OTAGO BOYS' HIGH SCHOOL, DUNEDIN.

REPORT

OF THE

TENTH MEETING

OF THE

AUSTRALASIAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE,

HELD AT

DUNEDIN, 1904.

EDITED BY

GEO. M. THOMSON, F.L.S., F.C.S.

Dunedin:
PUBLISHED BY THE ASSOCIATION.

NEW ZEALAND:
JOHN MACKAY, GOVERNMENT PRINTER, WELLINGTON.

1905.

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OFFICERS FOR THE DUNEDIN MEETING,

JANUARY, 1904.

PATRON:

His Excellency the Right Hon. UCHTER JOHN MARK, EARL OF RANFURLY, G.C.M.G.

PRESIDENT:

Professor T. W. EDGEWORTH DAVID, B.A., F.R.S., F.G.S., Professor of Geology, University of Sydney.

RETIRING PRESIDENT:

Captain F. W. HUTTON, M.A., F.R.S., F.G.S., C.M.Z.S., Canterbury Museum, Christchurch.

VICE-PRESIDENTS:

H. C. RUSSELL, B.A., C.M.G., F.R.S., F.R.A.S., Sydney (1888).
Sir JAMES HECTOR, M.D., K.C.M.G., F.R.S., Melbourne (1890).
Hon. A. C. GREGORY, C.M.G., F.R.G.S., M.L.C., Brisbane (1895).
Professor A. LIVERSIDGE, M.A., LL.D., F.R.S., Sydney (1898).
R. L. J. ELLERY, C.M.G., F.R.S., F.R.A.S., Melbourne (1900).

PERMANENT HON. SECRETARY:

Professor A. LIVERSIDGE, M.A., LL.D., F.R.S., University, Sydney.

HON. GENERAL TREASURER:

DAVID CARMENT, F.I.A., F.A.A., Sydney.

HON. SECRETARY FOR THE DUNEDIN SESSION:

GEO. M. THOMSON, F.L.S., F.C.S., Newington, Dunedin.

HON. TREASURER FOR THE DUNEDIN SESSION:

J. SINCLAIR THOMSON, Manager, National Bank of New Zealand, Dunedin.

HON. SECRETARIES FOR THE OTHER COLONIES:

New South Wales: Professor A. LIVERSIDGE, M.A., LL.D., F.R.S., the University, Sydney.
Victoria: E. F. J. LOVE, M.A., F.R.A.S., the University, Melbourne.
Queensland: JOHN SHIRLEY, B.Sc., District Inspector of Schools, Brisbane.
South Australia: Professor E. H. RENNIE, M.A., D.Sc., the University, Adelaide; Professor W. H. BRAGG, M.A., Adelaide.
Tasmania: ALEXANDER MORTON, F.L.S., the Museum, Hobart.

Ex-Officio Members of the Council:

The Council consists of—(1) Present and former Presidents, Vice-Presidents, Treasurers, and Secretaries of the Association, and present and former Presidents, Vice-Presidents, and Secretaries of the Sections who are subscribing members for the present meeting; (2) members of the Association delegated to the Council by scientific societies; (3) authors of reports or of papers published *in extenso* in the Annual Reports of the Association.

Trustees (Permanent):

R. L. J. Ellery, C.M.G., F.R.S., F.R.A.S.
Professor A. Liversidge, M.A., LL.D., F.R.S.
H. C. Russell, C.M.G., B.A., F.R.S., F.R.A.S.

Auditors:

R. Teece, F.I.A. R. A. Dallen.

Publication Committee:

The Hon. Secretary and Hon. Treasurer for New Zealand, and the Secretaries of Sections.

Recommendation Committee:

Professor T. W. E. David, B.A., F.R.S., F.G.S.
Professor W. B. Benham, M.D., D.Sc.
Professor W. H. Bragg, M.A.
Professor Baldwin Spencer, M.A., F.R.S.
G. M. Thomson, F.L.S., F.C.S.
A. Morton, F.L.S.
H. Deane, M.A., M.Inst.C.E.
J. Shirley, B.Sc.

Reception Committee for Dunedin:

(The Reception Committee consists of members of the Local Committee, together with representative gentlemen resident in the city and suburbs, elected by the Local Committee.)

Chairman: Most Rev. S. T. Nevill, D.D., Bishop of Dunedin, Primate of New Zealand.

Vice-Chairman: His Honour Mr. Justice Williams.

Allen, James, B.A., J.P., M.H.R.
Arnold, J. F., J.P., M.H.R.
Barnett, Dr. L. E.
Barr, G. M., C.E.
Barron, David.
Bathgate, Alexander.
Batchelor, Dr. F. C.
Bedford, H. D., M.A., M.H.R.
Begg, A. C., J.P.
Benham, Professor W. B., M.A., D.Sc.
Blomfield, Dr.
Brown, Thomas.
Burnside, J. A.
Burt, Alexander, J.P.
Butterworth, Charles P. M.
Chamberlain, C. W. S.
Chapman, His Honour Mr. Justice.
Chisholm, Robert, J.P.
Closs, Dr. J. O.
Colquhoun, Dr. D.
Cooper, J. S. S., M.A., B.Sc.
Denniston, G. L., J.P.
Duncan, Peter.
Evans, Dr. W.
Fairclough, Rev. P. W.
Fels, Willi.
Fenwick, George, J.P.
Fergus, Hon. Thomas.
Fitchett, Very Rev. Dean, M.A., D.D.
Fulton, Dr. R.
Fulton, H. V.
Glendining, Robert.
Goodman, W. T. G.
Goyen, P., F.L.S.
Hamilton, A.
Hewitson, Rev. W., B.A.

Hosking, J. H.
Israel, G. C.
MacDonald, Dr. W. Marshall.
MacGregor, John.
Marshall, P., M.A., D.Sc., F.G.S.
Melland, E.
Michie, Alexander.
Mills, James.
Moloney, John.
Moore, W. A.
Morris, Colonel C. C.
Nimmo, J. H.
Ogston, Dr. F.
Park, J. A.
Park, Professor J.
Paterson, A. S.
Pearce, T.D., M.A.
Pryde, P. G., J.P.
Ramsay, Keith, J.P.
Reid, Donald, jun., M.H.R.
Reynolds, Leslie H., C.E.
Richardson, Chas. R. D., B.A.
Ritchie, J. M., J.P.
Roberts, John, C.M.G., J.P.
Sale, Professor G., M.A.
Salmond, J. L.
Salmond, Professor W., D.D.
Sargood, Percy R.
Scott, Professor J. H., M.D.
Scott, Thomas, J.P. (Mayor of Dunedin).
Shand, Professor J., M.A., LL.D.
Sidey, T. K., B.A., LL.B., M.H.R.
Sinclair, J. R.
Smith, Lieut. Colonel E. R.
Smith, Hon. A. Lee, M.L.C.
Smith, Dr. W. M.
Stilling, F. J.
Tapper, E. A.
Thomson, J. C.
Verdon, Most Rev. Bishop, D.D.
Waddell, Rev. R., D.D.
Waters, D. B.
White, D. R., M.A.
Whitson, T. W.
Williams, Henry E.
Wilson, A., M.A.
Woodhouse, F. J.

Members of Council nominated by Societies.

New South Wales.

Carter, H. J. (Teachers' Association of N.S.W.).
Docker, His Honour Judge E. B., M.A. (Royal Society of N.S.W.).
Drummond, L. S. (British Astron. Assocn., N.S.W. Branch).
Grimshaw, J. W., M.I.C.E. (Royal Society of N.S.W.).
Halligan, G. H., M Inst.C.E. (Royal Society of N.S.W.).
Weigall, A. B. (Teachers' Association of N.S.W.).

Tasmania.

Legge, Colonel W. V. (Royal Society of Tasmania).
Morton, Alex. (Royal Society of N.S.W.).
Twelvetrees, W. H. (Royal Society of Tasmania).

South Australia.

Bragg, Professor W. H. (Royal Society of South Australia).

New Zealand.

Brown, Professor F. D., M.A., B.Sc. (Chemical Society of London).
Easterfield, Professor F. H., M.A., Ph.D., F.I.C. (Chemical Society of London).
Gray, G., F.C.S. (Chemical Society of London).
Tregear, E. (Polynesian Society).

Officers of Sections.

A. Astronomy, Mathematics, Physics, and Mechanics.

President: Professor W. H. Bragg, M.A., Adelaide.

Vice-Presidents: Professor G. H. H. Cook, M.A., Christchurch; C. W. Adams, C.E., Blenheim; J. W. A. Marchant, Surveyor-General, Wellington.

Secretaries: C. COLERIDGE FARR, D.Sc., Magnetic Survey, Christchurch; J. S. S. COOPER, M.A., B.Sc., High School, Dunedin.

Committee: Professor CARSLAW, Sydney; G. HOGBEN, M.A., Wellington; E. G. HOGG, M.A., Christchurch; Professor J. SHAND, M.A., LL.D., Dunedin; O. U. VONWILLER, B.Sc., Sydney.

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President: J. BROWNLIE HENDERSON, Government Analyst, Brisbane.

Vice-Presidents: Professor EASTERFIELD, Ph.D., Wellington; Professor W. E. EVANS, M.A., B.Sc., Christchurch; Professor FRED. D. BROWN, M.A., B.Sc., F.C.S., Auckland; GEO. GRAY, F.C.S., Agricultural College, Lincoln.

Secretaries: (In absence of Secretaries appointed, Professor EVANS acted.)

Committee: G. T. BILL, M.A., Adelaide; J. C. BRÜNNICH, F.C.S., Brisbane; J. H. HOWELL, B.A., B.Sc., Auckland; Professor MICA SMITH, B.Sc., Ballarat; W. J. CLUNIES ROSS, B.Sc., Sydney.

C.—GEOLOGY.

President: W. H. TWELVETREES, F.G.S., Hobart.

Vice-President: H. HILL, Inspector of Schools, Napier.

Secretaries: P. MARSHALL, M.A., D.Sc., F.G.S., Otago School of Mines; O. G. ADAMS, A.O.S.M., Thames School of Mines; E. K. MULGAN, M.A., Education Department, Auckland.

