, to permit air to pass over, across, or better still to have a series of rooms on either side of a central corridor, the latter having windows on both sides opening into the classrooms. All windows should be built as close up to the ceiling as possible; the top sash should be at least four inches shorter than its frame when locked. To prevent it closing at the top the sides could be blocked for the last four inches. This would ensure the free entrance and exit of air where windows faced each other. It is doubtful whether the box window is not the best of all.

Other systems have the disadvantage that they cannot be properly shaded, a great necessity here where we have so much bright sunshine; they are also more liable to get out of order. The sill should be protected by a wood, metal, or glass hopper, which would direct air currents upwards and well off the children's heads. Such a hopper is a great improvement on the "Hinckes-Bird" system.

The lighting of the room in this part of the world should never be artificial during the day time. It has been estimated that the illuminating surface should be at least one-fifth of the floor space. In an ideal classroom for 30 children this would equal 96 square feet. The panes should be as large as possible and should never be frosted or coloured; both these conditions interfere with the light. In most schools the walls are decorated with pretty pictures, which have a pleasant effect on the children. Physiological diagrams with the awful coloured pictures of the effects of alcohol on the stomach and liver, illustrations of our Australian snakes, wall cards on temperance, etc., can never be of any benefit except to give wrong impressions. A window with a pleasant outlook is always a pleasing distraction to the eyes. For this reason windows should not be too high up; a window with the sill only four feet from the ground would be most beneficial. Wire guards are generally fixed outside to protect the windows. One head-master assured me that the only windows that were damaged were those with wire guards. Because there is a guard most children are anxious to know whether they are effective, just as one likes to assure one's self that the notice "wet paint" is correct. The school child can be taught that it is no more necessary to protect the school windows than it is to protect the windows of a private house. The wire guards also tend to affect the sight. The lighting of the classroom should be equal from left to right, and no shadows will ensue. Next best is from the left, then from the right, but never from the front or back. Blinds regulate the amount of light to enter the classroom. If there is much light and the blind is lowered it cuts off the source of most light, which is from the upper part of the window. If lowered to its full extent too much light is cut off; if lowered to within a foot or so of the window ledge, horizontal rays enter, which are very irritating to the eyes of the teachers and pupils. To remedy this I have suggested spring roller-blinds reversed. Glazed holland of a dark green or blue is a most suitable material for blinds. Venetians are very dusty, soon get out of order, and fatigue all astigmatic eyes. Blinds interfere with the full entrance of air. If the air does enter, the blind is blown out of position and does not act as a shade. I would do away with all blinds and substitute light screens of some green or blue material, to be hinged on to one or both sides of the window. Where these have been adopted they are most effective. All infant departments should be on the ground floor. This saves the fatigue of going up, and the danger of falling down stairs, besides being more easy of egress in case of panic. Where there is an upper storey attention should be paid to the staircases. There should be at least two, and they should be fireproof and walled in. The rises should not be more than six inches, and the treads should be of some suitable material that is noiseless, will not wear out readily, and not become slippery. I have had experience of iron, stone, wood, and compositions such as ironite, etc. The iron is noisy and becomes polished and slippery, the wood and stone wear out very rapidly; the ironite is noisy, chips, and becomes very slippery and dangerous. A tread of asphalt nosed with hardwood is undoubtedly the best; it gives a good, firm, fairly noiseless tread, is never slippery, and when wearing out can be easily repaired.

The teacher is only human, and requires some amount of rest and comfort during the dinner hour. In Greece, Roumania and Hungary I noticed that the Superior Schools had well-furnished reception rooms for the use of the staff. I do not think it would be amiss to have such rooms for the use of the teaching staff in all schools. To add to the comfort it would be well to have a fixed washstand or sink and a gas ring. When a child feels poorly it has either to rest in the shelter-shed or in some shady spot in the playground. It would be advisable to have a room with a couch or two set apart for such cases.

The sanitary arrangements are an important factor in school hygiene, and also have a moral effect on the children. Where the out-offices are dark and improperly constructed the moral tone becomes lowered. This rarely happens with up-to-date structures. It is very important to choose a suitable site in the beginning. The out-offices should take up the two far corners of the playground, one for girls and the other for boys; the approach to each other would be by the verandah suggested. The infants should have their offices built midway between, or be divided amongst the girls and boys. By utilising 30 feet off each side of the corner there is enough room for twelve w.c's. and twelve washbasins, and the urinals would accommodate about 36; this would be suitable for a school with about 1,000 boys. Part of the structure could have shower baths fixed up. Where possible separate pan water-closets should be provided. The present trough system uses up too much water, is constantly choked up, and teaches dirty habits. The automatic self-flushing closet tends to make the users forgetful. The urinals should consist of some composition such as ironite, there should be no joins, and the extremities of the urinals should be rounded off. The wall should incline backwards; this is better for flushing. In ordinary flushing one often notices the water to fall vertically in front of the wall, where the latter slopes backwards the running water comes in better contact. To prevent the boys crowding there should be at intervals a partition of one inch piping let into the wall, bent over, and then let into the ground. If this piping were connected with the water supply, and each vertical portion had a form of sprinkler attached a very effective flushing would ensue. For the girls every w.c. should be provided with a door 4 ft. high and 1 ft. from the ground, and should be provided with an inside bolt near the top, so that a teacher can easily reach the bolt from above in case the doors have been locked by children creeping underneath. It must also be remembered that infants require lower and smaller pans and lower lavatory basins.

In conclusion I would like to point out the importance of having sanitary paper supplied to all schools. Some time ago when I made suggestions in connection with the out-offices, I was asked did I expect that the schools should be supplied with such elaborate lavatories as are found at the Central Railway Station and other places. I am sure you will agree with me that too much cannot be done for the health and welfare of our school children.

4.—A RAPID METHOD OF DETERMINING THE PROBABILITY OF DECOMPOSITION OCCURRING IN A SEWAGE EFFLUENT.

By EDWARD S. STOKES, M.B., Ch.M., D.P.H., Medical Officer, Metropolitan Board of Water Supply and Sewerage, Sydney, N.S.W.

At the present day the usual method of determining the putrescibility of sewage effluents is the application of the Incubation Test. This test, however, as applied varies so much in details that it becomes a matter of difficulty to compare the results obtained by one worker with those of another. The incubator test appears to have been first used in 1895 by Scudder, who determined the oxygen absorbed from cold acid permanganate in three minutes before and after an incubation period of five to six days at 75°F. Later, Scudder included the determination of dissolved oxygen and nitrates before and after incubation.

A simpler form of incubator test than the above consists in merely noting the appearance and smell of the liquid after incubation. If the sediment has become dark-coloured from the formation of sulphide of iron, the smell is invariably putrid, whereas, if it remains brownish red, the liquid is usually quite inoffensive. McGowan found that these two tests ran for the most part together in the case of land effluents.

Barwise carries out the incubator test by determining the oxygen absorbed in three minutes before and after incubating at 80°F. for a week. He makes no suggestion with reference to determination or influence of nitrites. He apparently follows the practice laid down at the Manchester inquiry in 1899.

The Committee of the American Public Health Association, appointed to report on Standard Methods of Water Analysis in 1905, lays down the following procedure :—

" Determinations are made of the dissolved oxygen, nitrogen as nitrites and nitrates, and the oxygen consumed by digestion in an acid solution with potassium permanganate at room temperature for a period of three minutes. After the sample has been incubated for 24 hours or more at 37°C., observations are made as to the appearance of the sample, *i.e.*, whether it has turned black or not, and particular attention is given to the presence or absence of well-defined odours of putrefaction. Samples, which, after incubation, are black in appearance and which possess foul odours, may be unquestionably regarded as putrescible without making any further tests. Samples, which, at the end of the incubation period still contain an appreciable quantity of dissolved oxygen or oxygen available from the nitrates, and are free from sulphuretted hydrogen or other odours resulting from putrefaction, may be generally regarded with safety as non-putrescible. Samples in which dissolved oxygen and nitrogen in the form of nitrates are absent or nearly so, with more or less nitrogen in the form of nitrites, and in which the oxygen consumed in three minutes is increased on incubation, require more careful consideration before regarding definitely the result of the putrescibility test. The best procedures by which any additional information can be obtained appear to vary under different local conditions as to character of sewage treated, method of treatment, season of the year, etc., and it seems inadvisable now to specify in precise terms further procedures for use under all circumstances. As the applicability of this test is studied in various laboratories, it is recommended that reports set forth procedures by which conclusions have been arrived at with reference to putrescibility."

Stoddart, Dunbar and Thumm determine putrefaction by the presence of sulphuretted hydrogen. Adeney carried out the test by mixing the effluent with water from the stream into which it is proposed to discharge the same, in the proportion of their relative flows.

An exhaustive study of the whole subject of putrescibility has recently been made by Johnson, Copeland, and Kimberly.[1] These investigators endeavour to find a relation between the putrescibility or stability of an effluent and its chemical analysis, particularly the oxygen consumed figures on one hand representing oxidizable material and the available oxygen in the form of free oxygen, nitrates and nitrites on the other hand. The data required in establishing such a relation are :—(1) The available oxygen in the form of free oxygen, nitrates and nitrites, and (2) the consumed

1 *Journal Infectious Diseases*, 1906, Sept. II., p.80.

oxygen, this being taken as one-fifth of the oxygen consumed value as determined by the five-minute boiling method.

With these data the following provisional criteria of putrescibility were found to hold for the experiments in question :—(1) When the consumed oxygen value was equal to or in excess of dissolved oxygen figure, and there are no nitrates and nitrites present, the sample will putrefy. (2) When the consumed oxygen value is equal to or slightly less than the amount of oxygen in the effluent in the form of nitrates, nitrites and dissolved oxygen, the sample may or may not putrefy. (3) When the consumed oxygen value is less than the oxygen contained in the effluent in the form of nitrates and nitrites, under ordinary conditions the sample will not putrefy.

It may be noted that these investigators determined putrefaction by the presence of sulphuretted hydrogen or other odours as revealed by smell. Further reference to this paper will be made later.

More recently (1906) the use of methylene blue has been introduced by Spitta and Weldert as an indicator of putrefaction. This substance is an extremely sensitive indicator for sulphuretted hydrogen and other reducing bodies, being discolourised at once in the presence of even small traces. The test is made by adding one c.c. of a ·1 per cent. solution to theeffluent in a glass-stoppered bottle. The sample is then incubated. The blue colour of the solution remains practically un hanged until the available oxygen used in it is used up and putrefactive conditions arise. At this point, the dye is reduced and discolourised. Phelps and Winslow found[1] that, if the incubation temperature were 37°C., a positive result could be obtained in half the time that would be occupied were the samples kept at 20°C.

It must be obvious that all incubator tests suffer from a common disadvantage, viz., the time occupied in the test. It frequently happens that a report on a sewage effluent is required without delay, and it is my object in this communication to indicate how it may be possible to arrive at a conclusion as to the probability or otherwise of decomposition occurring in a given effluent from data which are afforded by ordinary analysis. The first point to decide was what evidence could be accepted as to the existence of putrefaction. Early in the inquiry the Manchester method was followed, samples, however, being incubated at 37°C. No notice was taken of the nitrates or nitrites in the incubated sample. It was soon found, however, that the results were both unsatisfactory and apparently contradictory. Samples, which obviously did not decompose so far as such condition could be determined by appearance and smell, showed a high degree of putrescibility by the oxygen absorbed in three minutes reading. On investigating this point, I found

1 *Journal Infectious Diseases*, 1907, Spt. III., page 1.

that the increase in oxygen absorbed could be accounted for by an increase in the amount of nitrites which occurred during incubation. I was, therefore, compelled to put this test aside, and I subsequently employed the methylene blue test. This test has proved satisfactory, and, for the past three years, with me has given results concordant with the smell test. In carrying out the oxygen absorbed test, I make use of a weak permanganate solution (1 c.c. contains .1 milligram of oxygen) and permit the sample to remain at room temperature. The results so obtained do not vary substantially from those which would follow if the test were made as recommended at 80°F.

In the following table I give the results of 108 samples of final effluents which have been tested in the routine way in my laboratory. Each is a composite sample made up of nine separate samples taken over a period of 24 hours. Series A and C are from installations comprising open septic tanks and contact beds. Series B are from closed septic tanks and sand filter beds worked on an intermittent downward filtration system. In the table I have shown (i.) the amount of oxygen in nitrites and nitrates; (ii.) the oxygen absorbed in four hours; (iii.), the figures obtained by dividing the former by the latter, which figures I have termed, for convenience sake, "decomposition factors," and also (iv.) the result of the incubation test. The figures in this and other tables represent parts per hundred thousand.

Of the 108 samples, 11 were found to have decomposed, and in all of these the decomposition factor was fess than ·7. Seven samples gave a factor of less than ·7, and of those three decomposed, two less than ·6 and one decomposed, six less than ·5 and three decomposed, four less than ·4 and all decomposed. Sample C34, which gave a decomposition factor of ·28 and yet failed to decompose, calls for some comment. This sample was taken immediately after very heavy rain, and was found to contain an undue amount of finely-divided suspended matter, which had apparently been washed through from the tanks. This matter, which is the organic residue resulting from decomposition in a tank and is somewhat of the nature of humus, does not undergo offensive decomposition, but still has the power of absorbing oxygen from permanganate. Under these circumstances I feel justified in classifying this sample in Table II. as having a factor between ·6 and ·7, which in all probability would represent the actual truth were the above matter not contained in it. It will be noted that I have presented no figures for dissolved oxygen in these samples, the conditions under which they were collected precluding the possibility of making any significant estimation of this element.

TABLE I.

No.	Oxygen. In Nitrites.	Oxygen. In Nitrates.	Oxygen. Total.	Oxygen Absorbed in 4 hours.	Decomposition Factor.	Incubated Test with Methylene Blue.
A 1	·02	2·85	2·87	·40	7·20	N.D.
2	·02	·55	·57	·71	·80	,,
3	·07	·81	·88	1·27	·69	D
4	·03	·25	·28	1·30	·22	D
5	·07	1·58	1·65	·72	2·29	N.D.
6	·09	·96	1·05	1·07	1·00	,,
7	·12	4·90	5·02	1·10	4·56	,,
8	·03	4·90	4·93	·43	11·47	,,
9	·01	1·45	1·46	·42	3·48	,,
10	·08	2·60	2·68	·55	4·87	,,
11	·05	2·43	2·48	·50	4·96	,,
12	·07	2·25	2·32	·54	4·30	,,
13	·03	3·66	3·69	·48	7·70	,,
14	·03	5·07	5·10	·19	26·81	,,
15	·03	2·02	2·05	·51	4·00	,,
16	·04	·40	·44	·81	·55	D
17	·02	1·53	1·55	·76	2·04	N.D.
18	·03	4·25	4·28	·74	5·78	,,
19	·05	7·40	7·45	·47	15·85	,,
20	·05	·68	·73	1·00	·73	,,
21	·03	1·37	1·40	·73	1·92	,,
22	·05	6·32	6·37	·32	19·73	,,
23	·15	5·90	6·05	·86	7·04	,,
24	·05	3·08	3·13	·31	10·10	,,
25	·02	·92	·94	·53	1·77	,,
26	·02	1·17	1·19	·58	2·06	,,
27	·03	2·82	2·85	·54	5·28	,,
28	·05	2·21	2·26	·54	4·19	,,
29	·05	1·29	1·34	·82	1·63	,,
30	·02	·95	·97	·65	1·50	,,
31	·12	1·06	1·18	·59	2·00	,,
32	·05	·76	·81	1·03	·79	,,
33	·03	3·10	3·13	·73	4·28	,,
34	·02	·76	·78	·69	1·13	,,
35	·02	·37	·39	·37	1·06	,,
36	·03	1·40	1·43	·39	3·67	,,
B 1	·03	2·86	2·89	·43	6·72	N.D.
2	·02	1·89	1·91	·33	5·80	,,
3	·36	1·66	2·02	·45	4·48	,,
4	·03	1·69	1·72	·49	3·51	,,
5	·06	1·40	1·46	·52	2·82	,,
6	·02	1·36	1·38	·55	2·51	,,
7	·05	2·75	2·80	·55	5·10	,,
8	·02	1·29	1·31	·64	2·05	,,
9	·03	1·04	1·07	·86	1·24	,,
10	·04	1·66	1·70	·61	2·78	,,
11	·01	·46	·47	·38	1·24	,,
12	·07	2·90	2·97	·38	7·80	,,
13	·02	1·71	1·73	·56	3·10	,,
14	.10	1·03	1·13	·65	1·70	,,
15	.03	1·93	1·96	·65	3·00	,,
16	.06	·18	·24	·88	·27	D
17	.09	6·48	6·57	·66	9·95	N.D.