Committee: Professor J. PARK, School of Mines, Dunedin; Professor T. W. EDGEWORTH DAVID, F.R.S., the University, Sydney; Professor F. W. HUTTON, F.R.S., Canterbury Museum, Christchurch.

D.—BIOLOGY.

President: Colonel W. V. LEGGE, R.A., F.L.S., F.R.A.S., Hobart.

Vice-Presidents: Professor CHAS CHILTON, M.A., D.Sc., M.B., C.M., F.L.S., Christchurch; T. F. CHEESEMAN, F.L.S., the Museum, Auckland; CHAS. HEDLEY, F.L.S., Australian Museum, Sydney; Captain HUTTON, F.R.S., Canterbury Museum, Christchurch; H. SUTER, the Museum, Auckland; Professor A. P. W. THOMAS, M.A., F.L.S., Auckland.

Secretaries: L. COCKAYNE, Ph.D., Wellington; F. W. HILGENDORF, M.A., D.Sc., Agricultural College, Lincoln.

Committee: W. T. ADAMS, Greendale, N.Z.; Professor W. B. BENHAM, M.A., D.Sc., Dunedin; Professor H. B. KIRK, M.A., Wellington.

E.—GEOGRAPHY.

President: Professor J. W. GREGORY, D.Sc., F.R.S., Melbourne.

Vice-Presidents: Hon. C. C. BOWEN, M.L.C., Christchurch; MARTIN CHAPMAN, Wellington; THOMAS TANNER, Napier.

Secretary: J. S. TENNANT, M.A., B.Sc., Ashburton.

F.—ANTHROPOLOGY AND PHILOLOGY.

President: W. BALDWIN SPENCER, M.A., F.R.S., Professor of Biology, University of Melbourne.

Vice-Presidents: Professor J. BROWN, M.A., Wellington; ALEXANDER MORTON, Hobart; S. PERCY SMITH, Matai-moana, New Plymouth; EDWARD TREGEAR, Wellington.

Secretaries: AUGUSTUS HAMILTON, Wellington; W. H. SKINNER, New Plymouth.

G 1.—Social and Statistical Science.

President: (Office not filled).

Vice-President: His Honour Mr. Justice Denniston, Christchurch.

Secretaries: C. E. Adams, B.Sc., Wellington; Donald Reid, Jun., M.H.R., Dunedin.

G 2.—Agriculture.

President: J. D. Towar, Principal, Roseworthy Agricultural College, South Australia.

Vice-Presidents: J. A. Gilruth, M.R.C.V.S., Chief Veterinarian and Bacteriologist, Wellington; T. W. Kirk, Department of Agriculture, Wellington; Henry Matthews, Forestry Department, Dunedin.

Secretaries: H. V. Fulton, Dunedin; Henry Wilkie, F.R.C.V.S., Dunedin.

Committee: A. C. Begg, Dunedin; A. D. Bell, Shag Valley, N.Z.; J. C. Blackmore, Wellington; W. Burnett, Dunedin; W. C. Cato, Hobart; Geo. Gray, F.C.S., Canterbury, N.Z.; F. W. Hilgendorf, M.A., B.Sc., Invercargill; John Roberts, C.M.G., Dunedin.

H.—Architecture, Engineering, and Mining.

President: H. Deane, M.A., M.Inst.C.E., Public Works Department, Sydney.

Vice-Presidents: Howard Jackson, Blue Spur, Lawrence; Professor R. J. Scott, M.Inst.Mech.C.E., Christchurch.

Secretaries: G. M. Barr, M.Inst.C.E., Dunedin; S. Hurst Seager, A.R., Inst.Br.Arch., Christchurch.

I.—Sanitary Science and Hygiene.

President: Dr. Frank Tidswell, Department of Public Health, Sydney.

Vice-Presidents: Dr. J. M. Mason, Department of Public Health, Wellington; Dr. E. Jennings, Christchurch; Dr. P. A. Lindsay, Auckland.

Secretaries: Dr. W. Evans, Dunedin; Dr. W. Marshall Macdonald, Dunedin.

J.—Mental Science and Education.

President: John Shirley, B.Sc., Inspector of Schools, Brisbane.

Vice-Presidents: Professor T. G. R. Blunt, M.A., Christchurch; Geo. Hogben, M.A., Education Department, Wellington; His Honour Sir Robert Stout, K.C.M.G., Wellington; Right Rev. Bishop Wallis, D.D., Wellington; T. S. Weston, New Plymouth.

Secretaries: William Gray, M.A., Inspector of Schools, Wanganui; T. D. Pearce, M.A., Rector, High School, Invercargill; C. R. D. Richardson, B.A., Inspector of Schools, Dunedin.

Committee: H. J. Carter, B.A., Sydney; W. S. Fitzgerald, Dunedin; P. Goyen, F.L.S., Dunedin; Jas. Reid, Milton, N.Z.; D. R. White, M.A., Dunedin.

OBJECTS AND RULES OF THE ASSOCIATION.

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 Colonies 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.

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 subscriptions.
4. Ladies' 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.

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 intrusted to the Local Committee.

Council.

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, 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.
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 colonies by Local Committees. The Local Committee of each colony shall consist of the members of Council resident in that colony.

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 by the Council.

Reception Committee.

10. The Local Committee of the colony in which the session is to be held shall appoint 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 volumes 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 colony, and be 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 colony in which the next ensuing session is to be held, which shall have power to expend money collected or otherwise obtained in that colony. Such disbursements shall be audited, and the balance-sheet and the surplus funds be 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 colony 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 annually 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. Committees and individuals to whom grants of money have been intrusted 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 money 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.
C.—Geology and Mineralogy.
D.—Biology.
E.—Geography.
F.—Ethnology and Anthropology.
G.—Economic Science and Agriculture.

H.—Engineering and Architecture.
I.—Sanitary Science and Hygiene.
J.—Mental Science and Education.

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 colony 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 Organizing 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 Organizing 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 Committees 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.

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 Committees 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.

33. 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 number 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 Secretaries 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.

Publication Committee.

38. 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. No alteration 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 Association.

BALANCE-SHEETS, DUNEDIN SESSION, 1904.

Australasian Association for the Advancement of Science.

Victoria.

Dr.		£	s.	d.
1903.	To Balance in bank, 21st January, 1903 ..	1	12	6
	Cash in hand..	0	19	7
	Seventy-seven subscriptions for Dunedin meeting, 1904	77	0	0
	Extra shillings and exchanges	0	10	6
	One (overdue) subscription for Hobart meeting, 1902	1	0	0
	One copy of Report (Vol. viii.) and postage	1	1	3
	Refunds of postages	0	1	6
		£82	5	4

Cr.		£	s.	d.
1903.	By Tate and Co.	1	5	6
	Carrier	0	1	6
	Ford and Son, outstanding account (1900)	0	12	6
	Ford and Son, printing	0	8	6
	Advertisements	0	12	0
	Cablegram	0	6	0
	Postage and duty stamps	0	17	2
	Exchange on cheques	0	4	0
	Bank charges and cheque book	0	12	0
	Refund of one subscription (A. Card) ..	1	0	0
1904.	Ford and Son, receipt-books	0	10	0
	Postage	0	0	10
	Cheque to Sydney	70	0	0
	Auditor's fee	1	0	0
	Cash in hand..	0	13	7
	Balance in bank	4	0	9
		£82	5	4

Audited and found correct.
(Signed.) E. H. Sugden.

E. F. J. Love,
Local Secretary.

BALANCE-SHEETS, DUNEDIN SESSION, 1904—*continued*.

SOUTH AUSTRALIA.

Dr.	£	s.	d.	Dr.	£	s.	d.
To Balance in savings-bank from Hobart meeting ..	0	10	0	By Cost of distribution of Hobart volumes ..	1	14	6
Interest, savings-bank	0	15	7	Carriage on three Hobart volumes . ..	0	6	9
Thirty-eight subscriptions at £1	38	0	0	Stationery	0	7	6
				Advertising	5	15	10
				Postage and telegrams	0	13	6½
				Remittance to Sydney, including exchange ..	25	2	6
				Balance in savings-bank	5	0	0
				Cash in hand	0	4	11½
	£39	5	7		£39	5	7

(Signed.) EDWARD H. RENNIE.
W. H. BRAGG.

QUEENSLAND.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Forty-four subscriptions at £1	44	0	0	By Freight and charges on Tasmanian proceedings, Vol. ix.	1	1	6
				Postage on Vol. ix.	0	19	0
				Stamps	1	5	0
				Stationery	0	10	0
				Remittance to Honorary Treasurer	40	4	6
	£44	0	0		£44	0	0

JOHN SHIRLEY, Honorary Secretary.

Balance-sheets, Dunedin Session, 1904—*continued.*

Hobart.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Subscriptions	34	0	0	By Stationery	1	18	6
				Postage and telegrams	2	10	0
				Exchanges	0	8	0
				Advertising and printing	3	10	0
				Draft to Sydney	25	0	0
				Cash in hand	0	13	6
	£34	0	0		£34	0	0

Alex. Morton, Local Secretary.

Dunedin.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance in hand, 4th June, 1903	0	16	7	By General printing, advertising, and office rent	176	18	0
Subscriptions: 324 at £1	324	0	0	Entertainments	549	9	11
〃 378 at 5s.	94	10	0	Expenses of meeting	79	8	8
Government subsidy	500	0	0	Clerical assistance	41	3	6
Returns from excursions, lunch and tea tickets, and sale of handbooks	119	5	0	Audit fee	2	2	0
				Exchange on cheques, bank charge, and cheque-book	2	17	6
				Postage-stamps	0	15	0
				Draft to Sydney	180	0	0
				Exchange on draft	0	18	1
				Bank balance	3	16	10
				Cash in hand	1	2	1
	£1,038	11	7		£1,038	11	7

J. Sinclair Thomson, Honorary Treasurer.

C. Grater, Auditor.

GENERAL BALANCE-SHEET, SYDNEY OFFICE.

THE HONORARY TREASURER IN ACCOUNT WITH THE AUSTRALASIAN ASSOCIATION.—DUNEDIN SESSION.