TABLE I.—(*Continued*)

No.	Oxygen.			Oxygen Absorbed in 4 hours.	Decomposition Factor.	Incubated Test with Methylene Blue.
	In Nitrites.	In Nitrates.	Total.			
B 18	·02	·69	·71	·79	·90	N.D.
19	·05	·12	·17	·71	·24	D
20	·10	2·70	2·80	·60	4·66	N.D.
21	·02	1·26	1·28	·63	2·03	,,
22	·05	1·20	1·25	·72	1·74	,,
23	·01	·31	·32	·58	·55	,,
24	0	·28	·28	·85	·33	D
25	·03	·37	·40	·62	·65	N.D.
26	·05	·46	·51	·75	·68	,,
27	·02	·31	·33	·52	·63	,,
28	0	·40	·40	·53	·76	,,
29	·02	·32	·34	·56	2·40	,,
30	·02	1·52	1·54	·48	3·21	,,
31	0	·57	·57	·47	1·21	,,
32	·14	·37	·51	1·26	·41	,,
33	0	·37	·37	·80	·46	D
34	·02	·29	·31	·63	·49	N.D.
35	·05	·57	·62	1·05	·49	D
36	·21	·23	·44	1·10	·40	D
C 1	·19	·48	·67	1·11	·60	D
2	·19	3·35	3·54	1·35	2·62	N.D.
3	·69	5·10	5·79	·60	9·82	,,
4	·14	·48	·62	1·33	·47	,,
5	·05	1·53	1·58	·75	2·11	,,
6	·20	7·10	7·30	·48	15·20	,,
7	·09	6·58	6·67	·68	9·80	,,
8	·07	2·85	2·92	·91	3·21	,,
9	·04	4·92	4·96	·71	7·00	,,
10	·03	5·50	5·53	·48	11·52	,,
11	·07	5·00	5·07	·34	14·93	,,
12	·07	4·25	4·32	·57	7·60	,,
13	·03	·57	·60	·84	·72	,,
14	·02	4·44	4·44	·66	6·72	,,
15	·02	4·28	4·30	·53	8·11	,,
16	·02	6·43	6·45	·48	13·45	,,
17	·13	9·10	9·23	·70	13·20	,,
18	·04	9·00	9·04	·63	14·35	,,
19	·05	9·55	9·60	·68	14·05	,,
20	·01	4·86	4·87	·50	9·74	,,
21	·03	8·55	8·58	·50	17·16	,,
22	·04	9·42	9·46	·48	19·70	,,
23	·02	8·85	8·87	·41	21·65	,,
24	·07	2·57	2·64	·66	4·00	,,
25	·02	1·25	1·27	·92	1·38	,,
26	·04	4·37	4·41	·63	7·00	,,
27	·02	·75	·77	·70	1·10	,,
28	·05	7·05	7·10	·51	13·95	,,
29	·05	·92	·97	·88	1·12	,,
30	·07	6·10	6·17	·54	11·40	,,
31	·04	4·57	4·61	·90	5·12	,,
32	·04	2·60	2·64	·74	3·56	,,
33	·02	1·25	1·27	·69	1·87	,,
34	·05	·26	·31	1·10	·28	,,
35	·07	1·66	1·73	·86	2·00	,,
36	·20	·46	·66	·97	·68	D

TABLE II.

SUMMARY OF RESULTS GIVEN IN TABLE I.

Decomposition Factor.	No. of Samples.	No. Decomposed.
1.0 and over	83	0
Over ·9 and under 1·0	1	0
,, ·8 ,, ·9	1	0
,, ·7 ,, ·8	4	0
,, ·6 ,, ·7	7	3
,, ·5 ,, ·6	2	1
,, ·4 ,, ·5	6	3
,, ·3 ,, ·4	1	1
,, ·2 ,, ·3	3	3

The conclusions that one would be justified in drawing from the above statement of facts are that, if the decomposition factor is below ·4, the sample will decompose, but if it be above ·7 this condition will not occur. Between these figures the chances are that above 50 per cent. of the samples will go. Of course I cannot claim that these figures will hold for all effluents, because the dissolved oxygen is not taken into consideration in my analysis, and undoubtedly the amount of this will vary, *e.g.*, it is found to be greater in effluents from percolating than from contact beds.

In order to see whether a better indication of the probability of decomposition could be obtained from a review of the absolute amounts either of oxygen absorbed or of oxidized nitrogen considered separately rather than from the ratio between the two, I have compiled the following tables. One shows the influence of oxygen in nitrites and nitrates and the other oxygen absorbed.

TABLE III.

Oxygen Absorbed.	No. of Samples.	No. Decomposed.
1·0 and over	13	5
Over ·9 and under 1·0	4	1
,, ·8 ,, ·9	10	4
,, ·7 ,, ·8	15	1
,, ·6 ,, ·7	19	0
,, ·5 ,, ·6	23	0
,, ·4 ,, ·5	15	0
,, ·3 ,, ·4	8	0
,, ·2 ,, ·3	0	0
,, ·1 ,, ·2	1	0

TABLE IV.

Oxygen in Nitrites and Nitrates.	No. of Samples.	No. Decomposed.
1·0 and over	74	0
Over ·9 and under 1·0	3	0
,, ·8 ,, ·9	2	1
,, ·7 ,, ·8	4	0
,, ·6 ,, ·7	5	3
,, ·5 ,, ·6	4	0
,, ·4 ,, ·5	5	2
,, ·3 ,, ·4	7	1
,, ·2 ,, ·3	3	3
,, ·1 ,, ·2	1	1

With regard to the second (Table IV), when the amount of oxygen was below ·3 all four samples decomposed, and when above ·9 none (77) went. Between these there were 20 samples, of which seven decomposed, but the intermediate series presented great irregularities.

The relation between oxygen absorbed and decomposition (Table III) showed similar irregularities. When the amount was less than ·7 no decomposition occurred (66 samples). Between ·7 and 1·0, 6 out of 29 samples went, and above 1·0, 5 out of 13. Further, the samples with the highest figures (C2 and C4, 1.35 and 1·33 respectively) did not decompose, while others with much lower figures, *e.g.*, B35 and B36 (1·05 and 1·10) went the opposite way.

Whilst, therefore, one may broadly say that the probability of decomposition is inversely proportional to the amount of oxygen in nitrites and nitrates and directly to the oxygen absorbed figures, still a much closer approximation of this chance may be made by estimating the ratio between these two factors.

Reference has been made above to a paper by Johnston and others. Those authors take the oxygen absorbed in three minutes at 80°F. as a basis of calculation, but they arrive at this by doing a boiling-for-five-minutes' test and by dividing the result by 5. They consider this as giving substantially the same figure as the ordinary three-minute test, but consider it better inasmuch as the influence of such substances as nitrites is minimised thereby. Their third conclusion states that when the consumed oxygen value is less than the oxygen in nitrites and nitrates, under ordinary conditions, the sample will not putrefy.

In the following table I have shown the relation between these two factors in 105 samples of 108 dealt with above. The three-minute oxygen absorbed test was made in the usual way.

TABLE V.

No.	A Oxygen in Nitrites and Nitrates	A Oxygen Absorb'd in 3 min.	A Ratio.	B Oxygen in Nitrites and Nitrates	B Oxygen Absorb'd in 3 min.	B Ratio.	C Oxygen in Nitrites and Nitrates	C Oxygen Absorb'd in 3 min.	C Ratio.
1	2·87	·10	28·70	2·89	·09	32·11	·67	.68	.99†
2	·57	—	—	1·91	—	—	3·54	—	
3	·88	·46	1·92†	2·02	·15	13·35	5·79	·16	36·20
4	·28	·43	·64†	1·72	·14	12·43	·62	·36	1·75
5	1·65	·22	7·50	1·46	·13	11·27	1·58	·24	6·58
6	1·05	·34	3·12	1·38	·16	8·62	7·30	·13	56·20
7	5·05	·21	23·90	2·80	·16	17·50	6·67	·21	31·80
8	4·93	·10	49·30	1·31	·19	6·90	2·92	·25	11·70
9	1·46	·23	6·35	1·07	·26	4·12	4·96	·21	23·60
10	2·68	·17	15·75	1·70	·19	8·95	5·53	·14	39·60
11	2·48	·15	16·55	·47	·12	3·92	5·07	·08	63·40
12	2·32	·16	14·50	2·97	·09	33·00	4·32	·17	25·50
13	3·69	·16	23·10	1·73	·19	9·10	·60	·26	2·30
14	5·10	·05	102·00	1·13	·18	6·28	4·44	·16	27·70
15	2·05	·16	12·80	1·96	·20	9·80	4·30	·14	30·70
16	·44	·28	1·57†	·24	·28	·85†	6·45	·12	53·70
17	1·55	·23	6·75	6·57	·17	38·70	9·23	·18	51·20
18	4·28	·23	18·60	·71	·25	2·84	9·04	·23	39·40
19	7·45	·15	49·60	·17	·20	·85†	9·60	·20	48·00
20	·73	·30	2·43	2·80	·16	17·50	4·87	·11	44·30
21	1·40	·23	6·10	1·28	·19	6·73	8·58	·14	61·30
22	6·37	·11	57·90	1·25	·26	4·80	9·46	·14	67·50
23	6·05	·22	27·50	·32	·20	1·60	8·87	·15	59·30
24	3·13	·10	31·30	·28	·30	·93†	2·64	·20	13·20
25	·94	·16	5·87	·40	·21	1·90	1·27	·28	4·54
26	1·19	·17	7·00	·51	·24	2·12	4·41	·18	24·50
27	2·85	·17	16·75	·33	·16	2·06	·77	·23	3·35
28	2·26	·16	14·15	·40	·16	2·42	7·10	·13	54·60
29	1·34	·24	5·60	·37	·19	1·95	·97	·30	3·23
30	·97	·19	5·10	1·54	·15	10·27	6·17	·16	38·60
31	1·18	·16	7·37	·57	·17	3·35	4·61	·26	17·70
32	·81	·32	2·53	·51	·29	1·26	2·64	·22	12·00
33	3·13	·22	14·25	·37	·24	1·54†	1·27	·20	6·35
34	·78	·20	3·90	·31	·17	1·82	·31	·30	1·03
35	·39	·11	3·55	·62	·33	1·87†	1·73	·26	6·65
36	1·43	·13	11·00	·44	·28	1·52†	·66	·25	2·64†

† Decomposed.

TABLE VI.

Ratio.	No. of Samples.	No. Decomposed.
3 and over	80	0
Over 2 and under 3	8	1
,, 1 ,, 2	12	5
Under 1	5	5

In all cases when the ratio was under 1 every sample decomposed, this being in accordance with Johnston and others' conclusion. They, however, do not state a converse, but leave one to infer that if the ratio is over 1 the samples will be stable. This does not seem to be so, for 5 out of 12 with a ratio between 1 and 2 decomposed. With a ratio of 3 andover none of the samples went.

Table VII shows the relation between the absolute amounts of oxygen absorbed in three minutes and decomposition. When the amount was over .4 all samples (three) decomposed ; when less than .2 none (56) went. Between these extremes 9 out of 46 decomposed.

Table VII.

Oxygen Absorbed in 3 min.	No. of Samples.	No. Decomposed.
Under ·1	4	0
,, ·2 and over ·1	52	0
,, ·3 ,, ·2	38	6
,, ·4 ,, ·3	8	2
,, ·5 ,, ·4	2	2
,, ·7 ,, ·5	1	1

In conclusion, then, I submit that a very fair idea may be obtained as to the probability of decomposition occurring in a sewage effluent by calculating the ratio between the oxygen absorbed and the oxygen in nitrites and nitrates. This is a matter of a few minutes only, and can be worked out by the following formula :—

Decomposition factor=N (as N_2O_3) x 1·71+N (as N_2O_5) x 2·86 ÷ oxygen absorbed in 4 hours.

I do not think that, as a general rule, an effluent could be satisfactory unless this factor exceeds ·7, because if nitrification be low the probabilities are that dissolved oxygen will also be low, both conditions resulting from insufficient aeration of the beds. Below this figure the chances of decomposition are great and continue to increase as the ratio falls, but above it apparently lies safety.

5—.ON THE ORIGIN OF SULPHURETTED HYDROGEN AND SULPHIDE OF IRON IN BRACKISH LAGOONS.

By Dr. H. G. CHAPMAN.

Abstract.

From many brackish creeks and lagoons on the coast of New South Wales sulphuretted hydrogen is given off more or less continuously, and at times in large quantities. If a small amount of the mud at the bottom of such brackish waters be added to sterilised sea water the evolution of sulphuretted hydrogen begins in a few hours at a suitable temperature. From such muds certain bacteria are readily separated which grow freely at summer temperature.

If sterilised sea water be inoculated with these bacteria, sulphuretted hydrogen may be given off in small quantities, but when organic matter or a salt of ammonia is added to the sea water much greater amounts of sulphuretted hydrogen are given off. This evolution of sulphuretted hydrogen may continue until the whole of the sulphates in the sea water has disappeared.

Should the soakage waters or streams entering the brackish creeks or lagoons contain flocculi of oxide of iron, then sulphide of iron is formed with the sulphuretted hydrogen set free by the bacterial action. The sulphide of iron settles into the mud at the bottom of the creek or lagoon and the accumulation of such sulphide of iron in the mud produces the black colour which is so frequently found in the muds in these creeks and lagoons.

6.—SCHOOL ANTHROPOMETRICS: THE IMPORTANCE OF AUSTRALASIAN MEASUREMENTS CONFORMING TO THE SCHEDULE OF THE BRITISH ANTHROPOMETRIC COMMITTEE, 1908.

By Dr. MARY BOOTH, B.A., M.B., C.M. (Edin.).

Anthropometry has for its object the exact measurement of the anatomical, physiological and psychological characters of man; for example, his height and weight, eye and hair colours, vision and hearing, and mental attributes such as attention and memory. It takes into count the facts of his heredity and the kind and the quality of the factors of his environment; for example, race, food, clothing, climate, sleep, duration and time of work. It is the physical basis of the enquiry as to whether heredity or environment is the more potent influence in his mental and physical development—that is the determination of the relation of man to his environment and of the laws of human evolution. The scientist values the enquiry as advancing his knowledge of man. The social economist is beginning to appreciate it for certain practical advantages which he anticipates to the race; to him the collection of anthropometric data means a stock-taking of the physical fitness of the nation and an estimate of the heredity and environmental factors at work on the whole or sections of society.

Anthropometry had its beginning in the measurement of the proportions of the human body for the purposes of art. In the ancient civilisations of Egypt and Greece certain ideal standards of physical beauty were formulated. Down to the 16th and 17th centuries of the Christian era it still held the artist. He measured that he might portray with truth—and, by the way, added considerably to the exact knowledge of man—*e.g.*, the measurements of the facial line and angle. The greatest amount of work at this period, however, was done in anthropology and the scientific study of man. The student was engaged, as one has said of him, digging in the scrap heaps of the past to unravel his racial origin. Later he searched the same field zealously to discover human origins and affinities. The 18th century especially was prolific in the study of man's relations to the ape.

In the 19th century the special feature of physical anthropometry has been its application to the study of the living. The study of man became quantitative as well as qualitative, and henceforth the science was to have a higher value and greater significance. The artist and anatomist found a new claimant in the field with different ends in view, viz., the eugenist. The artist had studied to know man as he is, the anthropologist what he is and has been racially. The anthropomist measures him physiologically and psychologically and anatomically. The eugenist, in conformity with modern thought that science has its highest sanction when it is of service to man, makes use of the data of anthropometry for his study of what the race may become.

During the last half-century physical anthropometry has received much attention for several different reasons—scientific, hygienic, and educational. In science it was owing to the impetus given to scientific enquiry by the work of Darwin, in hygiene, owing to the greater value placed on human life and the consideration required of every factor that could even remotely affect it; in education, owing more particularly to the conception of moulding the physical destiny. The work of Ling of Sweden in founding a school of physical culture on anatomical and physiological principles appealed to the trained teacher, and its results had to be checked by accurate measurement. Further, the apparent ease with which anatomical measurements could be made as compared for instance with physiological, tempted observers of every kind and degree, there being no necessity for long periods of training to acquire skill or extensive laboratory equipment.