CASH STATEMENT, 1ST JANUARY, 1903, TO 30TH JUNE, 1904.

DR.	£	s.	d.	£	s.	d.
To Balance in bank, 31st December, 1902 ..				13	5	4
Subscriptions—						
New South Wales members ..	175	0	6			
Victoria „ ..	70	0	0			
South Australia „ ..	25	0	0			
Queensland „ ..	40	4	6			
Tasmania „ ..	25	0	0			
New Zealand „ ..	180	0	0			
				515	5	0
From Tasmania for 1902 Session—						
New South Wales members ..	26	0	0			
Tasmanian „ ..	57	6	8			
				83	6	8
Sale of President's Address (1902)				0	10	0
Donation				1	0	0
				£613	7	0

CR.	£	s.	d.	£	s.	d.
By Clerical assistance, January to December, 1903				45	0	0
Printing and stationery				4	3	6
Petty expenses				4	18	6
Bank charges and exchanges				1	13	1
Expenses of distribution of Vol. ix.—						
Freight and charges	6	11	6			
Postage	26	2	6			
Printing	5	16	6			
Telegrams	0	6	4			
Packing sundries	0	4	8			
				39	1	6
Transferred to Research Fund				500	0	0
Balance in bank, 30th June, 1904				18	10	5
				£613	7	0

General Balance-sheet, Sydney Office—*continued.*

Research Fund.

	£	s.	d.	£	s.	d.
To Amount of Research Fund, 31st December, 1902	1,944	4	9			
Less invested at that date ..	1,898	15	8			
Balance in bank, 31st December, 1902				45	9	1
Interest on mortgage	84	0	0			
" bank deposits ..	11	4	2			
				95	4	2
Transferred from General Account ..				500	0	0
				£640	13	3

	£	s.	d.
By Grant for research	80	0	0
Fixed deposit, November, 1903	201	4	4
" June, 1904	350	0	0
Balance in bank, 30th June, 1904	9	8	11
	£640	13	3

Total investments, 30th June, 1904—

Mortgage ..	£1,400
Bank deposits ..	1,050
	£2,450

Audited and found correct.
ROBERT A. DALLEN.

D. CARMENT,
Honorary Treasurer.

EXTRACTS FROM THE MINUTES.

Wednesday, 6th January, 1904.

First General Council Meeting.

A meeting of the General Council was held in the Boys' High School, Dunedin, at 11.30 a.m.

Present: C. E. Adams, B.Sc. (Wellington), C. W. Adams (Blenheim), O. G. Adams, A.O.S.M., G. M. Barr, M.I.C.E. (Dunedin), W. B. Benham, M.A., D.Sc. (Dunedin), W. H. Bragg, M.A. (Adelaide), F. D. Brown, M.A. (Auckland), C. Chilton, M.A. D.Sc., M.B., C.M., F.L.S. (Christchurch), L. Cockayne, Ph.D. (Christchurch), G. H. H. Cook, M.A. (Christchurch), J. S. S. Cooper, M.A., B.Sc. (Dunedin), T. W. E. David, B.A., F.R.S., F.G.S. (Sydney), H. Deane, M.A., M.I.C.E. (Sydney), His Honour Judge Docker, M.A. (Sydney), L. S. Drummond, F.S.A.A. (Sydney), T. H. Easterfield, M.A., Ph.D., F.I.C., F.C.S. (Wellington), W. E. Evans, M.A., Ph.D., F.C.S. (Christchurch), C. C. Farr, D.Sc. (Christchurch), T. S. Foster, M.A. (Christchurch), H. V. Fulton (Dunedin), Robt. Fulton, M.B., C.M. (Dunedin), G. Gray, F.C.S. (Canterbury), W. Gray, M.A. (Wanganui), Prof. J. W. Gregory, D.Sc., F.R.S. (Melbourne), J. W. Grimshaw, M.Inst.C.E. (Sydney), A. Hamilton (Wellington), G. H. Halligan (Sydney), C. Hedley, F.L.S. (Sydney), J. Brownlie Henderson, F.C.S. (Brisbane), F. W. Hilgendorf, D.Sc. (Canterbury), G. Hogben, M.A. (Wellington), T. W. Kirk, F.L.S. (Wellington), H. B. Kirk, M.A. (Wellington), Colonel W. V. Legge (Tasmania), T. D. Pearce, M.A. (Invercargill), S. Hurst Seager (Christchurch), J. Shirley, B.Sc. (Brisbane), W. H. Skinner (New Plymouth), S. Percy Smith (New Plymouth), W. Baldwin Spencer, M.A., F.R.S. (Melbourne), J. S. Tennant, M.A., B.Sc. (Ashburton), A. P. W. Thomas, M.A., F.L.S., F.G.S. (Auckland), G. M. Thomson, F.L.S., F.C.S. (Dunedin), E. Tregear (Wellington), and Henry Wilkie (Dunedin).

The retiring President, Captain F. W. Hutton, being absent through illness, it was resolved, on the motion of Professor Benham, that Professor W. Baldwin Spencer take the chair.

The subscribing members (of £1 each) whose names appeared upon the printed lists were elected members of the Association for the Dunedin session.

The following delegates were announced by the General Secretary:—Royal Society of New South Wales—Mr. Justice Docker, Mr. J. W. Grimshaw, and Mr. G. H. Halligan; British Astronomical Association (New South Wales Branch)—Mr. L. S. Drummond; Teachers' Association of New South Wales—Mr. A. B. Weigall and Mr. H. J. Carter; Royal Society of Tasmania—Colonel Legge, Mr. W. H. Twelvetrees, and Mr. A. Morton; Polynesian Society—Mr. E. Tregear, as President; Chemical Society of London—Professor F. D. Brown, Professor F. H. Easterfield, and Mr. G. Gray; Royal Society of South Australia—Professor W. H. Bragg.

The amended rules as carried at the Hobart meeting were unanimously adopted.

Correspondence.—Correspondence was read and received from the Premier of Tasmania regretting that he could not see his way by legislation to give effect to the Association's recommendations relative to installation and maintenance of Milne horizontal pendulums (for earthquake purposes) and sanitary legislation and sanatorium for treatment of tuberculous patients.

Reports were received from the following Research Committees:—

(1.) Magnetic Survey of New Zealand (C. C. Farr, Secretary).

(2.) Seismological Committee.

(3.) Glacial Committee (Professor David, Secretary).

(4.) Committee for recording Structural Features (Professor David, Secretary).

(5.) Igneous Rocks of Australasia (W. H. Twelvetrees and G. W. Card, Secretaries).

On the motion of Mr. Carter, seconded by Dr. Chilton, the following Recommendation Committee was appointed: Professors David, Benham, Bragg, and Baldwin Spencer, and Messrs. G. M. Thomson, A. Morton, H. Deane, and J. Shirley.

President for 1906. Professor Bragg (Adelaide) moved, and Mr. Morton (Tasmania) seconded, That Professor W. Baldwin Spencer, F.R.S. (Melbourne), be elected President of the Association for the Adelaide (1906) session. Carried.

On the motion of Professor Benham (Dunedin), seconded by Professor David (Sydney), Mr. W. Howchin, F.G.S., and Mr. J. P. V. Madsen, B.Sc., B.C.E. (of Adelaide), were appointed Secretaries.

Election of Treasurer. A letter was read from Professor A. Liversidge, of Sydney, stating that Mr. H. C. Russell, C.M.G., F.R.S., Government Astronomer, New South Wales, was unable to carry on the duties of Honorary General Treasurer on account of ill health.

On the motion of Colonel Legge (Tasmania), seconded by Professor David (Sydney), it was resolved, That Mr. David Carment, F.I.A. (Great Britain) and F.A.A. (Scotland and Ireland), of Sydney, be appointed Honorary General Treasurer.

It was resolved, on the motion of Mr. H. Deane, seconded by Professor David, to send a letter to Mr. Russell expressing the sincere sympathy of the Council with him in his illness, and its appreciation of the work he has done for the Association.

Professor Bragg (Adelaide) moved, and Mr. Hogben (Wellington) seconded, That the next meeting be held in Adelaide in September, 1906.—Agreed to.

On the motion of Mr. Shirley (Brisbane), it was resolved, That Brisbane be the place of meeting in June, 1908.

Tuesday, 12th January, 1904.

Second Meeting of the General Council.

The second meeting of the General Council was held in the Boys' High School at 2.30 p.m., and there were about twenty members present; Professor David, President, in the chair.

The minutes of the first meeting were read and confirmed.

The report of the Recommendations Committee (for details see page xxviii) was presented and adopted.

On the motion of Mr. Morton (Tasmania), seconded by the Hon. C. C. Bowen (New Zealand), it was resolved, That Captain Hutton, F.R.S., and Professor W. Baldwin Spencer, F.R.S., be elected life members of the Association.

Mr. Morton gave notice of the following motion for next meeting: "That in future the appointment of life members of the Association be made by the General Council on the advice of an absolute majority of the Recommendations Committee, and that not more than one life member be appointed at any meeting of the Association."

A report was received from the Mueller Medal Committee announcing that the medal was awarded to Mr. A. W. Howitt, of Victoria.

The President presented the medal to Professor Spencer for transmission to Mr. Howitt.

The following were appointed the Mueller Medal Committee: Professor David (President) and Professor Liversidge (General Secretary), *ex officio*, together with the following four: Dr. E. C. Stirling, Professor Baldwin Spencer, Professor Gregory, and Mr. J. H. Maiden.

Messrs. R. Teece and R. A. Dallen were appointed General Auditors.

The Secretary and Treasurer for New Zealand and the secretaries of sections were appointed a Publication Committee.