The enquiry animated by such varied interests naturally had a wide range.

In the domain of scientific research, Quetelet, of Belgium, sought to find the typical in man irrespective of race and environment. He is recognised also as being the earliest to give improved mathematical expression to his results.

The racial differentiation attracted many on account of its anthropological interest—an enquiry which is to-day taking on a new value in the study of the problem of race culture. Virchow in Germany examined 6,000,000 children as to their eye and hair colour ; Beddoe in England made extensive studies in pigmentation. Both drew up standard colour schemes.

In the interests of education and hygiene the standardisation of physical efficiency, especially from records of height and weight, was undertaken on a large scale. In England in 1875 the "average standard" of the British Anthropometric Committee was established, and in America a standard for colleges and universities founded on measurements taken in accordance with the schedule of the American Association for the Advancement of Physical

Culture. Among the best known series of the latter are records of Bowditch of Boston and MacDonald of Washington.

A further development from the hygienic aspect was the enquiry into the physique of groups of the population according to environment, comparisons being made between rural and urban, manufacturing and agricultural, professional and artisan classes. An enquiry of this kind was begun, Haddon says, as early as 1834 by Villerme, who also examined the physique of children in coal mines.

Special mention should be made of the first state of health of school children. Warner examined 1,000,000 school children. In his book on the study of children, which was the text-book on the subject for many years; he insisted on the necessity of obtaining exact physical records.

The foregoing series of measurements are classic. Within the past ten years the investigations have multiplied enormously and the comparisons been extended. Among the more important in the British Empire have been—

(1) The Report on the Physical Condition of Glasgow School Children, by Dr. W. Leslie Mackenzie and Captain Foster, who analysed the records of the height and weight of over 72,000 children, and investigated the relation of their physical condition to their housing conditions, *i.e.*, according as there were children living in one, two, three, or four-roomed houses.

(2) The Report of the London County Council on the Examination of 20,000 children.

(3) A series, small, but significant for us, since they have been made in Australia. The first systematic survey of Australian children was made in 1901 on Sydney boys and girls and reported to the congress of this Association at Hobart in 1902—an experimental and suggestive survey. More recently observations have been made in connection with medical inspection in some of the States.

It will be seen from the above series of measurements how much attention has been paid during recent years to the anthropometry of childhood or school anthropometrics. It is natural that this should be so in what has been called "The Century of the Child." Every phase of him from the prenatal period (teratology) through infancy, childhood and adolescence to adult life has been the subject of special study, in the physiological, psychological and anthropometrical aspects. The progress on the physiological side has been sound and thoroughly scientific, as from its nature it can only be pursued in a laboratory and by the specially-trained expert. The psychology of childhood has engaged earnest thinkers and become the basis of the newer educational method. The pseudo-scientist has been abroad, however, and brought much of the work into disrepute. There is to-day a healthy reaction against him in favour of extended experimental research. Physical anthropometry on the other hand has not made the sound progress that physiology and psychology have done, or found the same practical issue. In the past an immense amount of material has been amassed, but the value of it in adding to our knowledge of the development of the child has not been commensurate with the effort expended. For this there have been several reasons—

(1) The inherent difficulties in deciding upon the kind and quantity of the data to be collected and the method of collection.

(2) Inadequate treatment of the data collected.

(3) The quality of the work frequently suffered from the observer having given the subject no preliminary study and bringing pre-conceptions and biassed judgment to bear on his enquiry.

Such preliminary groping has not been, in a sense, wasted effort, since it has helped to reveal the deficiencies in the material and its treatment judged according to modern anthropological and statistical requirements. It has advanced us to a better understanding of what are the essential requirements in determining the relative importance of heredity and environment on the mental and physical fitness of the child. Environment has had for long an almost exclusive following as the chief factor, and much of modern hygiene has been developed in a firm belief in its potency. Quite recently, however, the school of thinkers, beginning with Galton and continued by Karl Pearson and the rigid statistical methods of the Eugenics Laboratory, have made strong claims for the investigation of heredity as a primary factor.

The essentials of a profitable anthropometric enquiry would seem to be—

(1) Careful selection of data appropriate to the enquiry and the needs of the statistician, *i.e.*, of (*a*) physical facts, (*b*) environmental factors, hygienic, economic, and social ; (*c*) racial origin of at least parents and grandparents.

(2) Accurate and uniform method of collection according to an accredited standard.

(3) Treatment accorded to modern statistical method.

As showing the importance of the first essential, namely, careful selection of data, one cannot do better than take the recent memoir of the Eugenics Laboratory of London University, by David Heron on "The Influence of Defective Physique and Unfavourable Environment on the Intelligence of School Children."

He approaches his problem by some observations on what is essential for arriving at the truth. He says that enquiries as to origin of parents, and observations on eye and hair colour, must accompany the records of height, weight and chest measurements. He points out that if a number of children attending a school in a poor neighbourhood are found to be much under the average height and weight it may be the result of environment, or it may equally be a racial difference ; further enquiry may show different hair and eye colours and a poor-class Irish or Italian community. He says also that the environment itself may be racially selected, attracting an inferior population. Again, given uniformity of race an inferior environment may be the centre to which the mentally and physically inferior parent naturally gravitates. As a further illustration he says it is misleading to compare children so racially different to one another as Devonshire or Lancashire children or to compare either with the British " average standard " based upon measurements taken all over England. He maintains that these considerations are of supreme importance to the hygienist and educationist alike, and urges that the services of social workers should be enlisted into the anthropometric enquiry.

Methods of Anthropology.—The widespread conviction that standardisation to uniformity of the many recognised methods of collecting anthropometric data had become necessary led recently to two important results :—

(1) The international agreement at Monaco, 1906, on standards for head measurements.

(2) The appointment by the B.A.A.S. in 1903 of a special committee to enquire into the state of anthropology in the British Isles. Professor Cunningham, of Edinburgh, was chairman, and with him were associated Haddon, of Cambridge ; Waterston, of the King's College, London ; Dr. Sadlier and Dr. Kerr, and J. Grey of the Royal Anthropological Institute of London. After five years' enquiry on sectional committees, they testified to the value of the science and prepared a schedule of standard measurements. The committee, as such, came to an end, and a new committee with much the same personelle was formed for the purpose of furthering the introduction of anthropometry into schools and colleges. A full report is given in the Proceedings of the B.A.A.S., Dublin, 1908. The schedule is issued in pamphlet form by the Royal Anthropological Institute, with illustrations.

The schedule does not differ from recognised standards in such measurements as height, weight, and head, but it has fixed methods for testing the more variable and difficult characters, such as the colour of the hair and eyes. One important feature has been the selection of the points for chest measurements at the level of the junction of the fourth costal cartilege with the sternum and the recommendation that calliper measurements of diameters should be taken. This will be welcomed by any observer who has experienced the difficulty of making chest measurements and obtaining results which could be comparable to the observations of others. The reasons for this decision are given in full in the report of the proceedings for 1907.

If Australasian work in the future is to have any scientific value or give results of practical use to the nation, it is incumbent on observers throughout the Commonwealth and New Zealand to adhere to this British standard of 1908.

(3) Adequate treatment of anthropometric data has become possible by reason of the greater analytic efficiency of modern

statistics. One need only refer to the important work being carried on by the Galton School.

Subjecting data to rigid statistical analysis, such as is being undertaken in the Eugenics Laboratory, is producing some surprising and illuminating results. For instance, the figures of the Glasgow enquiry, have been dealt with. These had showed that boys who lived in one-roomed houses were 11.4 lb. lighter and 4.7 inches shorter than boys in four-roomed houses. Similarly girls were 14 lb. lighter and 5.3 inches shorter. When these figures were corrected, the differences showed a much smaller range, namely, 5.5 lb. lighter, 2.4 inches shorter for boys, and 5.4 lb., 2.2 inches for girls.

The realisation of these facts should save us in Australia from hasty generalisations and fallacious deductions from imperfect data or methods such as are not unknown on the strength of our very small Australian contributions to anthropometry. For instance, in the Sydney survey of children, 1901, of 2,000 children between 5 and 15 years of age certain differences from the average standards of Europe and America were found, especially in smaller chest measurements. At the time neither observer who made the measurements nor statistician who collated them, claimed that this difference would be found in all Australian or even all Sydney children. They did say, however, that such an indication should be confirmed or disproved by further investigation. But the statement has been made repeatedly, and is commonly accepted as a fact, that the Sydney boy has a chest measurement $3\frac{1}{4}$ inches less than the British boy. Again, in an investigation made recently in another State on 1,000 children, rather better measurements than those of New South Wales were found. It was at once inferred that New South Wales must have an inefficient system of physical culture. New South Wales, however, had in a sense invited the unfavourable criticism by concluding that because the figures in her latest enquiry (1909) into the chest measurements of 2,000 boys showed better results than those of seven years previously, that the difference was due to improved breathing exercises. In both cases the numbers were too few to base conclusions on, and there is no proof that the methods adopted were uniform. Such an important question cannot be left unsettled. One might take to heart the example of Germany when she felt herself slandered, as Haddon tells in his History of Anthropology that during the siege of Paris some shells shattered part of the Natural History Museum, and Quatrefarges in his bitterness of feeling said the Germans were not Teutons at all, but Huns and Mongol invaders, and therefore barbarian and without love or appreciation of science. Germany ordered an official census into the colour of hair and eyes of 6,000,000 school children, which Virchow himself supervised, and completely repudiated the calumny.

The extent of any anthropometric survey must be determined largely by the means available for carrying it out, but to be of any use at all, it should include observations of height, weight and chest ; hair and eye colours ; place or origin of parents and grandparents, and environmental factors. The question arises, Are all these equally important and profitable in Australia ? It is not possible at this stage to affirm that they are or are not ; we must experiment for ourselves and ascertain the values. In any case we cannot, in the light of recent research, go on comparing ourselves with British or other standards, and deduce any differences favourable or unfavourable to ourselves as we have done in the past. It is in the future that probably any efforts in this direction of anthropometric enquiry will bear fruit. Australia is in a particularly well-favoured position for making very valuable contributions to the development of child-study.

The adoption of the British Standard, 1908, for Australia and New Zealand, would give us data comparable with the data of other countries. In time we should be able to compare ourselves with the stock from which we have sprung, to judge the influence (if any) of climate and other environmental factors on the race, by comparing the sub-tropical North Australia with the south of the continent or Tasmania. In other words to recognise the modifications (if any) which the new environment or Anglo-Celtic mixture of our population is producing. The problem of settling the Northern Territory is particularly inviting to an anthropometric survey, and can only be adequately solved by demonstrating how far the white race can control an unfavourable environment.

As regards the means of carrying out this enquiry it would seem most practicable to include it in the Medical Inspection Schemes of the States and for the examination of cadets for compulsory service under the Defence Scheme. In schools much of the work can be delegated to the teachers if care is taken to instruct them in the need for accuracy, and to stimulate their interest by showing them a practical use for measurements of heights and weights as giving opportunities for problems in arithmetic and for graph work to their pupils. The provision of good standards of colour will enable them to record pigmentation of hair and eyes. Information as to the number of generations a family has been in Australia as collected in Sydney in 1901 and extended in Victoria in 1910 can be best obtained by the plan adopted in some American schools of sending printed circulars to the parents with appropriate questions as to origin of parents, grandparents and environment.

The method of enlisting the services of the teacher will not involve any great loss of time or interference with school routine, —an aspect which the educational authority has to consider when any incursion into a school is imposed—and has the advantage of increasing their knowledge of the child's home environment.

It is necessary that medical inspection shall be extended to all children and not confined to those that have obvious pathological signs. The primary object of medical inspection is finding out the pathological states, but only a shortsighted policy will not confine it to such narrow limits. An enquiry that does not embrace the normal child permits the education authority through ignorance or partial knowledge to perpetuate educational schemes and mental and physical tests that will give results that are poor or worthless or even harmful. Hygiene has to-day shouldered the responsibility of guiding educational thought on questions of physical development of the child ; it must continue to see that the views taken are wide and deep enough. As an example of how little is really known of a matter of deep educational and national concern, take the annual rate of growth for school-children, and the variations found to exist at certain ages. No special study has been made and there are no facts established yet for Australia. It is, however, of primary importance from the physiological and psychological point of view that education should be modified to meet this condition of physiology working at high pressure. To give examples of other lines along which investigations have already been made in addition to those previously mentioned, namely, Heron's "Influence of Defective Physique and Unfavourable Home Environment on the Intelligence of School-children," and the Effect of Housing on the Physique of Children, we may quote the enquiry into the physique of children born in a year of heavy infant mortality ; the influence of parental alcoholism on the physique and intelligence of the offspring ; the influence of parental occupation and the home conditions on the physique of the offspring. Such enquiries, even when they give negative results, are valuable, as Heron says, by marking of lines of no thoroughfare.

From what has been said it will be realised how far-reaching are the possibilities of systematic measurement of children in determining the laws of human evolution—a knowledge of which, as it is stated in the British Anthropometric Committee's report, is of the highest importance to rulers, statesmen, and all authorities interested in social reform.

In Australia we have special opportunities and responsibilities to ourselves and to science in regard to a national survey. We are an old race in a new land, removed from the near neighbourhood of Teuton and Norman cousins to that of oriental races. We are a land given to hasty experimental social legislation. We have acquired responsibility for a Northern Territory full of new and untried problems, upon the solution of which depends our power to keep our continent our own. We must use every method science puts into our hands, and guide the national destiny by counsels based on our investigations.

We should begin by at once undertaking a survey of Australian children with due regard to social, environmental factors and heredity. Such an enquiry can have only a partial value unless it conforms to the standard of the British Anthropometric Committee.

"Much care and expense," says Dr. Kerr, of the London County Council, "is involved in the recording and analysis of vitality statistics concerning those whose lives have ceased. The vitality statistics of those who are about to enter on active service and the affairs of life, and whose energy is the chief of the national assets, is surely worth the cost of collection."

DISCUSSION UPON THE DISSEMINATION OF TUBERCULOSIS

IN HIS OPENING ADDRESS

Sir PHILIP SYDNEY JONES, M.D., said:—

THE importance of this subject could not well be exaggerated, tuberculosis being the most widespread, the most disabling and the most fatal of all diseases to which man and animals are subject. He thought that the purpose of the discussion would be best served if he mentioned in brief outline (time would not permit him to do more) (*a*) the conditions which determine the production of tuberculosis, (*b*) the sources from which the infective germ—the tubercle bacillus—is derived, (*c*) the paths of infection or channels through which the germ enters the body of man and animals, and finally (*d*) the preventive measures which these considerations suggest. He hoped that those who followed him would take up and elaborate such of the points as may seem to them desirable. First, then, as to the conditions which give rise to tuberculosis—the factors which determine its occurrence. They are at least three—the implantation of the bacillus, the susceptibility of the individual, and the environment. These factors may be conveniently spoken of as the seed, the soil, and the surroundings. It is true, of course, that the presence of the bacillus tuberculosis is the essential factor—where there is no tubercle bacillus there is no tuberculosis—but the other two factors are of almost equal importance. It is possible that a large dose of very virulent tubercle bacilli alone may give rise to an attack of tuberculosis, but in the large majority of cases there can, I think, be no doubt that the other two factors are present also. Just as in the growth of any plant there must be the proper seed, the suitable soil, and the appropriate environment—the sun, the rain and the wind—so in the production of tuberculosis there must be the specific bacillus, the favourable soil, and the appropriate surroundings. A few words must be said on each of these factors.

The bacillus of tubercle is a microscopic vegetable growth which has no habitat outside the bodies of men and animals. It never arises *de novo*, but is always derived from some pre-existing case of tuberculosis. Freely exposed to direct sunlight its vitality is quickly destroyed, but in a dark, dirty, badly-ventilated room, especially if the air of the apartment is tainted with the exhalations of a number of persons, it may retain its vitality for weeks and even months. The sources from which tubercle bacilli may be derived are the expectoration, the droplets ejected in coughing or sneezing, the fluids of the mouth, and the fœces of the consumptive, the urine in cases of tuberculosis of the urinary tract, the discharges from tuberculous abscesses and sores, and finally and next in importance to the sputum, the milk of tuberculous cows and the flesh of tuberculous cattle. The bovine type of the bacillus tuberculosis differs from the human in some respects, but it has frequently been found in the tubercular lesions of children.