Votes of thanks were passed to the following:—

(1.) To His Excellency the Right Hon. Uchter John Mark, Earl of Ranfurly, G.C.M.G., for presiding at the inaugural meeting.
(2.) To the Right Rev. the Bishop of Dunedin and Mrs. Nevill for hospitality.
(3.) To the Council of the University of Otago for hospitality.
(4.) To Mr. and Mrs. P. R. Sargood for hospitality.
(5.) To Mr. and Mrs. P. Duncan for hospitality.
(6.) To Mr. and Mrs. George Gray Russell for hospitality.
(7.) To A. Thomson, Esq., for hospitality.
(8.) To the Directors of the Union Steamship Company for hospitality.
(9.) To the Marine Fish-hatchery Board for hospitality.
(10.) To the Government of New Zealand for its generosity in providing a vote of money towards defraying the expenses of the meeting and the printing of the Journal, and also for the privilege of franking the correspondence of the Association.
(11.) To the Board of Governors of the Boys' High School for the use of the building.
(12.) To the Hon. Sir Joseph Ward, K.C.M.G., Minister for Railways, for very liberal concessions granted by the Government to members of the Association.
(13.) To the Railway Commissioners of New South Wales, Victoria, South Australia, Queensland, Tasmania, and West Australia for concessions, and to the Union Steamship Company, Messrs. Huddart, Parker, and Co., the Australasian United Steam Navigation Company, and the Adelaide Steamship Company for reduction in fares granted to members of the Association.
(14.) To the Press for the excellent manner in which the reporting of the meetings has been conducted.
(15.) To Mr. G. M. Thomson for his services as General Secretary in connection with the meeting.
(16.) To the President, Professor T. W. E. David, M.A., F.R.S.

COMMITTEES OF INVESTIGATION.

No. 1.—Seismological Committee.

On the recommendation of Section A (Astronomy, Mathematics, Physics, and Mechanics), it was agreed, That the Seismological Committee consist of Sir Charles Todd, Professors David and Gregory, Dr. Coleridge Farr, Messrs. W. E. Cook, Tarlton Phillips (Queensland), A. Macaulay (Tasmania), and Messrs. P. Baracchi and G. Hogben (secretaries).

No. 2.—Glacial Committee.

On the recommendation of Section C (Geology), it was agreed, That the following be the members of the Glacial Committee: Captain Hutton, Messrs. E. G. Hogg, A. Gibb Maitland, B. Dunstan, R. M. Johnston, G. Sweet, W. H. Twelvetrees, W. Howchin, G. A. Waller, R. Speight, A. E. Kitson, Dr. Marshall, and Professor David (secretary).

No. 3.—Committee for recording Structural Features in Australasia.

On the recommendation of Section C (Geology), it was agreed, That the following be the committee for recording structural features, such as important folds and faults in Australasia, with a view to studying the evolutions of the Australasian land-surface: Professor Gregory, Messrs. W. H. Twelvetrees, G. A. Waller, T. S. Hall, H. Y. L. Brown, Walter Howchin, A. Gibb Maitland, E. F. Pittman, B. Dunstan, W. J. Clunies Ross, R. Speight, P. Marshall, and Professor David (secretary).

No. 4.—Committee on Australasian Igneous Rocks.

On the recommendation of Section C (Geology), it was agreed, That the following committee be appointed for the recommendation of a uniform system for the nomenclature of Australasian igneous rocks: Professor David, Professor Gregory, Messrs. A. W. Howitt, W. G. Woolnough, Dr. Marshall, W. H. Twelvetrees, G. W. Card, and S. Jevans (the two last-named gentlemen to act as joint secretaries).

No. 5.—Committee on New Zealand Food Fishes.

On the recommendation of Section D (Biology), it was agreed, That a committee, consisting of Messrs. C. W. Chamberlain, D. Barron, and G. M. Thomson, be appointed to investigate the local conditions affecting the food-supply of food fishes of New Zealand seas at the fish-hatchery at Portobello, and that Mr. G. M. Thomson be appointed secretary and convener, and that a grant of £30 be placed at their disposal.

No. 6.—Committee on Sea-surface Temperatures.

On the recommendation of Section D (Biology), it was agreed, That a committee, consisting of Dr. Benham, Mr. Hamilton, and Mr. L. F. Ayson, be appointed to obtain maximum and minimum decimal records of sea-surface temperatures at selected stations on New Zealand coast; that Mr. Hamilton be appointed secretary and convener, and that a grant of £10 for the purchase of thermometers be placed at their disposal.

No. 7.—Committee for Biological and Hydrographical Study of the New Zealand Coast.

On the recommendation of Section D (Biology), it was agreed, That a committee, consisting of Captain Hutton, Dr. Chilton, Professor Thomas, Mr. Hamilton, and Dr. Benham, be appointed to initiate a biological and hydrographical survey of the continental shelf of New Zealand by dredging and sounding; that Dr. Chilton be appointed secretary and convener, and that a grant of £50 be placed at their disposal.

No. 8.—Committee on Spelling of Native Names.

On the recommendation of Section F (Anthropology and Philology), i was agreed, That the committee of the Anthropology and Philology Section recommend the following names as a committee for the correction of the spelling of native places, names, &c.: For Victoria—Dr. Fison and Professor B. Spencer; for New South Wales—Dr. Brown and Rev. J. J. Prescott; for South Australia—Mr. Maurice and Mr. Gillen; Tasmania—Mr. Alex. Morton and Mr. R. M. Johnston; Queensland—Dr. Roth and Mr. J. F. Bailey; New Zealand—Captain Hutton, Messrs. Percy Smith, E. Tregear, and A. Hamilton; West Australia—Mr. Alex. Morton and Mr. Prinseps; with power to add to their number.

No. 9.—Committee on Teaching of Science.

On the recommendation of Section J (Mental Science and Education), it was agreed, That a committee be appointed to inquire into the teaching of science in primary and secondary schools, technical colleges, and universities, and to consult with local authorities on education as to how such teaching can be made most effective by proper methods, co-ordination, &c.; and that the committee consist of the following: Professor Carslaw (secretary, Australia and Tasmania), Mr. J. Shirley, B.Sc., Professor Bragg, Professor Gregory, Mr. G. H. Knibbs, Mr. Frank Tate, Mr. J. Masters, Professor David, Professor Benham (secretary, New Zealand), Mr. G. M. Thomson, and Mr. G. Hogben.

RECOMMENDATIONS AGREED TO.

Teaching of Mathematics.

No. 1.—On the recommendation of Sections A and I, it was agreed, That letters be written to the various universities and training-colleges of Australasia, pointing out that it is highly desirable that provision should be made for the training of mathematical teachers.

Seismological Stations.

No. 2. On the recommendation of Section A, it was agreed, That letters be written to the various State and other Governments, pointing out that it is highly desirable that Milne seismographs should be installed at Sydney, Brisbane, Hobart, Adelaide, Norfolk Island, and, if possible, Tonga.

Magnetic Curves.

No. 3. On the recommendation of Section A, it was agreed, That a request be sent to the Government of Victoria to continue the annual grant made to Mr. Baracchi for the reduction and discussion of magnetic curves accumulated at the Melbourne Observatory, and that the attention of the New Zealand Government be drawn to the desirability of promptly reducing the magnetic curves at Christchurch, and that they be asked to provide the necessary unskilled assistance at an approximate cost of £80 per annum for two years.

New Zealand Fossils.

No. 4. On the recommendation of Section C, it was agreed, That the following resolution be forwarded to the New Zealand Government: That whereas this Association considers that the description of the large collection of fossils now at the Wellington Museum is one of the most important services which the New Zealand Government could at the present time render to science, and that it is one which would be for the advancement of science throughout the world; that whereas the work would be of economic as well as of scientific interest, as it is only by its means that the coalfields of New Zealand can be properly correlated, and the broad relations and modes of origin of its metalliferous deposits understood; that whereas, according to the annual reports, there are more than thirty thousand fossil specimens in the exhibition-cases at Wellington Museum, by far the larger part of which are unnamed and undescribed, and besides about five hundred boxes of fossils still unpacked in the same Museum; and that whereas these collections, made at considerable expense to New Zealand, are obviously useless in their present state, this Council recommends, (1.) That the description of these fossils should be commenced immediately, and that if this recommendation is adopted by the New Zealand Government the undermentioned groups of fossils be sent for description to the following workers at once: The graptolites, to T. S. Hall, M.A.; the foraminifera and ostracods, to F. W. Chapman; the echinoids, to Professor Gregory; the Palæozoic fossils, other than those in the above groups, to R. Etheridge, jun. (Curator, Australian Museum, Sydney), and W. S. Dun (Palæontologist, Geological Survey, New South Wales). (2.) That, with regard to the large and important collections of Mesozoic and Cainozoic fossils (other than echinoids, foraminifera, and ostracods) in the Wellington Museum, the Council recommends that advice as to their description be delegated, so far as this Association is concerned, to a committee consisting of the following: Captain F. W. Hutton (retiring President), Professor David (President), Professor Baldwin Spencer (President-elect), and A. Hamilton, Esq. (Curator of the Colonial Museum, Wellington).

Permanent Bench-marks.

No. 5.—On the recommendation of Sections A and C, it was agreed, That permanent bench-marks referring to one common datum be established at frequent intervals in Australasia, and that all levels for engineering and other scientific work be by law reduced to those marks; that mean sea-level, being the least likely to change, should be adopted as the common datum; that, in order to ascertain the mean sea-level at the various ports, harbours, and islands on the coast, automatic tide-gauges be installed, and the records submitted to a competent officer for analysis and report; that all tide-gauge stations shall have a barograph and anemograph in their immediate vicinity, and the records of these instruments to be considered as part of the installation; that permanent bench-marks be made of the type used in the British Ordnance Survey, as near as convenient to each tide-guage, and to be carefully guarded from injury and used for special reference only; that the standard bench-marks be connected by precise levelling, and the records and instruments used for this purpose shall be in the charge of the officer above alluded to. The cost of installation of one tide-station is variously estimated at from £10 to £100, according to local conditions and the type of gauge used; but the gain in accuracy and the saving of time by the adoption of a common datum might be estimated at many hundreds a year in New Zealand, and at an even larger amount in Australia.

Preservation of New Zealand Fauna and Flora.

No. 6.—On the recommendation of Section D, it was agreed, That this Association gratefully recognises the aid which the New Zealand Government has afforded for the preservation of the native fauna and flora of New Zealand, especially in the passing of the recent Act for the preservation of scenery in the colony, and expresses a hope that further facilities will be granted to naturalists for investigating the natural history of the outlying islands.