The paths of infection or channels by which the bacillus enters the system are heredity and inoculation, the respiratory tract and the alimentary tract. Heredity a d inoculation need not detain us, they are so uncommon. A child born with tuberculosis is an exceedingly rare event, and inoculation in the human being is an accidental circumstance. The important thing to remember is that practically there are but two portals—the respiratory and the alimentary. The bacilli are in the air we breathe or in the food which we consume. Although the evidence in favour of the entry of the bacilli by the intestinal tract is much stronger than it was some years ago, I am still one of those who believe that in by far the larger number of cases, at any rate in the adult, they find access to the body through the respiratory passages.

We pass now to the second factor in the causation of tuberculosis, namely the susceptibility of the individual, the condition of the soil upon which the seed falls. This susceptibility or lack of resisting power may be local or constitutional. The local circumstances which predispose are those catarrhal conditions of the mucous lining of the air passages which are found in measles, whooping-cough, pneumonia, influenza and in repeated colds. The presence of the micro-organisms of these diseases renders the soil fertile to the growth of tubercle bacilli. It is this fact which accounts for the firmly fixed popular belief that consumption is caused by neglected colds. Repeated colds do not of themselves give rise to consumption, but they so affect the mucosa of the respiratory tract that the bacillus of tuberculosis when deposited upon it finds a suitable soil and grows luxuriantly in consequence. Another local condition which makes an individual susceptible, is mechanical injury of the mucous membrane of the air passages, as seen in stonemasons, steel filers, rockchoppers, all of whom are highly predisposed to tuberculosis of the lungs.

The constitutional conditions which render man susceptible are any of those diseases or habits which lower the general tone and diminish resisting power; convalescence from acute diseases, especially the exanthemata, poor and insufficient food, alcoholism, syphilis, diabetes, dissipation, exhausting pursuits, insufficient exercise and above all, the occupation of dwellings and workshops into which fresh air and sunlight are not freely admitted. Consumption has been well called the "house disease." Then there is an inherited constitutional susceptibility in some cases. None of us believe that tubercle bacilli are inherited, but there can be no question that some persons are born with a constitutional tendency to tuberculosis.

The third factor in the causation of tuberculosis is the environment. If this be healthy, the vitality of the bacillus of tubercle is lowered or even destroyed, and under such a condition hundreds of bacilli may fall upon the lungs or come in contact with the intestinal mucous membrane without producing any ill effect. The seed finding nothing in its environment to favour its growth, perishes. When the opposite conditions prevail, when the surroundings are unhealthy, and especially when the atmosphere is tainted by the exhalations from the lungs and skins of a large number of people in a confined space, or even by those of one person breathing the same air for hours together, as, for instance, in a small bedroom with closed doors and windows, then the vitality of any bacilli of tubercle which may be present, is preserved, and should they enter the respiratory or alimentary passages of a susceptible person, will take root and grow. Darkness, dampness, an impure subsoil, and dirt also constitute an environment which is exceedingly favourable to the life and growth of the bacillus.

It follows from what has just been said that to prevent the spread of tuberculosis we must endeavour to secure three things: (1) An atmosphere free from the bacilli of tubercle; (2) an invigoration of the body which will enable it to resist infection; and (3) a healthy environment. These three things must be done if we are to make a successful fight against tuberculosis. All the measures of prevention which are or should be employed have one or all of these objects in view. Time will not permit me even to enumerate them all, but I may say that for the individual consumptive the most important preventive measures which he should observe are: (1) Care of the sputum, its reception into a covered vessel containing some antiseptic liquid to protect it from flies and to prevent it from becoming dry, mixing with the dust of the atmosphere and becoming inhaled or contaminating food; finally, its destruction by fire or powerful germicides. (2) The placing a handkerchief before the face when coughing or sneezing to prevent the bacilli suspended in the spume which is ejected from contaminating the air or food or from falling upon clothing or furniture. (3) The avoidance of kissing, especially upon the mouth, a practice which should be generally discouraged in view of the possibility of infection. (4) The use of paper handkerchiefs, which should afterwards be burned, for wiping the mouth. (5) The disinfection of fæces, urine, and tuberculous discharges. (6) The boiling of milk unless it is certain that it has been obtained from cows that have not reacted to the tuberculin test. (7) The avoidance of suckling when the mother is tuberculous. (8) The separate bed. (9) Living out of doors as much as possible and sleeping in the open air. (9) Absolute cleanliness in the widest sense of the word.

We pass now to the measures of prevention which should be adopted by the State. These are the enactment of laws making notification compulsory, and indiscriminate spitting a punishable offence; making regulations for the suppression of smoke and dust; for the compulsory disinfection of houses that have been occupied by consumptive persons, and periodically of conveyances and public buildings where a large number of people are accustomed to assemble, improvement of the dwellings of the working classes ; the provision of open-air schools, reserves, parks and playgrounds ; the frequent and close inspection of dairies and slaughter-houses, and the compulsory application of the tuberculin test to all dairy cattle, and the destruction of those found to be tubercular with compensation to the owner ; the establishment of tuberculosis dispensaries, of sanatoria and hospitals for advanced and incurable cases, of farm colonies for the reception of those in whom the disease has been arrested in the sanatorium, and the consolidation of their cure ; the establishment of a fund for the support of the families of bread-winners who are under treatment in the sanatorium or hospital ; and, finally, making provision for the education of the people by leaflets, by popular lectures, and especially by travelling tuberculosis exhibitions.

On two of these State measures of prevention I must say a few words. The first is compulsory notification, which should be made applicable to the whole State. There are still a few educated people who oppose compulsory notification, mainly on the ground that it is unnecessary and that its operation is harsh and cruel. The answer to the first objection is that without compulsory notification it is practically impossible to discover a large number of the most advanced, and therefore most infectious, cases of pulmonary tuberculosis. Further, that by notification many early "contact" cases are found, and being treated may be prevented from passing into the advanced stages, and so becoming new centres of infection. Again, and this I think should be a convincing answer to the statement that compulsory notification is unnecessary, the International Tuberculosis Congress, which met in Washington in 1908, composed of experts in the study of tuberculosis from all parts of the world, unanimously resolved that compulsory notification is a necessary factor in the crusade against that disease.

In answer to the second objection raised to compulsory notification, namely, that its operation is harsh and cruel, it should be sufficient to point out that in 55 large cities in the United States, including New York, where the law has been in operation for 13 years, in Denmark, in Sheffield and Bolton, in Edinburgh and Glasgow, and in the city of Sydney, the report is that the Compulsory Notification Acts have worked smoothly and without complaint. Even where the law provides for the compulsory removal of a consumptive who will not or can not take proper precautions, the patients, although objecting at first, have afterwards, finding themselves in clean and healthy surroundings and provided with abundant nourishment, expressed their satisfaction. I freely admit, however, that wherever notification is made compulsory it is the bounden duty of the State to provide sanatoria and hospitals for the reception and free treatment of those who may be unable to carry out a proper system of treatment in their own homes. In connection with this subject it is right to say that sometimes a consumptive person not of the pauper class finds it difficult to obtain admission to a hotel or boarding-house on account of the unjustifiable fears of the occupants. Also that from the same fears opposition is sometimes offered to the establishment of a sanatorium in a neighbourhood. The remedy for these difficulties is education of the people. They know enough about tuberculosis to alarm them, but not enough about the preventive measures which the careful consumptive takes to make himself quite harmless to those about him.

Dr. Ashburton Thompson, President of the Board of Health of New South Wales, said :—

The present discussion is on the dissemination of tuberculosis, and whatever general interest it may have, its importance lies in the guidance it may afford those who would devise practical methods of preventing dissemination. Now, the ways in which tuberculosis may be communicated are doubtless various, but they are of vastly different degrees of efficiency. The value, in this sense, of some of them still remains doubtful for lack of direct evidence. I shall endeavour, therefore, to confine the few and brief remarks I propose to make to matters which are agreed by a great majority of those who are best entitled to pronounce upon them, In the first place, it is now generally admitted, I believe, that the most important of the various sources of infection is the sick ; that for practical purposes the term " the sick " may be taken to mean only those who suffer from that form of tuberculosis which is called phthisis ; and that the efficiency of the phthisical as causes of tuberculosis in others is roughly proportioned to the amount of expectoration thrown off by them. Further, opinion seems to be forming that usually the communication of the infection from the sick to the healthy is either direct, or, if literally indirect, then mainly by intermediate means which imply lapse of no long time. On the whole it appears to me that this brief statement, crude as it may appear, includes the points on which those who would reduce the prevalence of consumption on a broad or national scale had better fix attention for the present.

If this view can be accepted as a guide to immediate and practical effort, it follows indisputably that segregation of the sick from the healthy should be our aim. But it would be unnecessary, useless, impracticable and improper, to advise segregation as a routine measure to be inexorably carried out in every case. All consumptives are not dangerous ; few consumptives are dangerous throughout their illness ; and even those consumptives who are most dangerous can surely live among the healthy with safety to them, by punctual observance of simple and easy precautions. The proportion of the phthisical at any time existing who should be segregated, depends, then, on circumstances. The circumstances will be found to differ in different cases. They should be enquired into by medical men, for no others can be in the least degree competent to estimate their importance. With medical men the decision on each case also must rest; they alone can say what kind and extent of precaution is necessary in each case.

The characteristic of this plan lies in examination into, and consideration of, the circumstances surrounding each individual case of phthisis; and on no other principle can restraint of consumption be attended with hope of success. Such, at least, is my firm opinion. Consequently universal notification of all cases of phthisis is the indispensable foundation. On the need for notification I am confident there cannot be two opinions among us here present, and therefore I say no more about it. On that foundation a superstructure must be reared. Its general character, I think I have sufficiently indicated already; but the administrative factor needs consideration. Two requirements involve legislation. The first is universal notification; the second is power to enforce segregation in cases where it is clear that the safety of the healthy cannot be otherwise ensured. This latter power would carry with it power to make and to enforce regulations for the conduct of consumptives allowed to remain at home. As regards the executive, in the first place every member of the medical profession must be enlisted—that is to say, every member must be employed, or be liable to be employed, by Government on this business in his own neighbourhood, and must be paid for his services; and in the second place, sanatoriums to accommodate the segregated must be erected. You may consider, sir, and the members of this Section may consider, that this proposal which I have sketched only in the broadest outline, and merely so as to indicate a principal of action, is arbitrary, would be distasteful, and might be oppressive. Very likely. But it must be remembered that we are concerned with natural phenomena. If we do not divert the forces, and alter the conditions which lead to the dissemination of tuberculosis, they will continue to take their proper effect, and relentlessly. Humanity is one thing, and to be cultivated; sentimentality is quite another. When fear takes possession of the people as, for instance, in relation to smallpox and plague, there is no proceeding so arbitrary, so distasteful, and actually so oppressive, that they will not sanction it, nothing, necessary or unnecessary, which they will not enjoin and enforce, even in spite of the reasoned recommendations of well-informed advisers. Why, then, should we be deterred by such considerations from commencing to advocate a course in the case of phthisis which is supported by all sound knowledge? For my own part, I must say clearly that I have formed a very definite opinion that endeavours to reduce the prevalence of phthisis on any other plan will drag on interminably, and in the end will be found to have failed.

Dr. W. G. Armstrong, D.P.H., Medical Officer of Health, Sydney, said:—

The point which I particularly wish to emphasise in this discussion is the importance of co-ordinating the measures, whatever they may be, which are now in operation, or which are I hope about to be put into operation against tuberculosis. No one wishes to decry the work which has already been done, nor the fine results of which it has been productive. Of these results, confining oneself for the moment to New South Wales, it is only necessary to point out that the death rate from tuberculosis in this State has fallen over 33 per cent. since Koch's announcement of his discovery of the tubercle bacillus in the year 1882, while in the other Australian States approximately similar reductions have taken place.

But successful as these measures have been, it is impossible to deny that they have been to a large extent desultory. There has been little or no co-ordination ; and when one says this one does not speak of Australia only, but of the whole English-speaking world. Private benevolence and private enterprise have stepped in here and there and done a great deal. Large municipalities, and even the State itself, have come forward, but hitherto nearly all the work done has been disjointed. Here in Australia, for instance, our special means of fighting consumption consist in brief of a few sanatoriums controlled by charitable societies for the poorer sick, and by private enterprise for the better-to-do ; in some of the States there are State hospitals for the more advanced cases ; but everywhere the accommodation in both these classes of institutions is notoriously inadequate for the numbers who need them. Then we have some localised systems of notification. In the city of Sydney, to take a case in point, notification of consumption is compulsory within the city boundaries only ; while throughout the whole of the suburbs, which contain four fifths of the population of the metropolitan area known as Sydney, consumption is not notifiable, and this statement is equally true of the rest of New South Wales. The results of this localised system of notification are sometimes rather absurd. A consumptive patient residing on the north of Cleveland Street will be notified ; he will be visited from the city health office ; he will be instructed in all the precautions he ought to take to avoid the spread of infection, and his domicile will be visited from time to time to observe that he is carrying out the advice which has been given him. Finally, when he moves away from his house, a trained staff of disinfectors will visit the place and thoroughly disinfect the rooms he has used. If, on the other hand, our consumptive lives just south of Cleveland Street and so outside the city boundaries, he will not be notified, though the neighbourhood he is living in is quite as populous, and the conditions existing in it essentially the same as those in the city just across the street.

Finally, we have in each State a public health service with generally very inadequate powers to deal specially with consumption, and insufficient funds allotted to them for that special purpose.

It may be asked, if our past measures have been inadequate, how is it that the mortality from consumption has diminished so greatly as it has ? I believe the answer to this objection is that the great decline in the death rate from consumption has been due primarily to general social betterment among the poorer classes of society, and the operation of public health Acts and other laws which aim at the improvement of dwellings, the diminution of overcrowding, and the enforcing generally of better sanitary conditions, especially in towns. Add to these the active dissemination of knowledge of the disease by the public health services and the medical profession. Other special measures against consumption have, I believe, played a part in the reduction of the mortality which is but a secondary one to that of the influences I have just referred to.

But the time has come when measures directed more especially against consumption must have a greater importance than they have had hitherto, and it is evident that the various agencies must be co-ordinated together, and their powers extended if the question of the abolition of tuberculosis is to be seriously attacked. There are good reasons to hope that a movement in this direction is at hand in Australia. Public attention has been directed towards the control of tuberculosis, and public opinion is beginning to make itself felt.

The Governments of the various States would appear to be the proper co-ordinating authorities. The State Governments have most of the machinery at hand in their public health departments. They have the financial means, they have the power of compelling compliance ; and, in Australia, Governments have already acquired the habit of dealing with questions of this kind more than in most other parts of the world.

The exact method which might be followed by Australian Governments in carrying this policy into effect would no doubt be governed by a variety of considerations ; but I venture to suggest a trinity of measures which might be regarded as within the sphere of any Australian Government. They are :—

1. Compulsory notification of consumption.
2. The provision of a sufficient establishment of hospitals for advanced and incurable cases to meet present needs.
3. The establishment in towns of consumption dispensaries.

If these three things were carried out by the Government of a State they would, I think, form a co-ordinating nucleus round which any factors already working, or in future to be worked, through the agency of charitable societies or private persons, would naturally group themselves. (To them one might add a fourth, which, though probably not yet within the realm of practical politics, will be so, one would hope, in the future, viz., the provision of financial aid to distressed families whose breadwinner is forced into a sanatorium by consumption.)

The establishment of sanitoriums for the treatment of early cases might probably well be left to private individuals and associations. These institutions differ essentially from the segregation hospitals for advanced and incurable cases, inasmuch as the latter benefit not only the actual sufferers but also the community at large by removing from among them persons who are liable to be sources of infection.

Compulsory notification must now be looked on as a weapon of proved value. It is already successfully in force in South Australia, New Zealand, West Australia, some Victorian towns, and in the city of Sydney. It is the one and only method by which a knowledge of all cases of consumption in a community can be obtained. The most workable system of notification appears to me to be that in which districts or groups of districts are proclaimed by the central authority as areas within which notification of consumption must be made. Notification becomes effective only within such proclaimed areas, and it would become the duty of the central authority to proclaim as notification areas only those districts in which requisite machinery existed for performing to the notified patients those services without which notification would itself be of little use.

The third member of the trinity of measures I have enumerated is the establishment of consumptive dispensaries. It would seem that here also is a fair field for the expenditure of public money either in the direct foundation of these places or, preferably, in the shape of special subsidies to existing hospitals to enable them to maintain consumptive dispensaries. Especially in country towns, where otherwise there might be an absence of machinery to deal with consumptive patients, would it be useful to establish these dispensaries in relation to the existing hospitals. The wonderful work which has been carried out in the Victoria Dispensary, Edinburgh, established by Dr. R. W. Phillips, has amply demonstrated the value of such institutions.

The following is the programme of the Victoria Dispensary :—

1. The reception and examination of patients and the keeping of a complete record of every case.
2. The bacteriological examination of expectoration.
3. The instruction of patients how to treat themselves and how to prevent the risk of infection to others.
4. The dispensing of medicines, sputum bottles, disinfectants, and even, when necessary, food.
5. The visitation of patients at their own homes by (1) a qualified medical man and (2) by a nurse, for the double purpose of treatment and of investigating the condition of the dwelling and the risk of infection to others.
6. The selection of patients for hospital or sanatorium treatment.
7. The guidance generally of tuberculous patients and their friends and replying to enquiries on every question concerning tuberculosis.

Dr. JANE GREIG, Education Department, Melbourne, said:

I would like to refer to an aspect of tuberculosis which we have had to deal with recently in Victoria. Owing to a more general knowledge of the subject on the part of the public, much attention was directed to the question of tuberculosis amongst teachers, and the risk of their presence in the schools.

A special committee was appointed by the Cabinet, consisting of the Chairman of the Board of Public Health, the Government Medical Officer and the School Medical Officers, who were asked to report on the matter.

The facts I am about to state, though based on experience with teachers, would apply equally to all branches of the Civil Service, and also to banks and similar institutions. Investigation showed that there was comparatively little tuberculosis amongst teachers in Victoria, only 11 cases existing out of 4,500 teachers; at least these were all the cases known in the Department, and this shows a much lower percentage than is found in the general community; not only that, but investigation showed that 10 of these cases were in an advanced state.

Are we then to assume that there is really less tuberculosis amongst teachers than amongst the general public, or is it possible that there may be cases in teachers not known or not notified to the Department?

It is a fact that in the cases already mentioned there was often a long period in which each teacher had a considerable amount of sick leave, stated to be on account of other conditions, such as anæmia, bronchitis, influenza, pleurisy, ect., before the tuberculosis was notified.

Why is it that cases are always so far advanced before the Department knows?

One reason probably is that this disease is usually so insidious in onset that individuals are infected for a considerable time before they themselves realise that they are ill.

Secondly, that when they do suspect the nature of the disease, they refrain from attending a doctor in case the nature of the disease should be disclosed or reported, and that they would be compelled to stop work, which would cut off their only source of income, as the allowance of sick pay is very small and covers a comparatively short period.

The allowance of sick leave for the Public Service of the State of Victoria in any one year is as follows:—Under 5 years' service: 2 weeks, full pay, 2 weeks, half-pay; 5 years and under 15 years: 3 weeks, full pay, 3 weeks, half-pay; 15 years and upwards: 4 weeks, full pay, 4 weeks, half-pay. Any person absent on sick leave for three months or over must be examined by the Government medical officer before resuming duty.

In dealing with tuberculosis, three facts are to be emphasised: —(1) That it is preventable; (2) that it is curable; (3) that time required for cure is lengthy ; minimum has been stated to be two years.

In regard to the first of these, every case of pulmonary tuberculosis may be a source of infection, unless supervised. Our best means of prevention is to get all cases as early as possible—in fact do everything we can for the early detection of cases ; a great help to this would be to urge self notification.

For the second, whilst we recognise and want to impress the fact that the disease is curable, we must remember that tuberculosis is curable only in proportion to the extent of the disease. This usually means the duration of the disease. Whilst probably all early cases are curable, only a very small proportion of advanced cases respond to treatment. This is again a reason for getting cases as early as possible.

Thirdly, a very special feature of cure in tuberculosis is the length of time required, the usually accepted minimum being two years. It is this length of time that makes treatment so expensive, on account of the cost of living for so long under special conditions and without earning anything ; likewise we might add that the length of time required for treatment is really proportionate to the stage of the disease in which it is started ; so that for economy we should try to get cases at their earliest onset. In fact, instead of getting early detection with its valuable effect on prevention and cure, at the present time exactly the opposite state of things exists amongst State School teachers and Civil servants ; the tendency is to hide the nature of the illness and remain at work ; in this way infection may be disseminated amongst those with whom they are associated, and when the true nature of the condition is discovered the cases are frequently too far advanced for permanent cure.

In consideration, therefore, of the necessity of prevention of infection, of the difficulty of obtaining early detection of tuberculosis, together with the value of the lives to be saved, we have made the following recommendations :—

That teachers suffering from tuberculosis shall be referred to the Government Medical Officer.

That on the certificate of the Government Medical Officer the Education Department be empowered to grant leave of absence in favourable cases, irrespective of the length of service of the teacher concerned, for a minimum period of six months, and a maximum period of two years, on the terms and conditions as follows :—

That full pay be allowed for the first six months, and, if extended leave is necessary, half-pay be allowed for a further period of six months.

That in favourable cases in which leave of absence under special conditions is recommended, treatment in an approved sanatorium is compulsory, and that supervision by the Department extend over the whole period of absence. Failure to comply with these conditions shall cause the pay to be withdrawn, and the teacher to be compulsorily retired.

That teachers receiving leave be examined periodically.

That teachers whose cases are considered unfavourable, *i.e.*, those who are permanently unfit for service, or who do not respond to treatment, be retired on the recommendation of the Government Medical Officer.

That teachers compulsorily retired on account of their suffering from tuberculosis be given reasonable compensation in proportion to their length of service.

That before it is again occupied, a school residence, vacated by a tuberculous teacher, shall be disinfected accorning to the regulations of the Board of Health.

That no teacher who has suffered from tuberculosis shall be allowed to resume duty without the consent of the Medical Examiner.

A teacher with tubercle in sputum must not be employed in school.

That experience gained in the sanitorium should be faithfully adhered to by the teacher, both in school and home life. Any departure from the recognised precautions should lead to the retirement of such an officer.

All teachers known to have suffered from tuberculosis should undergo periodical medical examination after resuming duty.

The value of such recommendations lies in the fact that the best methods are adopted for preventing the spread of the disease and result in true economy, both in saving of life and in saving to the Department the valuable services of a specially trained and experienced teacher, who, by personal experience of the disease, is likely to be an enthusiastic worker in the interests of public health, and especially in the campaign against tuberculosis.

As a result of the above recommendations, the Public Service Commissioner for Victoria on October 17th, 1910, made an addendum to Chapter XIV. of the Public Service Regulations (Leave of Absence) as under, for submission to the Governor-in-Council :—

> 6. Leave of absence may be granted to State school teachers certified by the Government Medical Officer to be suffering from consumption, on the following terms, irrespective of length of service, viz., full pay for six months, and half-pay for six months, provided that such pay be made conditional on the teacher undergoing treatment in an approved sanatorium when recommended by the Government Medical Officer.

The Education Department has since then dealt with all existing cases on this basis.

Dr. Cumpston, Medical Officer of Health of Western Australia, said :—

We have heard a good deal this morning about the frequency with which human beings are invaded by tuberculosis ; and Dr. Mills has stated that every man has been invaded by the bacillus of tuberculosis, but has successfully resisted this invasion. Dr. Mills, however, laid stress upon the fact that the dosage of tubercle bacillus had been great enough to confer upon each of us a definite degree of immunity. This statement that every man has at some time had a slight degree of tuberculosis has been repeated so often that it is now accepted as fact. It may be true for England, France, or Germany, but there is not, so far as I am aware, any evidence available that this general statement is true for Australia. I am not aware of any records of pathologists dealing with this matter, and until such are forthcoming there is no justification for the application to Australia of the sweeping statement that every man has had tuberculosis.

I do not propose to discuss the question of human and bovine tuberculosis and their relative importance, beyond simply stating that I definitely register my adhesion to the principles of the resolution of the International Congress held at Washington in September, 1909, and believe that the most important factor in the production of human tuberculosis is pre-existing human tuberculosis. Bovine tuberculosis probably plays its part, most likely in the production of tuberculosis in children and adolescents ; but our problem to-day is the suppression of adult pulmonary tuberculosis, and here there seems to be an unanimous opinion that pre-existing pulmonary tuberculosis of the infectious type is the principal factor at work.

While agreeing with this general statement, I am inclined to go one step further and say that it is not the incidental and occasional exposure to infection that is important, but that a repeated exposure to infection is necessary. I am not at one with those who clamour of the danger of spitting in the streets, of travelling in trams, and other similar hypothetical exposures to infection, for I do not think these play much part. It is the repetition of fairly large doses of bacilli that is the danger, and I would go so far as to say that the probability of any person becoming infected is directly proportional to his continued proximity to an infectious consumptive. Prof. Pannwitz, in addressing the Tuberculosis Congress at Washington, put this fact neatly : "But it must be stated emphatically that exposure must occur repeatedly before infection can take place. A single exposure is almost without danger, hence panic fear of infection is unfounded."

The logical deduction, then, from this necessity for continued exposure to infection is that the one single measure to which the greatest importance must be attached is effective segregation. Many may hold the opinion that segregation may be effective in the home. I am very doubtful of this, and would prefer to see provision for all consumptives in the form of institutions. Before notification is enforced there should be some place for the consumptive to go to.

Finally, I think that the whole control of measures instituted against tuberculosis should be in the hands of a central authority.

Dr. Boelke said : You have probably all seen articles in our scientific papers in which the authors gave the results of their investigations into the incidence of tuberculosis after using von Pirquet's test. Hamburger of Vienna states that he had 94 per cent. of positive reactions in cases of 17 years of age. Nothman gives his results as 100 per cent. at the same age limit. Many other investigators publish similar results. When this test became known some years ago I tried it on many children and adults, with the result that all the adults gave a positive reaction. I therefore had to abandon it, at any rate as far as adults were concerned. But the tests showed that even here in Australia the number of people who became infected at some period of their lives is very much greater than one would expect. Fortunately the infection must have been very mild, considering that most of these people were never even aware of the fact that they had been infected, and that, without changing their mode of living in any way they never showed any symptom of tuberculosis.

In view of the wide distribution of the source of the infecting agent, and the mildness of the nature of the disease in most cases, I would judge that most of these people had contracted the malady by taking some tainted food, most probably milk, which contained tubercle bacilli. I make this statement because I am firmly convinced that the bacillus which we find in animal food, that is the bovine bacillus, although much more prevalent is much less virulent in the case of human beings than the human type of tubercle bacillus. The question arises, how is it possible to check infection of this kind ? The supervision of our meat supply is fairly strict, and probably very little tubercular meat is sold. As regards our milk supply, I am afraid that much can still be done to improve it. Most of the measures adopted so far aim at the prevention of the further adulteration of milk, but in many cases this milk already contains living tubercle bacilli. Pasteurisation certainly will kill these bacilli, but it would be difficult to convince me, and I think most medical men, that such milk is as good as fresh, unboiled milk. The whole question is one of £.s.d. Compensate the farmers, and they will be only too glad to have their herds tested and the infected animals destroyed, but I am afraid that the expense would be beyond the resources of the State. There is only one other way out of the difficulty, so far as I can see, and that is to induce farmers to have the tuberculin test applied, and the infected cows destroyed, by giving the farmer a certificate guaranteeing the freedom of their dairies from tuberculosis. Of course these tests would have to be repeated at regular intervals. If milk from such a dairy could be put up for sale under such conditions that it would not be mixed with untested milk from other dairies, I think it would command such an enhanced price that other dairymen would soon be induced to adopt the same methods.

With regard to our food supplies, I am of opinion that no person affected with tuberculosis in an open form should be allowed to work in an industry which requires the handling of food for human consumption.

A few words with regard to pulmonary tuberculosis. Koch has stated that pulmonary tuberculosis is always caused by the human type of tubercle bacillus, and those of you who have read the publications on the work done, especially in Germany, during the last few years will, I think, agree with him. Of thousands of specimens of sputa examined by means of cultivation and inoculation, in not one single instance could infection of the bovine character be traced.

Pulmonary tuberculosis in man is purely a disease due to the human bacillus ; and in order to fight the spread of this form of the disease we must treat patients already afflicted with it. To my mind the first and most important step is compulsory notification. The bill which was lately before the Legislative Council had two great drawbacks. If notification had to be made to Shire Councils and municipal bodies it would be almost impossible to ensure that strict secrecy which is so essential in such a delicate matter. At present patients sometimes come to us in the earliest stages of the disease. If these were frightened by the knowledge that their ailment might be made public, I think that many of them would prefer to remain ignorant of the exact nature of their disease rather than run the risk of publicity. To my mind the Board of Health is the authority to which notification of the existence of the disease should be made. After notification no further steps should be taken, provided that the medical attendant guaranteed that all precautions had been observed to prevent the spread of infection. Furthermore, only cases of open tuberculosis should be notifiable. There does not seem to be any sense in notifying, for instance, a case of tubercular knee-joint, seeing that there is not the slightest danger of infection.

With regard to tuberculosis dispensaries, so much has been said lately on the subject, and the benefits of these establishments are so apparent, that I shall only lay stress on one point. With these dispensaries in existence poor people will be able to have their disease diagnosed in the very earliest stages, and possibly they may undergo treatment. Under present conditions persons suffering from commencing tuberculosis must go to a sanatorium for some months at least in order to have a chance of recovery. But what happens to their families in the meantime ? If in such dispensaries we were able to diagnose the disease before there was any actual breaking down of lung tissue, that is before the disease had reached the open stage—and this certainly can be done—we might treat persons afflicted and cure them without its being necessary for them to stay away from their work for a single day. Those of you who have tried the treatment of tuberculosis by means of the various tuberculin methods will bear me out in this statement.

The whole question of the dissemination of the human kind of tuberculosis could be settled at once if we only had the chance of testing and treating people before their illness had gone too far.

Here we have in our State a society, "The National Association for the Prevention and Cure of Consumption." We are willing to assist the State in this vital question, to educate the people, to help and to treat these unfortunates who are either already infected or who may be specially predisposed to tubercular troubles. I understand several letters have been written to the Government to give us an interview to explain what we are willing to do. So far the only satisfaction we have got is that our request will receive attention.

I suppose about £2000 a year would enable us to make a start. In America they are spending many hundreds of thousands of pounds a year for the same purpose. Considering that in 1908 in New South Wales 1276 people died from tuberculosis (I do not consider the large number of people, who, suffering from tuberculosis, may be incapacitated for years), and taking the value of each life as worth about £200 to the State, we have the enormous amount of £255,200 for one year only. £255,200 ! and we cannot raise £2000. We talk about immigration : let us keep our own people alive first. What I have just stated will also explain why so very little has been heard of this new society lately.

In speaking on this subject, "The Dissemination of Tuberculosis," it is not a question of what one can say (the subject is so large), but when to stop, and I trust that these few remarks may be of some slight value in this important discussion.

Dr. F. S. W. Zlotkowski, Royal Alexandra Hospital for Children, said :—

In any discussion on the dissemination of tuberculosis, it seems necessary to speak not only of the means by which the disease may be spread, but also, and more important still, the means by which dissemination may be prevented.

Despite differences of opinion we all know the main channels through which the tubercular bacilli are discharged, and although quite well aware of how the disease is conveyed we are more or less content to allow the matter there to remain. Again and again efforts have been made by small bodies of men interested in the cause to carry out a campaign against the disease, and again and again those efforts have failed, not through want of energy or of knowledge on the part of those in charge of the movement, but from lack of practical sympathy from the ruling powers for the time being in the State. The fault lies partly in the disease consumption itself; it is not a sufficiently spectacular disease. It is not frequently fulminating, and as it drags out its weary and deadly course, as a rule for a long period, it accustoms men to its existence and prevalence. There is nothing sufficiently dramatic in its onset, it so seldom stands in the glare of the limelight. Smallpox and plague, on the other hand, although claiming much fewer victims in our country, are promptly and drastically legislated for. Large sums of money are spent in the means of prevention, and rightly so. Why then this deadly apathy in connection with the prevention of tuberculosis—a disease which is for ever going on in our midst?