Examinations in Mathematics.

No. 7.—On the recommendation of Sections A and J, it was agreed, That it be a recommendation to the examining bodies of Australia and New Zealand that they base the regulations for their public examinations (in mathematics) on the syllabus adopted by the University of Cambridge.

Life Members.

No. 8.—The following resolution, proposed by the Recommendations Committee, was agreed to: That it be a recommendation to the General Council that Captain Hutton, F.R.S., and Professor Baldwin Spencer, F.R.S., be elected life members of the Association.

REPORT OF THE MUELLER MEMORIAL COMMITTEE.

A report was received from the Mueller Medal Committee stating they had met in the office of the General Secretary on Tuesday, the 12th January, at noon, when there were present: Professor David (President), Professor Spencer, and Mr. A. Morton. It was resolved unanimously, the consent of the absent members having been ascertained, That the first award of the Mueller Medal be made to Mr. A. W. Howitt, of Victoria, for his distinguished researches as an ethnologist and geologist, and for his explorations in Central Australia.

NOTICE OF MOTION.

Mr. A. Morton gave notice to move at next meeting of the General Council, That in future the appointment of life members of the Association be made by the General Council on the advice of an absolute majority of the Recommendations Committee, and that not more than one life member be appointed at any meeting of the Association.

GENERAL PROGRAMME.

WEDNESDAY, 6TH JANUARY, 1904.

10.30 a.m.—Sectional Committees meet in Section rooms.
11.30 a.m.—Meeting of General Council in room of Section J.
3.30 p.m—Garden party at Bishopsgrove; reception by the Right Rev. the Bishop of Dunedin, Chairman of the Reception Committee.
8 p.m.—Inaugural meeting of members in the Garrison Hall, His Excellency the Earl of Ranfurly in the chair; His Worship the Mayor, Thomas Scott, Esq., will welcome the visitors to the city; presidential address by Professor T. W. E. David, B.A. F.R.S., on "The Aims and Ideals of Australasian Science."

THURSDAY, 7TH JANUARY.

10 a.m.—Sectional Committees meet in Section rooms.
10.30 a.m. to 1 p.m.—Presidential addresses in Sections A, B, F, and H.
2.30 p.m. to 5 p.m.—Presidential addresses in Sections C, D, I, and J.
8 p.m.—Lecture in the Garrison Hall, by Professor W. Baldwin Spencer, M.A., F.R.S., on "The Central Australian Aborigines, their Habits and Customs."

FRIDAY, 8TH JANUARY.

10 a.m.—Sectional Committees meet in Section rooms.
10.30 a.m. to 1 p.m.; 2 p.m. to 5 p.m.—Sections meet for reading and discussion of papers.
8 p.m.—Conversazione in the University buildings.

SATURDAY, 9TH JANUARY.

10 a.m.—Sectional Committees meet.
10.30 a.m. to 1 p.m.—Sections meet for reading and discussion of papers.
Excursions.—Taieri Mouth, by special train and steamer; Portobello, by drag; Wairongoa (property of A. Thomson, Esq.), by drag; Waitati, by drag. Each excursion will be limited to a certain number.

MONDAY, 11TH JANUARY.

10 a.m.—Sectional Committees meet.
10.30 a.m.—Sections meet for reading and discussion of papers.
3.30 p.m.—Garden party at Marinoto (grounds of P. Sargood, Esq.) and Tolcarne (grounds of P. Duncan, Esq.).
8 p.m.—Lecture in Garrison Hall, by Professor Gregory, F.R.S., on "The Southern Ocean and its Climatic Control over Australasia."

TUESDAY, 12TH JANUARY.

10 a.m. —Sectional Committees meet.
10.30 a.m.—Sections meet for reading and discussion of papers.
2.30 p.m. —Second meeting of General Council; botanical excursion to top of Swampy Hill, under leadership of Dr. Cockayne and Mr. W. M. Thomson, M.A.; geological excursion to top of Flagstaff Hill, under the leadership of Dr. P. Marshall.
8 p.m.—Lecture in Garrison Hall, on "New South Wales Scenery," by His Honour Judge Docker, M.A., President, New South Wales Photographic Society.

WEDNESDAY, 13TH JANUARY.

9.30 a.m.—Geological excursion to Sea View, under the leadership of Dr. P. Marshall.
1.30 p.m.—Lunch, tendered by directors of Union Steamship Company, on board s.s. "Manuka" (limited to 100); excursion to Marine Fish hatchery, Portobello, leaving Rattray Street by steamer and launch (limited to 100).
3 p.m.—Afternoon tea on board s.s. "Manuka," tendered by directors of Union Steamship Company.

INAUGURAL ADDRESS

BY

Professor T. W. EDGEWORTH DAVID, B.A., F.R.S., F.G.S., President.

THE AIMS AND IDEALS OF AUSTRALASIAN SCIENCE.

I.—INTRODUCTORY.

The advancement of science, the great end for which our Association exists, is a cause which has found favour in the past with peoples and rulers of peoples. Forty-four years ago the founder of science-teaching in Great Britain, the Prince Consort, in his presidential address to the British Association, expressed the hope that the State would always recognise in science one of its elements of strength and prosperity, and would consider itself bound by dictates of self-interest to foster and protect science, and that the relations of the State to science would ever be those of parent and child. The good tradition established by that enlightened ruler has been followed now for many years by our vice-regal Governors in Australasia; and I know that I am voicing the feelings of this assembly when I say that we rejoice that it has been followed on this occasion by the patron of this society, the Earl of Ranfurly, who honours us with his presence to-night, and to whom we extend a very hearty welcome. His presence signifies not only his personal interest in science, but also the recognition by him of the fact that the meeting of this society is a matter of national importance. Those of us who belong to Columbus's category of strange creatures from other lands cast up by the sea upon your shores, would like to take this occasion of expressing to the New Zealand Government gratitude for its liberality, which we hope will "bless both him that gives and him that takes."

While we have much occasion for rejoicing, there is one matter which cannot but fill us with regret, and that is that the man whom, at our last meeting, we all delighted to honour—the man to whom Australasian science in general, and New Zealand science in particular, owes so much—our good friend the late president, Captain F. W. Hutton, is unable through illness to be present with us. It is gratifying to know that he is now out of danger and rapidly recovering his normal health. That he may yet be spared for many years of useful and happy life must be the sincere wish of every one of us here, as of scientific men generally throughout the world.

This Association has now been in existence since the year 1888, and this, its tenth meeting, seems to me a fitting occasion for reviewing briefly some of its past work and suggesting what seems to me some useful lines on which it may work in the future.* Before reviewing this work it may be as well to remind members of the objects for which our Association was called into being.

The objects of the Association are defined for us in our volumes as follows:—

1. To give stronger impulse and a more systematic direction to scientific inquiry.

2. To promote the intercourse of those who cultivate science in different parts of the British Empire with one another.

3. To obtain a greater degree of national attention to objects of science.

4. To secure a removal of any disadvantages of a public nature which impede its progress.

I propose, first, to consider how far the Association has fulfilled its task; and, secondly, to review lines of work which would be good to follow, especially that of scientific education.

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* In referring to possible lines of research and ideals no attempt will be made to review the whole of the valuable work done by our members. That would be a task entirely beyond the scope of one address. Much of the work already done has to be passed over in silence, either because I wish to call attention specially to what has been left undone, or because I do not feel competent to deal with certain of the subjects.

II.—PAST AIMS AND IDEALS.

Those who have attended our meetings or who have inwardly digested the volumes of our Proceedings, will I think, admit that the Association has justified by works the faith reposed in it by its founder and indefatigable general secretary, Professor Liversidge. Sydney, Melbourne, Hobart, Adelaide, Christchurch, and Brisbane have in turn been visited, and now we are met together once more in this beautiful land, meet nurse for the scientific child, the land of the Maori and the moa, the land of smiling plains and frowning fiords, a land of ice and fire, a land of still lakes and swift-flowing rivers. At every step we take we are reminded of what science has done to bring these fair islands into the service of man, how the road has been driven, the ford bridged, the rivers harnessed, the land girdled with iron, its harbours filled with the shipping of all nations, and its shores gemmed with fair cities. What more inspiring place could have been chosen for our meeting than this city, girt with hills and bowered in green, so full of life, nestling among the dead volcanoes—this second Edinburgh — dear to us as the home of the patient mineralogist and untiring worker in the field of geology, the late Professor Ulrich; also the home of that world-famed and much-loved biologist, Parker! The fame that these men won grows still—and long may it continue to grow!—in the work of their worthy successors.

One of the most important results of our gatherings has been that we have travelled round, met our scientific neighbours, and learned to love them as ourselves. It would be difficult to overstate the benefit which Australasian science has derived from this feeling of brotherhood which our Association has done so much to foster. Have we not learned more from personal intercourse with master minds than we have ever gathered from reams of correspondence and piles of ponderous tomes? Have not currents of thought been induced and strengthened in us when, at these meetings, our ideas are revolved in the magnetic field of some fellow-scientist? Then, too, our

Association has done much to promote that concentration and co-ordination of effort which is such a feature in the scientific life of to-day. In its early days science in Australasia passed through its heroic age. Among the heroes who worked in the sad splendour of isolation were Dunlop, the first Australian astronomer; Sir Thomas Brisbane, who founded the first scientific society in Australia; Strelecki, stout of heart and strong of limb; Clarke, the father of Australian geology; and Mueller, the father of Australian botany. Few countries can boast of more hardy pioneers than Australia had in Flinders and Wentworth, Eyre and Leichhardt, Burke and Wills, and our veteran past president, A. C. Gregory, or more resolute science workers than New Zealand had in Dieffenbach, Hochstetter, and Haast. Many names could be added to this list of early workers, but the few quoted stand as good types of the men of our heroic age.

To the heroic age succeeded the scattered brotherhoods of workers associated in scientific societies, Government scientific departments, museums, and universities. These scattered brotherhoods are now united for more perfect co-ordination of work and fellowship in the larger brotherhood of this Association.