Years ago a good stand was made, and sanatoria for both early and advanced cases were established. This is well, but is only the commencement of a movement which should aim at completeness and finality.

The main factor appears to be the ignorance of the people as to the way the disease is disseminated. They should be taught exactly how it is conveyed and the methods by which its spread may be prevented. The people are willing and waiting to be taught, and the most effective way of doing so is to establish tuberculosis dispensaries in easily accessible spots in the city, where sufferers may come for advice. There their disease may be diagnosed and treated, and they may be shown the dangers of spitting, the necessity for sunlight and fresh air, and a gospel of hope preached to them. Thus would the sufferings of thousands be lessened and the seeds of future resistance to the disease firmly implanted. Surely this is little enough to ask of any paternal Government: that a few hundred pounds annually be set aside for the upkeep of even one of such dispensaries. This is not a matter for public charity—a dole from a few interested and kind enthusiasts, but a question of truly national importance. It deals with the constant and steady destruction of a large percentage of our population. What, then, should interest a Government more closely than this? What shall we do to open the eyes of those who sit in high places, and make them see the crying necessity of at once allowing us to start on our work of eradication? We know what is required, and we know that nothing of any lasting benefit can be done without funds. With a comparatively small amount we would be enabled to start our work of aggression, and we know by the experience of other countries that this is no idle experiment, but that great good has been done, and still remains to be done. Much has already been accomplished here. Our Board of Health and City Council have worked well, but the bulk of the work remains to do, and cannot be done unless the necessary money is forthcoming. Surely this is an object to arouse the sympathies of any Government in the world.

When those in authority are told by experts in tuberculosis that thousands of lives are being sacrificed annually to a disease which can be prevented, surely that should be enough to awaken them to a sense of their grave responsibility.

The efforts which are being made by the National Association for the Prevention of Consumption are hampered all along the line by the everlasting want of funds. Representations have been made to two Governments, and still we are marking time.

The people should know that efforts are being made to show them the methods by which the disease may be prevented, but that although this could be done, and would be done, nothing can be done because we find it impossible to sufficiently interest those who have it in their power to help us to stamp it out.

Several things are first necessary in this movement :—

1. Universal notification, and only to the Central Board of Health should this be done ;
2. The establishment of tuberculosis dispensaries ; and
3. A campaign of education of the people in the means by which the disease is spread and the methods to combat them.

With sufficient funds for the establishment of a tuberculosis dispensary much could be done, and a firm forward step taken in the direction of stamping out this fearful and preventible disease.

The sources of infection are sufficiently well agreed upon to admit of positive statements being made concerning them, though differences still exist about the relative danger of human bovine tuberculosis.

The most potent factor in dissemination is of course the human sputum, either directly in the form of spray from the mouth, or in a dried form as dust.

Flugge's work goes to show that great danger exists in the direct transmission of the tubercle bacillus, inasmuch as a cloud of spray from the patient's mouth may extend for a distance of at least four feet and be inhaled by anyone within that radius.

In advanced cases also the urine and fæces are of an infective character and constitute a danger. It has been long a matter of controversy whether the milk and flesh of tuberculous cattle were or were not sources of infection, and the weight of opinion now appears to have decided that they are.

The experiments of Fibiger and Jensen who procured cultures virulent to calves from two children who had ingested milk from tuberculous cows appears to be convincing proof.

Von Behring has suggested that through long residence in the human subject the bovine tubercular bacilli may become so modified in virulence as to be indistinguishable from the human types.

On the whole we must admit the transmission of infection through milk and meat, but this must occur proportionately, only of course to the amount of tuberculosis which may exist in any particular country among the domestic animals, which varies very greatly; thus Kitasato states that in Japan this must be a very minor factor, because milk is so sparely used and the existing cattle do not have the disease.

Other observers, such as Woodhead, Behring, etc., consider it of grave significance in the British Isles.

The external means of dissemination begin from the time of birth, some cases being on record where infected midwives have been supposed to have infected new born children by breathing into their mouths.

Bacilli have been discovered by Dieudonné and Schutz and others under the finger nails and on the hands of children in consumptive families; therefore it is obvious that one source of transmission may be through the toys, handkerchiefs, etc., left about in the dwellings of the consumptive poor. Contamination must be extremely common through the use of handkerchiefs which come in contact with the hands, pockets, dresses, etc., of the patient and those with whom he associates. The parent may transmit the bacilli to the child through food, household utensils, etc., and the part taken by flies, cockroaches and lice in the carrying of the bacilli has been proved by such observers as Spillman, Weber, Lord, and others.

It has been shewn that the virulence of infection appears to be much greater when the bacilli are in a damp form than when dried, in which latter case their vitality seems to be in some way impaired.

The danger of direct infection lies chiefly from coughing, sneezing; ordinary breathing has been shown to carry no infection.

The act of kissing on the lips is in the first place extremely insanitary, and in the case of children should be firmly forbidden.

The use of the communion cup as practised at present should be denounced as insanitary and a grave menace to the health of healthy individuals. The idea of drinking from a cup which has just been used by a person with phthisis (or other infectious disease) is revolting, and stringent measures should be adopted to insist upon the introduction of some method whereby no person will have to run the risk of infection from his neighbour whilst at the communion table.

Many persons are now debarred from communicating through this sole cause that they cannot bring themselves to consume the salivary emanations of a number of unknown people, any or all of whom may have a disease of an infective nature. The use of a separate cup for each person should be insisted upon.

Mention should also be made of the barbarous and disgusting custom which compels the officiating priest to himself drink the dregs of the cup after all communicants present have drunk from it.

Section J

MENTAL SCIENCE AND EDUCATION.

ADDRESS BY THE PRESIDENT:

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MUSIC.

Before I address myself to the topic to which I specially desire to direct your attention, there are some matters on which as President of this Section I think I ought to say a word or two at the opening of our sessions. First I wish to express our sense of the loss which psychology has recently sustained in the death of Professor William James. If Socrates brought down philosophy from heaven to earth, it may be truly said that Prof. James carried the process still further and brought philosophy from the lecture room into the market place. The freshness and unconventionality of his treatment and the homeliness and everyday character of his illustrations have induced a wider interest in psychology than it has ever before enjoyed. As M. Jourdain found to his amazement that he had been talking prose all his life without knowing it, so have we learned that we have all been more or less psychologists and philosophers though we had no suspicion of any such thing. He has taught us the practical value of psychology to the teacher, and has brought home its moral lessons with a new and striking force; and he has reclaimed for Science the hitherto almost neglected field of religious experience, so that conversion and sanctification are no longer regarded as abnormal and hysterical phenomena, but as normal experiences as worthy of serious scientific study as the laws of association or the freedom of the will. His own personal character was as attractive as his teaching; and I venture to think that time will only increase our sense of the value and originality of his work.

Then I desire to congratulate the Section on the growing interest in education, which is one of the most hopeful features of our day. The registration of secondary teachers and the improvement of the social and financial status of the teaching profession, which is beginning already to result from that most necessary and far-reaching reform are distinctly a movement in the right direction. The extension of secondary education to all classes of the community will be hailed with satisfaction by us all ; and it is to be hoped that in the course of our discussions some light may be thrown upon the best method for accomplishing so desirable an end without injustice to those who have hitherto been doing the greater part of this work and have embarked in it their capital both of money and of energy. I trust also that some word of protest will go forth from this meeting against the growing tyranny of the examination system, which is fast reducing our secondary schools to mere cramming-shops and making all originality in teaching too risky to be attempted. It is the parents, not the teachers, who are responsible for the present state of affairs ; so long as they persist in looking upon a pass at matriculation or some other examination as the chief test of their children's educational progress, and in judging schools by the number of passes and honours they secure, so long teachers, who unfortunately have their living to make, must conform to the present craze for results and subordinate their curricula to the requirements of the Examination Boards. I could wish also that some wise counsels may be given as to the best way of making the Bible available as a subject of real study in our State schools without offence to the susceptibilities or convictions of any class of our fellow-citizens. The value of the Bible as an instrument of education no one will question ; but the difficulties in the way are more serious than some of the advocates of the Bible in State schools seem to recognise. To introduce into any school a subject that is not to be scientifically taught is a fatal mistake ; if the Bible is to be introduced at all it must be as a subject of study as real and as scientifically directed as every other. Our brightest hope lies in the saner views of the Bible and its literature which are gradually emerging from the processes of the so-called higher criticism, and are vindicating for that literature its human and progressive character.

Upon these and many other live questions I trust that this assembly of teachers and thinkers will be able to give to the community suggestions of real value and importance ; for my own part I wish to put in a plea for the recognition of music as a subject of study and an instrument of education second to none in the curriculum of our schools.

It will be as well to state at the outset that when I speak of music I am not thinking of piano-playing, which ought not to be taught at all, except to those children who have special musical ability ; but I mean first of all, such training in ear and voice as shall give every child the power to sing in tune and in a pleasant and properly produced tone ; and then such knowledge of musical notation that the child shall be able to read and sing at sight any ordinary vocal composition, and to follow the score of any instrumental work that he may hear played. To this should be added later the general rules of harmony and exercises in the harmonisation of melodies and the composition of simple four-part songs. In other words, the teaching of music should be carried out on parallel lines to the teaching of English. First the child is taught to speak distinctly and to pronounce correctly ; then he learns the meaning of the alphabetical symbols, printed and written, and is made to translate them into their vocal equivalents with intelligence and expression ; and of course the extracts which are given to him to read are chosen so as to cultivate his literary taste and to lead him to admire only what is good in literature ; and finally he learns grammar, so that he may be able both to express himself correctly and to detect mistakes in the expression of others. Just in the same way and equally early he should learn to use his singing voice, to read and express vocally exercises carefully selected for their musical purity and taste ; and then to appreciate the simpler laws of their composition, and to express himself in accordance with them.

In both cases the most important thirg is learning to read, and it ought to be as disgraceful not to be able to sing a part at sight as not to be able to read intelligently a paragraph from the daily paper. The ordinary musical notation should be employed, not the tonic sol-fa or any other supposed labour-saving contrivance, for the same reason that we teach the ordinary alphabet as the foundation of English reading, because it is only through it that the great mass of literature is made accessible to the child. Music has a vast and glorious literature, only a very small part of which has been translated into sof-fa notation ; and it is only through a knowledge of the ordinary notation that it becomes available. The ordinary notation is much easier to learn than the alphabet ; with two hours good teaching a week I am confident that any child of ordinary intelligence would master it in a year, and be able to sing anything of an ordinary character at sight. The greatest danger to be avoided by the teacher is that the children should get into the way of singing by ear and imitation. They pick up a melody almost at once, and if the teacher is not careful, they will catch the notes by ear from him and not from the printed symbols. This is the peril of class singing ; a few children will sing from the notes, but the rest will simply follow them by ear. Therefore each child must be made to sing alone and to read exercises which have not been sung to him ; new things must be constantly introduced, instead of frequently repeating those which are already known. The teacher must never forget that he is not a conductor endeavouring to get a perfect performance of a few pieces, but an instructor whose object is to teach the children to read the notes before them—not to recite, however perfectly, from memory and imitation. Imagine the futility of trying to teach children to read by the constant repetition in class-recitation of half-a-dozen well-known short poems, after the fashion with which some of our girls' schools' speech days have made us sadly familiar ; yet this is the method employed for teaching singing in many, if not most, of our schools. A few part songs or school songs are sung over and over again until they are known by ear to all the members of the class, and they are then performed at the breaking-up of the school with such vigour and precision that the parents are deluded into the idea that singing is splendidly taught; but when all is done, not five per cent. of the children could sing a simple melody at sight, or even recognise one of their own school songs from the notes if they were put before them. No school can claim to teach music adequately unless it is possible to put an entirely new part-song into the hands of the children and to have it sung correctly at first sight by the whole class. And I verily believe that this result could be attained without any greater expenditure of time than is now comparatively wasted in the futile getting up of show pieces. The fact is that we are not yet emancipated from the idea that music is a mere graceful accomplishment, not worthy of serious study.

And yet it would be difficult to find any subject of greater educational value. In the first place it furnishes the child with a new means of self-expression. To teach the child to realise and express his own experiences is the first object of the educator, as his name implies; he is not to cram information into the pupil, but to draw out from him—to teach him how to express what is already there potentially. Hence the basis of all education is language. The infant passes out of in-fancy—that is, inability to talk, by learning to speak; through speech he expresses himself, and in expression realises himself; at the same time he becomes capable of receiving impressions from others, first through vocal and then through written or printed speech; and when he has learned to read and write, his power of expression and of impression is daily enlarged. Now music is a natural emotional language by which feelings, only very imperfectly expressible in speech, receive their instinctive embodiment; and until the child has learned to sing, his emotional nature is necessarily undeveloped, for it is only through expression that development can take place. In fact, children sing as instinctively as they speak, for there is more truth than at first appears in Dogberry's dictum that reading and writing come by nature; if they didn't, they would never have come at all; but just as the instinctive speech of the child must be reduced to order and form by training before it can be of much service to him, so must his instinctive song. His artless wood-notes wild must be cultivated and pruned until for every phase of feeling the right musical expression at once suggests itself. It may perhaps be thought by some that ordinary speech is quite sufficient as a medium for emotional expression, and that indeed all that can be expressed by music can be better and more intelligibly expressed by articulate speech; but that such a view is possible, only proves how little the average educated man knows about music. Every musician at all events knows the difference between reading a rhapsodical account of a symphony and hearing it played. Who can put into words the effect of Beethoven's C minor symphony or even of such a simple melody as "Home, sweet home"?

Other languages can be translated into English, but music is untranslatable ; it is parallel to speech, but not convertible into speech. The man who does not know music is as incapable of proper emotional development as one who is deaf and dumb and blind is incapable of proper intellectual growth. In England, says the gravedigger, Hamlet's madness will not be recognised, for there they are all as mad as he ; and it is only the wide prevalence of musical idiocy (using the word in its proper sense) that prevents the unfortunate idiots from being looked upon with the compassion and treated with the remedies which are appropriate to their case. In sober truth, to teach a child to sing is to endow him with a new sense and a new power, both rich in the potency of otherwise unattainable joy.

If it is the aim of education to enable every man to live his life in the fullest and most intense fashion, to realise himself in the greatest variety of ways, then it is little short of a crime to refuse to our children that training in music which literally will add a new territory to the empire of their being, because, forsooth, music is not a compulsory subject for matriculation, and does not indeed lend itself well to examination tests and methods. Consider, too, that the knowledge of musical notation is the key to a vast and cosmopolitan literature which must otherwise remain a sealed book to our children. The symphonies of Beethoven, the operas of Mozart, the fugues of John Sebastian Bach rank with the plays of Shakespeare and the epics of Homer and Dante and Milton as amongst the finest achievements of the human intellect ; and the time is fast coming when no man will be regarded as educated who does not know the one as well as the other. Into this realm the curse of Babel has not come ; and when they discourse sweet music German and Pole, Russian and Englishman speak the same tongue. Hence the study of Music has a special value in promoting the wider spirit of Humanity which will one day link the nations of the world into a great confederacy of mutual sympathy and helpfulness.

Moreover, the value of Music, and especially of singing, as a recreation can hardly be exaggerated ; and it must be remembered that one of the most important functions of education is to provide the child with the taste and the means for the wise and healthy employment of his leisure time. It is little use securing eight hours out of the twenty-four for play unless we also teach our people how to play and what to play at. If they are only released from labour in order to loaf about the street corners and fuddle themselves in the public-houses, there is little gain in an eight-hours day ; nor is the case much better with those who have abundant leisure and can find no other occupation for it than playing bridge and talking scandal. As far as out-door sports are concerned, our secondary schools cannot be blamed for any neglect ; and it is a good thing that the State school authorities are taking up this side of education and encouraging cricket and football and rifle-shooting matches between the different schools. Much, too, is being done in the way of stimulating the habit of reading and the taste for good literature, though, unfortunately, the home conditions of a large proportion of our population are not such as to make the indulgence of that taste particularly easy ; and it lacks the social element unless reading societies are formed for the common enjoyment of literature. I would venture to suggest that there is here a fine opportunity for the useful employment of Sunday schools and other Church premises, especially in districts mostly inhabited by the working classes. Then the schools are doing something, and might do more, in the encouragement of nature-study and of the collection of specimens. But, after all, the Fine Arts are the noblest form of recreative activity, and of them all, music is by far the best and most attractive. A young fellow who spends an evening a week in singing in a choral society has added a new interest to his life, and he will easily find many other similar ways of enjoying himself in the exercise of his vocal abilities. He can get together a few of his companions into a glee club ; he can join his church choir ; he can himself add his modest contribution to the enjoyment of a social evening amongst his friends ; whilst the development of his taste for music will lead him to find constant pleasure in concerts and band performances where he can obtain the maximum of satisfaction at the minimum of expense. Let him leave school, able to read music and habituated to take his part in concerted singing, and a whole world of healthy recreation is open to him, which will be his protection against a thousand ways of wasting or abusing his leisure hours. It may be worth adding that choral singing is from the point of view of physical health one of the best prophylactics against tubercular trouble in the lungs ; and the constant habit of deep breathing which it necessitates has the best effect on the general health of the child and the man.

Turning now to the teachers' standpoint, it is certain that vocal music is a subject that combines in almost a unique manner the various characteristics required for educational purposes, in addition to the value of the information and capacity actually imparted. It holds the attention of the children with a continuous grip that few other subjects can command. It requires and trains the co-ordination of ear and eye and throat muscles, and is thus as practically serviceable in this way as Sloyd work or drawing or any other kindred subject ; and if combined, as it easily may be, with marching or dancing, it brings in other muscular controls as well as that of the vocal organs. In a special way it teaches the value of co-ordinated work, and the necessity of unselfish co-operation by all the class in order to get the desired effect. It is thus a magnificent disciplinary subject. Above all it demands that the child shall at once do something himself as the result of what he has learned ; indeed, passive recipiency or cramming is altogether out of the question. It lends itself almost necessarily to the Heuristic method of teaching ; and the child is continually excited and stimulated by finding out his power of translating into pleasing sound the cabalistic-looking score that is put before him, and, conversely, of writing down in notes the melodies which he himself is encouraged to compose. Honestly, I know no other subject which trains at once so many of the faculties of the child and in such an interesting way.

It is gratifying to recognise that in the State Schools, which are independent of the whims of foolish parents and the cast-iron requirements of University-prescribed examinations, the subject of music is rapidly gaining the position and importance that it deserves. The following extract from the last number of the "Musical Times" is full of significance and hope:—

"The Education Department of the London County Council recently issued a list of the music which it offers for requisition for use in the Elementary Schools. This Requisition List, as it is called, is in many respects a notable document. It bears eloquent testimony to the great change that has taken place in the ideas of educational authorities as to what music is good for use in schools. The new list classifies separately-published unison songs, two-part songs, three-part-songs and collections of songs, and, besides, it specifies class sight-readers, music for marching, dancing, drilling and singing games, and books for the teachers' use. Amongst the unison songs, intended of course for the senior classes, we find five songs by Brahms, two by Beethoven, eight by Handel, five by Mendelssohn, eighteen by Schubert, three by Haydn, seven by Schumann, and four by Tchaikovsky. The two-part song list is similarly adorned by well-known names. English composers are not forgotten: Arne, Sterndale Bennett, Henry Purcell, C. Hubert Parry, Sullivan, C. V. Stanford, Cowen, H. Smart, Madame V. White and Charles Wood are represented, and a large number of folk and national songs are mentioned. Two collections of classical songs (one with thirty-five and another with thirty-six songs) and all of Mendelssohn's two-part songs are on the list.

"It may be wondered how it is possible to teach such high-class music in 'elementary' schools, and whether the children have the capacity to assimilate it and derive benefit from the study. This will depend greatly on circumstances, the teacher's competence, and his skill to gauge the receptivity of the children. Those who are familiar with the musical achievements of the teachers and children in the best elementary schools know that the class of music we are discussing is quite within the powers of all concerned. The education of the taste of the children thus fed may have remarkable consequences, which certainly could never be looked for when the music used was of a poor character."

How far the programme here suggested is actually carried out in the London schools I am not in a position to say; but I should like to confirm from some little experience in teaching singing to the Sunday School children of a working-class suburb the opinion expressed in this extract that this class of music is well within the powers of ordinary State School scholars. In passing, may I be permitted to urge upon the authorities of Sunday Schools, in which a good deal of attention is given to training the children to sing for the anniversaries, the importance of choosing good music for these occasions instead of the banal stuff which nine times out of ten does duty at their annual functions. I have found no difficulty in training the children to sing such things as Brahms' Wiegenlied, Bach's "My Heart ever Faithful," Schubert's and Schumann's songs, and even Wagner's "Hail, Hall of Song" and Handel's "Hallelujah Chorus." Children will learn good music just as easily as bad, and by teaching them the noble melodies of the great masters, instead of the claptrap futilities which are so commnoly used for anniversaries, their taste is cultivated as well as that of those who come to hear them sing, and their minds are stored with a wealth of musical treasure which they will never forget.

I have been furnished by the courtesy of my friend Mr. Wrigley of the University Teachers' Training College in Melbourne, with the musical syllabus used in the Victorian State Schools, and it shows that the right idea has been seized ; and if it is properly carried out, no child should pass the sixth standard without being able to sing at sight. But if I have not misunderstood it, the teaching of music-reading is not begun soon enough ; it ought to begin in the very lowest classes, and not be left till the child has reached the fifth standard. No doubt there are members present who can tell us what is done in the other States of the Commonwealth.

It is not in the State Schools, however, but in the secondary schools, especially those for boys, that music is most neglected. I shall be glad to be set right if I am in error, but as far as I can ascertain there is no thorough and systematic teaching of sight singing in any of our secondary schools. There may be singing classes for those boys who are willing to join ; and the whole school may be taught by ear to sing a few school songs. But it is not recognised that the teaching of singing should begin in the lowest class and should be continued right through the school ; and that as much time should be devoted to it as to any other subject in the curriculum. It is still regarded as an extra—a mere accomplishment, not worth serious attention, and not as a fundamental part of every child's education.

The reason for this we all know. Music is not a compulsory subject at any of our public examinations ; and the secondary schools live for and by the results of these examinations. There is no time for anything which does not help to swell the number of passes and distinctions to be reported at the school speech day, and the parents will have it so. The junior and senior public examinations in music are only intended for students who are going on with musical studies, and the stress is laid, not upon reading and sight singing, which are the really important things, but upon theory and technical proficiency in the performance of specified songs and solfeggi. I do not propose to add singing of the sort I am advocating to the subjects of University examination. For heaven's sake let us keep one of the muses at least free from this universal prostitution. I recognise, too, that under present conditions no serious attention can be given to music in the higher forms, which are necessarily dominated by the examinations. But as a compromise, I would suggest that reading and sight singing should be begun as soon as a boy comes to school and continued until at any rate the fifth form is reached. By that time he would have gained what I regard as the essential matter—the power to read and sing at sight, and he might then drop music as a school subject, though facilities might be afforded for a voluntary singing class for those who wanted to keep up their knowledge by practice.

The most formidable difficulty in the way will be the securing of competent teachers. It is a counsel of perfection, I fear, to suggest that no one should be registered as a secondary teacher who cannot read music ; though there is nothing inherently more drastic in this demand than in requiring that every teacher should be able to read print and writing. Certainly it would be best that every form-master should teach singing to his own form ; but until the increase of musical cultivation has made this possible, it will probably be necessary to have a music teacher for the whole school. But it is essential that the form should be taught separately, so that the needful individual testing may be applied. If the whole school is taught together, most of the boys will just sing by ear and imitation, and some will not bother to sing at all. One of the most practical steps that could be taken would be the formation of a Music-teachers' Association on the lines of the one which was initiated in London two years ago, the objects of which are stated as follows :—

The motto " No examinations " is inscribed on the banner of the Music-Teachers' Association. The following are its stated objects :—

(i.) To promote progressive ideas upon the teaching of music, especially with a view to the more educative treatment of the subject in schools.

(ii.) To press upon heads of schools, and to stimulate and maintain amongst teachers, a recognition of the important and often overlooked fact that music is a literature, and should be taught and studied from that point of view.

(iii.) To insist most strongly—as a preparation for this " art of listening " —upon the necessity of systematic ear-training from early childhood.

(iv.) To promote class-singing, in which singing at sight shall be the chief aim, as an invaluable means of ear-training and of the cultivation of rhythmic and melodic perception.

(v.) To realise that the amount of time at the disposal of the average boy or girl for the overcoming of the technical difficulties of an instrument is, in the nature of things, usually insufficient to make them even passable executants, and therefore that it would be a wise thing to devote a certain amount of time to bringing the pupils into living touch with music itself, by means of carefully graded classes, in which the teacher should play to the pupils, giving them a simple and intelligent description of the form and character of the music, asking questions from time to time, in order to ascertain how much has been grasped by the class.

In conclusion, let me say that it is not the production of a Melba or an Ada Crossley or any number of similar great artists that will warrant us in claiming that Australia is a musical country, but the general diffusion of such musical knowledge as I have tried to indicate, amongst all classes of the community. " All deep things," says Carlyle, " are Song. It seems somehow of the very central essence of us, Song ; as if all the rest were but wrappings and hulls. The primal element of us ; of us and of all things. The Greeks fabled of Sphere-harmonies ; it was the feeling they had of the inner structure of Nature ; that the soul of all her voices and utterances was perfect music. See deep enough and you see musically—the heart of Nature *being* everywhere Music, if you can only reach it."

PAPERS READ IN SECTION J.

1.—SOCIOLOGY IN AUSTRALIA: A PLEA FOR ITS TEACHING.

By PROFESSOR FRANCIS ANDERSON, M.A., University of Sydney.

(ABSTRACT)

THE aim of the paper is not to deal with any special problem, but with the general importance of Sociology as the new science of Society.

Biology was the science of the nineteenth century; sociology seems destined to be the science of the twentieth century. Society is now being roused to a sense of its own importance and of the need of social security through social efficiency and social justice. The new science deals with the laws and processes of society in the making, and Australasia is a new society in the making. The material in Australia for sociological investigation is abundant, and it attracts every year students from European and American Universities, but there is no school of sociology in any Australian University, or apparently any expert capable of taking charge of one.

The duty of establishing a Chair of Sociology in the national University is incumbent on the national Government. Provision for the teaching of the new science is required, not only in the interest of the advancement of knowledge, but in order to supplement and broaden the intellectual discipline at present available to University students.

2.—THE SOCIOLOGICAL CONCEPT OF EDUCATION.

By C. H. NORTHCOTT, B.A.

(ABSTRACT)

ALONG with the evolution of Society there has come a gradual divergence of the subject matter of education from the conditions obtaining in real life. In the earliest days the child's share in social life—in the fishing and hunting at any rate—constituted his education. Later on the social customs and practical activities of the farm and guild workshop still supplied the bulk of the education. To-day, however, the social co-operation and social oversight of the simpler stage have been replaced by the isolation, exclusiveness, and disciplinary laxity of family life in the city The situation has also been complicated by industrial conditions. The "blind-alley" occupations have produced a vast army of youths whose education at the age of manhood, and viewed from the standpoint of social adaptation and efficiency, can be described only as a hollow sham. Nor are those who enter trades better off. Minutely subdivided labour has become monotonous and makes small demands upon the intelligence of the worker.

The teaching of Sociology reveals man as a social being who finds his highest life and noblest purposes in his responsibility to society, and whose welfare depends on his power of effective co-operation with other social units. This teaching has shifted the centre of educational theory. Instead of proposing as the end of education the harmonious development of the powers of the individual, we should rather seek to adjust him to his environment that he may master the world of experience the more easily and accurately. The age is practical, and tests institutions by a pragmatical standard of values. The popular imagination, too, is beginning to feel that a close connection exists between democracy and education. It is true that the schools are making an attempt to train their pupils in a sense of responsibility and self-direction; but some of the best schoolmasters of England are acknowledging the practical failure of this attempted training in social habits and social co-operation. Among the real remedies enunciated by them are "a closer connection between the school and the outside world" and "the reconstruction of curricula and the improving of teaching methods." Very important, too, is the demand that education should create habits and interests that will enable the developing youth to use the large amount of time which the industrial life of to-day, with its shorter hours of labour, places at his disposal. Until education has made the leisure hours of adolescence interesting, they will remain only a moral danger and a social menace. Three practical aids to the realisation of this organic concept of education would be found in the reform of teaching methods, a revision of the curriculum, and the effective organisation of trade and continuation schools.

3.—A PRELIMINARY STUDY OF RETARDATION IN THE ELEMENTARY SCHOOL.

By PROFESSOR A. MACKIE, M.A., Principal, Teachers' Training College, Sydney.

(Abstract)

During the past few years the problems connected with the rate of progress of children through the Elementary School have received much attention from American investigators. A preliminary investigation of the statistics of certain Sydney schools has shown the need for further study of the question in New South Wales. The paper discusses the methods of measuring retardation, examines the amount of retardation in typical schools and groups of schools, and offers a preliminary analysis of the causes of retardation. The percentage of retardation to class enrolment increases markedly from the first to the fifth class, and the investigation so far made appears to show that there is an excessive percentage of retarded children in each class beyond the first. As a result of the examination of 100 retarded children, it is clear that the number of over-age children is capable of considerable reduction by appropriate administrative measures and by changes in the curriculum and organisation of the schools.

4.—THE CURRICULUM OF THE ELEMENTARY SCHOOL.

By E. A. RILEY, M.A., Inspector of Schools, N.S.W.

(ABSTRACT.)

Scope of Education.—Education must give knowledge to the outer world, of humanity, and of the self; must train in right activity in this threefold direction, and inspire enthusiasm for the realisation of human ideals; what cannot function in the pupil's life now or hereafter should be excluded.

Limitations of the Curriculum.—The curriculum is limited in the first place by the quality and stage of development of the pupil's mind. The second limitation is furnished by the number of years which can be devoted to the gaining of an education. Everywhere this period is being pushed further into the adolescent years. A six-year elementary course, as is the case in New South Wales, is the best. At about twelve years of age logical power and vocational interests develop, and the pupil is ready to pass to the high or the vocational school. A third limitation is furnished by the child's life experiences, which furnish the basis for the interpretation of all other parts of the curriculum. A grave sin of the school has been its exclusion of the bulk of the child's natural, industrial and social experiences.

Increased Study of Environment Necessary.—The curriculum is overweighted with traditionary matter. Nature study is narrowly conceived, as by the country teacher who would not do much in nature study because beans were hard to get. In any case, the term is too narrow, and a new term, say, *Environmenta*, is needed to include Nature Study, Home Geography, parts of Civics, many applications of Arithmetic, besides much that relates to the homes and the industries and occupations of the community, and which is at present excluded from the school.

The Kindergarten Curriculum a Model for the Elementary.—The only curriculum adequately conceived is that of the kindergarten, which is based on man's need for food, shelter and clothing, on the material side, on social relationships on the moral and spiritual sides, and which provides for knowledge, training and inspiration. The curriculum of the elementary school should be conceived on exactly similar lines. Besides the traditionary subjects, it will contain such topics as food, shelter, clothing, production, transportation, manufacture, trade, communication, local government, and so on.

Environmenta.—In a pastoral district, Mary's lamb will follow her to school and will set the children not laughing, but studying sheep stations, paddocks, fences, bore drains, grass and herbage, drought and floods, land tenure, land taxes, shearing, transportation of sheep and wool, wool sales, wool buyers, frozen mutton, and so on, almost without limit. The study of the management of a bore will enable pupils to understand all important principles of taxation. The determination as to whether it pays to keep a cow will give better arithmetic than that furnished by the study of

H. C. F. The study and production of a butter cooler is typical of school work which will hasten the coming of the Country Home Comfortable.

Psychological Limitations.—Psychology calls for the exclusion from the elementary school curriculum of subjects which need developed logical powers for their comprehension. Grammar should be replaced by practical language teaching and composition; all theory of music, except such as will enable the pupil to turn black marks into a song, must go; hygiene and first aid must replace physiology; botany must give way to horticulture and agriculture, and so on all along the line.

Curriculum to Reflect all Major Activities of the Community.—Our complex civilisation demands a curriculum which reflects all its major elements, while psychology forbids the premature introduction of matter beyond the pupils' comprehension, and the time limitation forces strict selection to prevent overcrowding. No ideal solution, therefore, is possible, and the compromise thus necessitated calls for fairly frequent revision of the curriculum.