The appointment of Research Committees has, perhaps, been the most important step taken by the Association for the co-ordination and systematizing of scientific work. Committees have been appointed to report on the following subjects:—

- The Mineral Census of Australia.
- The Polynesian, Papuan, and Australian Races.
- The Establishment of Biological Stations.
- Town Sanitation.
- The Tides of South Australia and of Australia generally.
- The Improvement of Museums as a Means of Popular Education.
- The Investigation of the Movements of the New Zealand Glaciers.
- Earthquakes.

Rust in Wheat.

Glaciation, Past and Present.

Protection of the Native Fauna.

Mineral Waters of Australia.

Record of Chief Structural Features of the Australasian Land-surface.

On Uniform Nomenclature of the Igneous Rocks of Australia.

Photography in Geological Surveys.

Marine Biological Research in the Neighbourhood of Hobart.

Collecting of Names and Making of Recommendations as to the Spelling of Native Names of Places.

Education of Defective Children.

Special reference should be made to the valuable work done for the Seismological Committee by the enterprising and persevering secretary, Mr. G. Hogben. In establishing a systematic seismological observatory at Timaru he has set us an example which some of the Australian States would do well to follow. As an example of one good result of this co-ordination and co-operation of scientific workers resulting from the policy of this Association may be mentioned the fact that it paved the way for the Horn Expedition. Science owes much to the munificence of Horn; but had it not been for the meeting of scientific workers at gatherings of this Association, the most important and successful natural-history expedition ever made in Australia might never have been planned and executed.

This Association has also from time to time made important recommendations to the public in the interest of the people and of science. The following two were made at the last meeting:—

"That the General Council of this Association be asked to communicate with the Government of New Zealand, and to urge respectfully that the construction of the proposed biological station near Dunedin be proceeded with as a matter of colonial importance.

"That in the opinion of this Association the results of past experience demonstrate the urgent necessity for the observance throughout Australasia of certain principles for the effective conservation of forests:—

"(*a.*) That all forests be vested in permanent Boards, and rendered inalienable, unless under exceptional conditions, and that no selections whatever be permitted within their area.

"(*b.*) That other land, wholly or in part denuded of timber, be also vested in such Boards for forest cultivation or natural regeneration, such lands being the natural habitat of the species of trees, other than exotics, proposed to be grown.

"(*c.*) That the boundaries should, as far as possible. be natural boundaries.

"(*d.*) That the economic aspect of the question requires that such land reserved for forest-cultivation or natural regeneration be selected with due regard to its accessibility from towns or districts requiring the timber, or from ports of shipment.

"(*e.*) That large areas on the sources of rivers and streams, even though not actually containing good timber, be reserved, as the only means of securing a clean watershed and a pure supply of water for cities and towns now existing or hereafter to be built.

"And, further, the observance of these principles is the only effective means of checking the enormous waste of timber that is now going on, the systematic prevention of which would render the Forestry Department immediately self-supporting, and in the near future the source of large revenues."

Another useful work of the Association has been the moving of the New Zealand Government to secure reservations in New Zealand for the native fauna and flora. Resolution Island at Dusky Sound has been thus reserved. The Government has also reserved Little Barrier Island, off Auckland, at the instance of the Auckland Institute; and also several islands, including Stephen Island in Cook Strait, for the preservation of the tuatara lizard. New Zealand has also set Australia a good example in stopping the depasturing of sheep upon the alpine flora of Mount Cook, while the New Zealand Acclimatisation Society has secured the protection of the native birds at some of the smaller lakes, such as Lake Ohau, on the way to Mount Cook.* In addition to the nine volumes of its Reports published by the Association, in which much of the best scientific work of Australasia has been gathered together, the Association has done useful work in popularising science by issuing handbooks as a guide to the scientific study of the neighbourhood where our meetings are held. Our thanks are specially due on this occasion to the authors of the handbook of Dunedin, just published. Science-teachers would do well if they availed themselves of these handbooks.

Surely, if the Association is to be known by its fruits, it has proved itself a good tree. The problem of how to make the good tree bring forth more fruit suggests itself next for our consideration.

III.—FUTURE AIMS AND IDEALS.

As I find it impossible in most cases to consider these except in reference to the work already done by the Association; I propose to deal with them under the headings of our various sections. If I devote more space to the consideration of natural-history subjects and education than to chemistry, physics, astronomy, mathematics, engineering, economics, &c., it is not because I underrate the importance of these great branches of science, but because I feel less competent to deal with them.

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* The announcement appeared on the 13th January that the New Zealand Government had taken the important step, in the interests of the public and of science, of proclaiming the whole of the alpine and West Coast region of the South Island of New Zealand a Government reserve.

Section A.

ASTRONOMY.

It may be noted that an important departure may shortly be made in Australian astronomy. Professor Hussey, of the Lick Observatory, California, has recently been in New South Wales to ascertain the most suitable spot for establishing a branch of the Lick Observatory there. It is by no means certain as yet that the scheme will be carried through. If it is, we may be sure that our American cousins will see that their observatory is in every way well equipped. If they come, we in New South Wales will welcome them with open arms, and I venture to think that their welcome will be as wide as Australasia. Professor Hussey brought a small telescope with him, and during the very few clear nights available discovered fifteen new double stars. The subject of observatories suggests that there is room for at least one really well-equipped astronomical observatory in New Zealand—an observatory where meteorology may be as far as possible dissociated from pure astronomy. One of the great drawbacks hitherto to astronomical work in New South Wales, as well as in other States, is that the double burden of astronomical and meteorological observation is laid upon the same staff; and the work of daily forecasting has exacted so much of the observers' time that little or no time has been left over for pure astronomy.* It is chiefly through pressure of public opinion that some of our Australasian astronomers have had to follow meteorology rather than astronomy. It is a popular idea that any applied science pays, while a pure science does not. That is a pernicious fallacy fatal to the true interests of national progress. Pursuit of pure science means research, research means discovery, and discovery leads to important new applications of science which make for a nation's prosperity.

* At a recent conference of Australian Government Astronomers, at Melbourne, it was agreed that it would be best for the Federal Government to undertake the meteorological work for the whole Commonwealth, the astronomical work proper being left in charge of the individual States, as at present.

PHYSICS.

Under Section A, in physics there are certain lines of research which are specially applicable to the Southern Hemisphere. For example, very little has been done to study the nature of the aurora australis. Professor Dewar has shown us* what important conclusions may be drawn as to the composition of the upper layers of our atmosphere, from a study of the spectrum of the aurora borealis. We should expect theoretically that the gases of our atmosphere would be arranged above the earth's surface in the order of their liquefying and freezing points. With regard to the distribution of gases in the atmosphere, a gas like carbon-dioxide, which needs much less cold to liquefy and freeze it than does nitrogen or oxygen or hydrogen, cannot exist in the atmosphere to any appreciable extent above the zone of its liquefying point, which is $-78{\cdot}2^\circ$ C. On the other hand, hydrogen, which liquefies only at the very low temperature of $-252{\cdot}5^\circ$ C.,† theoretically, should exist to far greater heights in the atmosphere than the carbon-dioxide. Professor Dewar considers that at thirty-seven miles above the earth's surface there would be very little carbon-dioxide.‡ He considers it possible, however, that "the clouds that have been seen at an elevation of fifty miles above the earth's surface are probably formed of mist resulting from the condensation of carbon-dioxide."§ In other words, if one could ascend from the inner to the outer limits of the atmosphere one would pass first through a zone of water-dust or mist, then through a zone of water-crystals (the cirrus clouds), then (at between thirty-

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* Presidential address to British Association for Advancement of Science, Belfast, 1902.

† The temperature of space is considered to be -273° C.

‡ Samples of atmosphere have been obtained from nine miles above the earth's surface which do not show any appreciable difference of the earth's atmosphere there as compared with that near the earth's surface; but Professor Dewar points out that it must be remembered that the anti-trades have a powerful mixing influence up to that level in the latitude where the samples were obtained. It would be very interesting if samples of air could be obtained from high regions of the atmosphere near the poles, where the movements of the atmosphere are more sluggish.

§ Report of British Association for the Advancement of Science, Belfast, 1902, p. 41.

five and fifty miles) through a zone of carbon-dioxide mist, then through a zone of carbon-dioxide snow, then through a zone of nitrogen and oxygen mist, and through respectively nitrogen and oxygen snow, and, finally, through hydrogen-mist and perhaps hydrogen-snow.

The matter might be otherwise stated thus : If the earth's temperature were cooled down at the surface until all the sea was frozen solid, to — 200° C., a new ocean of liquid air would appear, covering the entire surface of the globe about 35 ft. deep. The only atmosphere left in this case would be hydrogen and such other volatile gases as neon, crypton, xenon, and helium. Dewar has shown that this theoretical arrangement of gases in the earth's atmosphere receives a beautiful confirmation from the study of the spectrum of the aurora borealis, the rosy tint so characteristic of the streamers of auroras showing lines which prove it to be due to neon, while " the red ray of hydrogen and one red ray of crypton have been noticed once." All the rays of nitrogen are absent from the aurora borealis. Trigonometrical measurements show that the base of the aurora is thirty-four miles above the earth's surface, and it has been proved experimentally that at a pressure such as oxygen and nitrogen would be subjected to at thirty-four miles (about one-tenth of a millimetre), neither of them would show visible rays, their rays fading long before this low pressure is reached, and being replaced by those of argon and other volatile atmospheric gases.

I must refer members to Professor Dewar's address for a popular account of how it has been demonstrated that " solar prominences are almost certainly solar auroras, and that the sun's coronal atmosphere is composed of the same substances as the earth's, and that it is rendered luminous in the same way—namely, by electric discharges." Professor Dewar adds,—

" This conclusion has plainly an important bearing on the explanation which should be given of the outburst of new stars and of the extraordinary and rapid changes in their spectra. Moreover, leaving on one side the question whether gases ever become luminous by the direct action of heat, apart from such transfers of energy as occur in chemical change and electric disturbance, it demands a revision of the theories which attribute more permanent differences between the spectra of different stars to differences of temperature, and a fuller consideration of the question whether they cannot with better reason be explained by differences in the electric conditions which prevail in the stellar atmosphere. . . . .

"Arrhenius points out that the frequent disturbances which we know to occur in the sun must cause electric discharges in the sun's atmosphere far exceeding any that occur in that of the earth. These will be attended with an ionization of the gases, and the negative ions will stream away through the outer atmosphere of the sun into the interplanetary space, becoming, as Wilson has shown, nuclei of aggregation of condensable vapours and cosmic dust. The liquid and solid particles thus formed will be of various sizes; the larger will gravitate back to the sun, while those with diameters less than one and a half thousandths of a millimetre, but nevertheless greater than a wave-length of light, will, in accordance with Clerk Maxwell's electro-magnetic theory, be driven away from the sun by the incidence of the solar rays upon them, with velocities which may become enormous, until they meet other celestial bodies, or increase their dimensions by picking up more cosmic dust, or diminish them by evaporation. The earth will catch its share of such particles on the side which is turned towards the sun, and its upper atmosphere will thereby become negatively electrified until the potential of the charge reaches such a point that a discharge occurs, which will be repeated as more charged particles reach the earth. This theory not only accounts for the auroral discharges, and the coincidence of their times of greatest frequency with those of the maxima of sun-spots, but also for the minor maxima and minima."

I have quoted at some length from Professor Dewar to show what extremely interesting problems are involved in the study of the aurora borealis by spectroscopic or other methods. Obviously, equally interesting problems are involved in the study of the aurora australis, and it is high time that we commenced to study them.

The subject of local conditions of terrestrial magnetism in Australasia is also one of great interest and importance. A committee, with Mr. Baracchi as secretary, has been appointed to report on this. It is gratifying to note that in Melbourne systematic magnetic observations are being recorded. Great credit is also due to a most active member of our Association, Dr. Farr, for establishing a magnetic observatory—the first of its kind—at Christchurch, in New Zealand, and he is to be congratulated on now having nearly completed the magnetic survey of the whole of New Zealand. Australasian science is much in need of more of these magnetic observatories. An important paper on "Possible Cause of Earth's Magnetism and the Theory of its Variations" has been read before this society by Mr. Sutherland.* Another work of great physical importance in the Southern Hemisphere is the making of gravity-determinations. Some years ago Professors Threlfall and Pollock devised at the Physics Laboratory at Sydney University a delicate static balance, depending on the torsion of a thread of fused quartz, for estimating the force of gravity. This balance was accurate to 1 in 500,000. The determinations, however, made with it were carried out chiefly with a view to testing the working of the instrument. What is needed is a systematic gravity survey, combined with geodetic survey.†

GEODETIC SURVEY.

Geodetic survey is another urgent need in Australasia. From the map‡ in the 1900 Report of the U.S.A. Coast and Geodetic Survey will be seen at a glance the present state of the data on which an opinion as to the figure of

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* Vol. viii., pp. 203–205, of the Association Reports.

† Professor Otto Klotz, of Canada, has lately completed a series of accurate pendulum determinations of the force of gravity in Australasia, but the results of his work are not yet published.

‡ Rep. Austr. Assoc. Adv. Sci., Vol. viii., Melbourne meeting, 1900, p. 203.

the earth can be founded, in so far as trigonometrical survey can supply information. The great latitude arc across the United States, the minor latitude arc, the two meridional arcs, and two other stretches, one running north-westerly on the west side and the other north-easterly on the east side of the United States, afford splendid evidence of the figure of the ideal spheroid most closely approximating to that continent.

There are now, besides these, two great arcs of meridian in Europe: (1) England, France, Spain; (2) the central European arc—the great arc of latitude extending right across Europe into Asia, the meridional and latitude arcs of India, a very small latitude arc in Algeria, and a small meridional arc at the Cape, and the historic meridional arc in Peru.

Looking at the map one recognises that practically the whole of Australia, Africa, and Siberia in Asia are geodetically unknown. By comparing the spheroids (ellipsoids of revolution) which most closely agree with the measured arcs the extent of the uncertainty is indicated, and it would be idle to formulate on such evidence any opinion as to the general figure of the earth, except as approximately representing the Northern Hemisphere. To use the spheroid which most closely agrees with the whole of this evidence as a basis for the reduction of surveys of the Southern Hemisphere would, of course, be satisfactory only for very limited areas.

If the continents of South America, Africa, and Australia are to be geodetically surveyed, their form must be independently investigated, as is done elsewhere; in fact, if ever there is to be a satisfactory and comprehensive geodetic survey of Australia it will have to be reduced in conformity with local evidence. Mr. G. H. Knibbs thinks that in our present state of survey it would not be a serious matter to complete an arc of meridian in New South Wales and Queensland, and an arc of parallel including the greater part of Victoria; and he considers that the reduction of the geodetic survey will never be satisfactory without this. An able paper, showing the present state of the geodetic survey of New South Wales and Victoria, was contributed to this Association by Mr. Furber.*

Accurate hydraulic surveys of artesian basins, and an investigation of the physical problems involved in the circulation of the artesian water of Australasia, would prove of great economic as well as scientific importance.

SIESMOLOGY.

Except for the work done at the Timaru Observatory† by Mr. Hogben, and at the Melbourne Observatory, this subject is being neglected in Australasia. It is particularly important that a seismological station should be established in Tasmania to record the shocks which emanate from the "rift valley" of Bass Strait.

METEOROLOGY.

There is great need in Australasia for studying the upper regions of the atmosphere. This can be done by means of high-level meteorological stations, by kites, and by means of small captive balloons. Through the enterprise of Mr. Wragge a high-level station was established at Kosciusko, at an altitude of about 7,328 ft. above the sea. A low-level station, where simultaneous readings were taken, was at the same time formed at Nimmitabel. To our shame be it confessed, this observatory is now abandoned for want of funds. Whatever views may be held as to the method of management, there can be but one opinion as to the value and importance to meteorological science of the maintenance of a permanent high-level station. It is just as reasonable to expect a meteorologist to make accurate forecasts of the weather and deny him access to the study of the upper currents of air, as to expect a chimney-sweep to give you the exact reason why your chimney smokes and forbid him to examine your chimney-pot. It is to be hoped that this Association will exert its influence for the reopening of the

* Austr. Assoc. Adv. Sci., Sydney, 1898, Vol. vii., pp. 176–237.

† This observatory has now been moved to Wellington, New Zealand.

high-level observatory at Kosciusko.* We need more information about the downward limit of the anti-trade-winds. We know that at Kosciusko, in latitude 36° S., in summer time their downward limit is somewhat less than 7,000 ft., whereas at Teneriffe, in the Northern Hemisphere, their downward limit is about 9,000 ft. Seasonable variation of this downward limit is also an important question.

The greatest problem of all seems to me how the air-stream, flowing from the belt of Antarctic calms (if such a belt exists), or flowing from the great permanent anti-cyclone over the South Pole, forces its way across the belt of "brave west winds," or "roaring forties," to the anti-cyclone high-pressure belt, the mean position of which in Australia lies between the latitude of Sydney and Brisbane. The great expanse of ocean in the Southern Hemisphere renders it favourable for such a study, as there is little land here as compared with ocean to complicate the problem.

The origin of the circular dust-storms, known in Australia as "willy-willy" or "burramugga," which raise such vast quantities of red dust into the higher regions

* Professor Gregory has urged that it would be more important to start meteorological kite-work in Australasia, such as is carried on at Blue Hill, U.S.A., than to maintain high-level meteorological stations. He points out that meteorological kites have at least three advantages over high-level stations: (1) Kite observations are usually made under conditions where atmospheric pressure and temperature are normal; whereas at high-level stations, unless situated at summits of very narrow peaks, abnormal pressures and temperatures are sure to exist through the deflecting influence of the high land on which the stations are built upon the low-level air-currents, the tendency being for the low-level air-currents to be forced over the high land; (2) records from any altitude up to over 10,000 ft. above the level of the observer can be obtained by kites; (3) kite observations on the whole would be cheaper than high-level-station observations. He recommends the use of kites of the pattern invented by Mr. Lawrence Hargrave, of Sydney. I quite agree with him as to the great importance of kite observations in Australasia; and certainly they would vastly enhance the value of records at high-level stations. At the same time I consider that records at the Kosciusko Observatory, made simultaneously with those at some conveniently situated low-level observatory in the same neighbourhood, would have a great value in showing in what way the circulation of the atmosphere in Eastern Australia is modified by the Australian Cordillera. The cost of a complete kite plant with set of self-recording meteorological instruments would probably not much exceed £100. It is much to be hoped that such kite-work will be carried on in the near future in Australasia.

of our atmosphere and then distribute it far and wide over Eastern Australia, is another problem awaiting investigation.

Section B.—Chemistry and Mineralogy.

CHEMISTRY.

While incompetent to discuss this branch of science, except in so far as it touches my own subject, geology, I might note that while this section has been favoured with many papers on pure chemistry, like Professor Orme Masson's "Relative Velocity of Ions,"* there have been a much larger number dealing with questions specially of Australasian interest, such as R. T. Baker's and H. G. Smith's valuable work on "The Eucalypts and their Essential Oils."† The fossil resins, oil-shales, and coals of Australasia call for a more thorough investigation than has yet been bestowed upon them.‡ For example, although we know the ultimate analyses of many of these substances, we know next to nothing, apart from the fine work of Bertrand and Renault on the "Kerosene-shale" of New South Wales,§ or of their mineral constitution, as studied microscopically or by means of solvents or microchemical reactions.

In inorganic chemistry much good work has been done on the mineral waters, including artesian waters, and the soils of Australasia.||

* Austr. Assoc. Adv. Sci., Melbourne, 1900, Vol. viii., pp. 205–215.

† "Research on the Eucalypts, especially in regard to their Essential Oils." By R. T. Baker and H. G. Smith, F.C.S. Government Printer, Sydney, 1902.

‡ Professor Easterfield, of Wellington, New Zealand, is at present, I understand, investigating the "retinites," or fossil resins, of the brown coals of New Zealand.