5.—THE PLACE OF THE PHILOSOPHICAL SCIENCES IN EDUCATION.

By the REV. E. N. MERRINGTON, M.A., Ph.D.

(ABSTRACT)

I.

EVERY subject in the higher education is worthy of its place, and philosophy recognises this fact. But in order to realise the true ideal of University education the philosophical sciences must be encouraged and advanced. More than acquisition of knowledge and technical training is required for the ends of culture, namely a spirit of "illumination" (Newman) and orientation of all the sciences and liberal studies. This is the "philosophical habit" which is essential to the ideal of the higher education. In comparison with other countries, Australasia has made slight provision for these subjects, although they are very necessary to our development. The new Universities in Australia seem to be without provision for such teaching. The tendency is in the direction of technical education. But there is no fundamental antagonism between the so-called "liberal" and the "useful" studies. Efficiency in the long run implies the trained mind and the wide horizon.

II.

Philosophy is a general name for a number of studies whose methods are scientific in the sense that they are rational, systematic and adapted to their special fields of human thought and action.

In two possible directions instruction in these philosophical sciences may be extended, viz, in (*a*) post-graduate courses, (*b*) secondary schools. Post-graduate courses have everything to commend them. A graduate school, such as those which exist in America, should be established in one of the Australian Universities. In regard to the secondary schools, the question of the introduction of elementary logic is worthy of consideration. But perhaps psychology and applied logic might serve educational ends better. If psychology were introduced into the schools, it should be taught along with at least two of the natural sciences, in order that the dangers of too much introspection at a susceptible age might be avoided. Applied logic might be a very useful subject in the schools.

III.

As to the place of the philosophical sciences in University studies, the needs of students are relative to three principal aims, which may be distinguished for purposes of analysis –(1) Professional and technical training, (2) scientific research, (3) liberal education as in Arts course. Each of these classes of needs implies training in one or more of the philosophical sciences. (1) This includes provision for developing future lawyers, clergymen and teachers. Logic is a direct part of this preparatory course. Similarly all philosophical disciplines should train the mind to professional efficiency. The scientist also is improved by a knowledge of the theory of scientific method, which belongs to the general study of logic. (2) Scientific investigation which aims at knowledge for its own sake cannot omit psychology, the science of the phenomena and states of consciousness. There has of late been immense labour and progress in this field. Psychology is now divided into many sub-sciences. Experimental psychology has been greatly developed; and in Germany, America, France and England psychological laboratories have been established. Australasia has not one as yet. (3) This brings us to the liberal side of University education, and here philosophy as metaphysic is still needed, if only to criticise and interpret the data, concepts and principles of the physical and psychical sciences. It is the arbiter among the sciences. It seeks the unity of knowledge. The influence of philosophy is as a leaven of reason and spirituality in education and life. This aspect of culture is fostered, too, by ethics and æsthetics. Philosophy is the propædeutic to the study of theology. In our day science, history, theology, literature and art are looking more than ever towards philosophy for an interpretation of their data, a commentary upon their methods and results, and a statement of final principles. So, also, national development requires that our people be trained to the use of ideas and to guidance by ideals. Our lack of an expert teacher in sociology, to which Professor Anderson referred, is only characteristic of our general neglect of the study of principles.

In peace or in war—and the latter may ere long be our experience—the plan of philosophical discipline still holds good. Train the people to look before and after. In a thousand ways philosophy brings reinforcements to progress, because it emphasises the things that are unseen and eternal. As an instance of its influence in the conflicts of life, commerce, and even war, one recalls the pronouncement of a French officer after the tragic end of the campaign with Prussia, quoted by the Bishop of Ripon in his History of the Church of England—"Not only have we seen German generals triumph over French armies, but we have seen also the triumph of the speculative geniuses of Germany, of those who during the last century have given an impetus to German literature, philosophy and science and, *ipso facto*, to 'public spirit'; we have been defeated by Kant and Fichte, by Gœthe and Schiller, by Alexander and William von Humboldt, by Gauss and Helmholtz, as well as by Bismarck and Moltke."

6.—THE PLACE OF THE HISTORY OF EDUCATION IN THE TRAINING OF TEACHERS.

By Dr. PERCIVAL R. COLE, Vice-Principal, Sydney Teachers' College.

(Abstract.)

In the normal schools and teachers' colleges of the United States there is no professional subject as generally insisted upon as the history of education. The college course in the history of education may be dominated by any one of three motives. Firstly, it may be viewed as a discipline in the patient extrication and elucidation of educational facts from historical sources. Secondly, it may be elevated to the height of a fountain of culture. Thirdly, it may be subordinated to the purpose of professional utility. In the Sydney Teachers' College, there is no attempt to subdivide the course in the history of education, so as to allot this portion to the interests of culture, that to professional utility, and that to discipline in research; but wherever the three motives enter into any sort of competition, the mere exercise of diligence in the collection of facts is minimised. Such a discipline, however, would be admirable for graduate students.

On the whole, the attempt to stir up a triangular rivalry between culture, utility and pure science in the field of the history of education would be to mistake the fundamental meaning of the history of education itself. The question of the value of the subject resolves itself into the general question of the value of the historical method in any field. Imagine political theory without political history, law without the chronicles of early codes, psychology stripped of genetic studies, ethics apart from the history of morals, philosophy without the history of philosophy, and you have a picture of educational theory without the history of education. It is not easy to determine the exact and proper scope of the subject. If, however, education may be defined as the process by which the

more mature members of society attempt to train and instruct the less mature members, in the interests of conformity, to a set of social standards and the individual achievement of certain social acquisitions, then the study of the history of education will be of the nature of a dual process involving firstly the estimation of the standards and culture of this and that age and people, and, secondly, the characterisation of the methods and institutions by which these ages and peoples have attempted to educate successive immature generations.

7.—THE UNIVERSITIES AND THEIR INFLUENCE ON THE CURRICULA OF THE SCHOOLS.

By PROFESSOR CARSLAW, D.Sc., University of Sydney.

(ABSTRACT.)

THE Universities must have some security for the previous training of those who wish to enter their classrooms, but the conditions which they impose affect the work of many who will never pursue their studies at the Universities. A tendency in England and elsewhere to substitute for a University Entrance Examination a school-leaving examination. This question to form one of the topics to be discussed at the Imperial Universities' Conference in London in 1912. Also the confusion which is caused by the different standards required in the several Universities.

The evil influence which some of the regulations for the English examinations have had upon the schools. Compulsory Latin and Greek still required at Oxford and Cambridge from almost all those proceeding to a degree in those Universities. The effect of this regulation upon the English schools. Influence of the Board of Education, and the other English Universities, in modifying the school curricula. The neglect of the study of elementary natural science in the schools, and the importance of some change in this respect. The crowding out of the school time-table of proper work at modern languages owing to the large amount of time given to the other subjects.

The position in Australia. The governing bodies influenced by the former customs of other Universities which have been changed in recent years. The different regulations in force in Queensland, New South Wales, Victoria, and South Australia will prevent closer co-operation among the Universities and cause confusion in the schools.

Effect of compulsory Higher Latin. Tendency towards premature specialisation in the schools. The schools should give a broad, modern or classical and liberal education. Specialisation to be reserved for the Universities. Increased importance of the work by the departments of Public Instruction in determining the curricula of the schools.

8.—THE PRESENT POSITION OF PROBLEMS OF PSYCHOLOGY.

By BERNARD MUSCIO, B.A.

(ABSTRACT.)

THE paper opened with reference to the logical development which had taken place in the subject matter of science. Inorganic nature had been treated first; then organic; lastly, mind. But even when mental life had thus won recognition by logical development, psychology was very hampered. The obstacles were mainly three:—(1) A prior and engrossing interest in inorganic nature; (2) interference in the construction of free hypotheses by a theological tradition, especially in regard to free will which could not allow, *e.g.*, psycho-physical causality; (3) the use of an unscientific nomenclature, which was connected with the unique nature of the subject matter, and the fact that psychological treatises were frequently written for popular approbation.

But psychology now stood in an exactly similar position to that of the other positive sciences. Its aim is the analysis of psychical phenomena into atomistic elements and the statement of their laws of active relationship.

Psychology had received a large amount of amorphous treatment; but among the mass of psychological talk and literature, certain problems were becoming distinct. These were mainly of three types:—(1) The influence of physiology had given rise to a two-sided hypothesis: (*a*) that every psychical modification had a distinct physiological correlate; (*b*) that every physiological modification had a distinct psychical correlate. Hence arose the problems of physiological-psychology. (2) Biology and the evolution theory had led to the attribution to man of a crowd of instincts, such being defined as psycho-physical tendencies. This had important consequences for certain theories of conduct and education. To follow instinct, then, turned out to be the acceptance of the standards of a long and indefinite line of ancestry rather than the ideals of reason. (3) Sociological influence had given rise to the problem of the dependence of the individual's mental life on society. In this the most important factor was suggestion, and hence this was one of the chief problems of social psychology.

Psychology then, at the present time, stands thus:—(1) It has, by logical development, come to receive scientific attention; (2) it has freed itself for the construction of any hypothesis whatsoever; (3) it is beginning to acquire an exact nomenclature. These represent so much vehicular accommodation.

As to its future, this has been largely determined by the influence of (*a*) physiology, (*b*) biology, and (*c*) sociology.

9.—THE EVOLUTION OF GIRLS' EDUCATION.

By Miss ALLMAN MARCHANT, M.A., Principal of Otago Girls' High School, Dunedin, N.Z.

(ABSTRACT.)

THIS paper sketched the position of women in ancient Egypt, Greece and Rome, and the effects of the teaching of Christianity on women's place in the social world. The outburst of culture of the Renaissance brought women to the fore, while the Reformation put her back again into the domestic sphere. The Teutonic ideals gave our forefathers a respect for womanhood, but our English system of education for women was very meagre till late on in the eighteenth century, though men like Steel and Defoe had warmly advocated woman's claims to educational rights equal to those of men. The growing recognition of this can be traced in literature through Jane Austen, Charlotte Bronté, Scott and Dickens. In Tennyson's Princess and in Ruskin the modern ideas were developed, while in practice Miss Buss and Miss Beale established the modern girls' schools. This system had had distinguished success, but a reaction had set in, and the question now is whether the old literary standards are to be discarded for a more modern course of work. There are many drawbacks, but great caution must be observed before changes can be made. The paper concluded with a sketch of Ibsen's and Meredith's attitudes towards women's rights.

10.—THE WORK OF THE INTERNATIONAL PHONETIC ASSOCIATION.

By Miss SYMONDS.

(ABSTRACT.)

THE International Phonetic Association was founded in 1886 to advance the scientific study of spoken language. It has branches in England, France and Germany. It claims that a student of a foreign language, with the aid of phonetics, will readily acquire a good pronunciation, and that imperfections of the native speech can be corrected by this means. Phonetics is the study of speech sounds, In order to promote the study of speed sounds, a phonetic notation has been adopted. This necessity is caused by the fact that the orthography of most languages, though once phonetic, is now distinctly not so. The phonetic notation is arranged on the basis of one sign for each sound, and after a short period of study this proves itself to be of the utmost value and help. After a thorough understanding of the sounds of a language has been acquired, the Association recommends for further study the " Direct

Method." This is first to study sentences, everyday idioms, to read books, grasping and observing grammatical facts in these studies, but to leave a more systematic study of construction, etc., until later. Reference to the native tongue is entirely omitted, the instruction being given in the language in question, and translation in all forms are left for a much later time in the course. The direct method follows the means by which a child grasps its native tongue, which is by imitation ; but as much of this ease and power of imitation flies with childhood, those of riper years require scientific aid. The difficulty of knowing what is the correct pronunciation of a language has been surmounted by settling on a standard pronunciation of every language phonetically treated. The standard German is that of the German stage ; the standard French that pronunciation heard in the districts round Paris ; and standard English is that spoken by the educated in London and the neighbourhood. The training for the acquirement of a phonetic understanding consists mainly of practical exercises in sounds and sound combinations ; a theoretical knowledge as to how these are formed ; phonetic dictations ; reading aloud from the phonetic notation, and a study of intonation, duration, stress, etc. By these means undesirable peculiarities and artificialities of speech are corrected. With regard to acquiring a good pronunciation, the same phonetic drillings are necessary ; comparison between the native language and that being studied, with practical exercises in the unfamiliar and dissimilar sounds and peculiarities are a most important feature in this branch.

MUELLER MEMORIAL MEDAL.

On 6th January, 1898 (see Vol. VII., p. XLII.), certain gentlemen were appointed a committee to suggest means for the establishment of a memorial in honour of the late Baron von Mueller. On the 12th idem (see p. XLIX.) certain resolutions were passed.

On the 30th December, 1901, Mr. T. S. Hall wrote (Vol. IX., p. LV.) stating that the Committee of the Mueller National Memorial Fund had collected about £450, and that it had been decided to found a Mueller Memorial Medal.

The Regulations for the Mueller Medal Fund were then set out (p. LV.). At p. XLVII. it is recorded that the trust was accepted by the Association.

At p. LVI. the names of the original Mueller Medal Committee are given, viz. :—The President (*ex officio*), and the permanent Honorary Secretary (*ex officio*), Professor W. Baldwin Spencer, M.A., F.R.S. ; J. W. Gregory, D.Sc., F.R.S. ; E. F. J. Love, M.A., and J. H. Maiden.

In Vol. X., p. XXV., the name of Dr. (Professor) E. C. Stirling was substituted for that of E. F. J. Love.

In Vol. XI., p. XXX. the name of Professor Skeats was added to the Committee, and the name of Mr. Love was inadvertently printed for that of Professor E. C. Stirling.

The Mueller Medallists.

1904.—Howitt, A. W., D.Sc., of Metung, Victoria, "for his distinguished researches as an enthnologist and geologist, and for his explorations in Central Australia." (See Vol. X., p. XXX.).

1907.—Hill, J. P., D.Sc., of University College, London (formerly of Sydney), for his researches in Australian Zoology. (Vol. XI., p. XXV.).

1909.—David, T. W. Edgeworth, B.A., F.R.S., Sydney, "in recognition of his work for the advancement of geology." (Vol. XII., p. XXI.).

1911.—Etheridge, Robert. (See Proceedings in the present volume.)

In publicly presenting the medal to Mr. Etheridge, the President (Professor Orme Masson, F.R.S.) used the following words :—

Mr. Etheridge comes from a scientific stock. His father, Mr. Robert Etheridge, F.R.S., was for many years Palæontologist to the British Museum, and Mr. Etheridge came out to Victoria to join the survey-staff that that State then had under Dr. A. R. C. Selwyn. Mr. Etheridge was engaged in mapping, and surveyed several of the geological quarter-sheets. With the political upheaval of 1878 the survey was swept away by a stroke of the pen on "Black Wednesday," and Mr. Etheridge left Australia.

He was appointed to the Geological Survey of Scotland, and here he met among others his life-long friend, R. L. Jack, formerly Director of the Geological Survey of Queensland. In conjunction with H. A. Nicholson, he wrote several important works on the silurian fossils of S.W. Scotland.

Later on he was appointed to the British Museum, where he had charge of the corals, and in co-operation with Carpenter wrote an important monograph on the Blastoidea, an extinct group allied to the sea-urchins.

About 1888 he was offered the position of Palæontologist to the N.S.W. Department of Mines and the Australian Museum, and during this period he wrote, with Dr. R. L. Jack, their great work on the Geology and Palæontology of Queensland.

In 1893 he resigned his post in the Mines Department and succeeded Dr. E. P. Ramsay as Curator of the Australian Museum, a post he still holds.

His palæontological papers are very numerous and deal with the fossils of every State in Australia, and with those of Natal.

He has long worked at the technological side of the Australian blacks, and has written several papers on their implements and weapons.

Besides this he has compiled several bibliographies on palæontological and ethnological subjects, which are of the greatest value to students.

In conjunction with Dr. R. L. Jack he has been awarded the Clarke Memorial Medal by the Royal Society of New South Wales, and he has been elected an honorary member of most of the Australian scientific Societies, and of very many others in various parts of the world.

The present award has met with the warmest approval of all those familiar with his work.

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AUSTRALASIAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

FOR THE SYDNEY MEETING, 1911

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Date of Election.

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1909. Liversidge, Prof. Archibald, LL.D., F.R.S.

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