§ "Reinschia Australis et Premières Remarques sur le Kerosene Shale de la Nouvelle Galles du Sud." MM. C. Eg. Bertrand and B. Renault. Autun, 1894. And "Nouvelles Remarques sur le Kerosene Shale de la Nouvelle Galles du Sud." Par M. C. Eg. Bertrand, Autun, 1896.

|| Rep. Austr. Assoc. Adv. Sci., Sydney, 1898, Vol. vii., pp. 87–108, Mineral Waters of Australia Committee's Report; and *ibidem*, Vol. vi., Brisbane, pp. 265–77, "Analyses of Artesian Waters," J. C. H. Mingaye, F.I.C., F.C.S. Also *ibidem*, pp. 228–93, Soil-analyses, by F. B. Guthrie. "The Chemical Nature of the Soils of New South Wales, with special reference to Irrigation," by F. B. Guthrie, F.I.C., F.C.S., Roy. Soc. Jour. N.S.W., Vol. xxxvii., pp. li.–lxv.

MINERALOGY.

A work on the minerals of New South Wales, as well as mineralogical papers to our Association, have been contributed by Professor Liversidge.* Mr. E. F. Pittman has published a detailed work on the mineral resources of New South Wales.† Mr. S. H. Cox has published a short work on the minerals of New Zealand,‡ and W. Skey has contributed useful papers on the same subject, while several mineral lists have been published in our volumes.§ G. F. Ulrich has briefly described the minerals of Victoria.|| A short account of the minerals of West Australia has been furnished by E. S. Simpson.¶ Excellent work on the chemical composition of Australian rocks and their minerals is now being done by Mr. J. C. H. Mingaye, F.I.C., F.C.S., for the geological survey of New South Wales.**

In New Zealand, Mr. Don has also done some very suggestive work on the minerals present in rocks in the neighbourhood of ore-deposits.††

Surely in Australasia, where our mineral deposits are so widespread and of such vast economic importance and scientific interest, there is great scope for work like the excellent work of Sandberger and Pošepny in Germany, and of Emmons, Van Hise, Kemp, &c., in America, on the genesis of our Australasian ore-deposits. The proper elucidation of this question must be undertaken conjointly by the chemist, the mineralogist, the mining engineer, and the geologist, and, like all questions in which much co-

* "Minerals of New South Wales." By A. Liversidge, M.A., F.R.S. Trübner & Co., London, 1888.

† "Mineral Resources of New South Wales." By E. F. Pittman, Assoc. R.S.M. Government Printer, Sydney, 1901.

‡ Trans. N.Z. Inst., Vol. xiv., 1881, p. 418; and *ibidem*, Vol. xv., 1882, pp. 361–410.

§ Austr. Assoc. Adv. Sc., Vol. ii., Melbourne, 1890, pp. 207–82.

|| "International Exhibition Catalogue, Australasia, 1866 – 67." "Geology and Mineralogy of Victoria," pp. 40–83.

¶ Geol. Surv. W. Austr., Bulletin No. 6. By E. S. Simpson, B.E., F.C.S., pp. 1–89.

** Records Geol. Surv., Vol. vii., Pt. iii. pp. 103–40, especially p. 138; and *ibidem* pp. 219–30, especially p. 230; and *ibidem* Pt. ii. pp. 93–101, and especially p. 97.

†† Trans. Amer. Inst. Mining Engineers, Vol. xxvii., 1898, pp. 564–668.

operation is needed, it is one in which our Association can very materially help.

Australasian meteorites have as yet been for the most part described more from the chemical than from the mineralogical and structural standpoint. Much valuable work on the chemical composition of Australian meteorites has been done by Professor Liversidge, but the value of the work would be much enhanced if the meteorites could now be submitted for determination of their minerals and structures to some special worker who has access to large museum collections of meteorites for comparison.

Those enigmatical bodies the obsidianites ("obsidian buttons"), so widely distributed in Australasia, and in all probability of meteoric origin, are most interesting objects for research.

Section C.—Geology.

The geological surveys of Australia and Tasmania are still working steadily; but in many cases, in deference to popular opinion, their chief efforts are directed to what is considered to be the bread-and-butter side of geology, to the exclusion of the study of broad geological features. In New Zealand in the past the work of the survey, in deference to popular opinion, has been chiefly directed to mines, a little time in intervals being devoted to sketching in broad geological features. Surely the time has now come for a systematic and vigorous geological survey of New Zealand — a survey which will not neglect the mines or anything of economic importance, but which will make the reports on how best to develop the natural mineral resources of the country more thorough by studying them in relation to the broad conditions of their environment, so that their mode of origin may be thoroughly understood.

Among geological problems in Australia, perhaps the phenomena of the three great glacial ages through which Australia has passed in Cambrian, in Permo-Carboniferous, and in late Cainozoic times, and the allied problem of what influence these ice ages have had upon the distribution of contemporaneous plants and animals, is still the most fascinating that Australian geology has to offer. No less interesting is the problem of the great glacier epoch of New Zealand*—an epoch when the "united glaciers of Lakes Te Anau and Manapouri extended to Blackmount, a distance of sixty-five miles" (*op. cit.*, p. 174). But of all the geological work in Australasia demanding earnest attention there is none more urgent than the need for the proper description of the extensive and valuable collection of fossils at the Wellington Museum. I do not know at the present moment of any greater service that New Zealand could render to science than that of efficiently carrying out this great work. There are stated to be nearly half a million fossil specimens in the Museum at Wellington, most of which are unnamed and undescribed. These have been collected chiefly by officers of the Geological Survey under Sir James Hector, and chiefly by the present Government Geologist, Mr. Alexander McKay. Nowhere in the Southern Hemisphere, as far as I am aware, is there such a thorough and complete record of the succession of animal and plant life from the close of Palæozoic time up to the present as in New Zealand, and nowhere else is there evidence of such a wonderful range of the *Spiriferidæ* high up into Mesozoic rocks. If this meeting of the Association can induce the Government of New Zealand to start this important work on a sound basis our meeting will not have been in vain. Surely with one in our midst who has done such excellent work for Australian and British palæontology as Mr. R. Etheridge, Jun., and workers like Captain F. W. Hutton, Professor Gregory, T. S. Hall, W. S. Dun, and F. Chapman, it should be possible to have the greater part, if not all, of this work done in the Southern Hemisphere. What may be termed the "New Geology," with which the name of Professor Davis, of Harvard University, U.S.A., is specially associated—viz., the reading of the past geographical history of a country from a study of its surface features—has already found exponents in the Southern Hemisphere in Professor Gregory and Mr. E. C.

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* "The Geological History of New Zealand," by Captain F. W. Hutton, F.R.S., read in 1899; Trans. N.Z. Inst., Vol. xxxii., pp. 173-78.

Andrews. New Zealand, especially the North Island, affords a splendid field for the application of the principles propounded by Davis.

There is also great scope for research in the [illegible] [illegible] [illegible] series of [illegible] rocks in Tasmania and New Zealand, such as those of Mount [illegible], Victoria (described by Professor Gregory), [illegible] in Tasmania (described by [illegible] and [illegible]) the [illegible] series (described by [illegible] and [illegible]) the [illegible] series (described by [illegible] and [illegible]) and the [illegible] and [illegible] ranges in New South Wales, the [illegible] Mountains (described by [illegible]) in Queensland, and the [illegible] series of lavas and tuffs described by [illegible] and Dr. [illegible] around [illegible], the latter being one of the most interesting groups of its kind in the world. The geological exploration of Pacific islands within easy reach of Australia should also be encouraged whenever possible. [illegible] and [illegible] have lately made known some of the interesting geology of the Fiji Islands, while [illegible] and [illegible], who have just returned from an expedition organized by the British Government, [illegible] to the New Hebrides, have brought back glowing accounts of that group as a field for research.

[illegible] — [illegible]

[illegible] — [illegible]

[illegible] — An [illegible] work, [illegible] [illegible] by Mr. [illegible], is the [illegible] of the

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marine fauna in the ocean near the edge of the continental shelf of East Australia, a work the importance of which is hard to overrate. Many forms, previously believed to be extinct, are now found living off the coast of New South Wales—*e.g.*, numbers of the supposed extinct species of Mollusca, characteristic of the Muddy Creek beds of Victoria, have recently been obtained living at depths of about 100 fathoms off the coast of New South Wales. Mr. Hedley considers that the Muddy Creek beds of Victoria are not of littoral origin, but have been laid down in an ocean of moderate depth, and are not of such geological antiquity as has hitherto been supposed. It is satisfactory to note that the value of Mr. Hedley's work is being much enhanced by a collateral series of observations, made by Mr. Gerald Halligan, on the trend of the prevalent ocean currents, and the density and temperature of the sea-water where Mr. Hedley's specimens are obtained.*

The present is a key to the past, and if we are ever to arrive at a logical classification of our marine Cainozoic deposits in Australasia we must first get to know more about the present marine fauna and flora in the deeper water lying off the shore.†

A closely allied and important work is that of establishing marine biological stations along our coast. It is satisfactory to note that recently the New Zealand Government has wisely established a fish-hatchery and marine biological station at Portobello, near this city. The untiring and unselfish efforts of our secretary, Mr. G. M. Thomson, are chiefly responsible for bringing about this happy result.

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* The distribution of forms of marine life is immensely influenced by oceanic currents. Pelagic larval forms, including larvæ of invertebrates and fish, would be specially influenced by such currents, which may form even more serious barriers to migrations of forms of life in the sea than do mountain ranges or deserts to forms on land.

† Subsequent to the reading of this address Mr. Hedley received kind assistance from the New Zealand Government and the Union Steamship Company, and had a very successful dredging in water of 100–200 fathoms depth off Auckland. Many Mollusca until then believed extinct were found at those depths.

Again, the Great Barrier Reef of Australia and the fauna and flora of the adjacent islands afford a most alluring field of research. We have not yet done justice from a scientific point of view to that part of our noble heritage.

The Fauna and Flora of Artesian Waters.—Professors Haswell and Chilton have already done some interesting work on the fauna of the artesian water of Christchurch, and the former is now undertaking the investigation of life-forms in the artesian waters of New South Wales.

Lake Fauna and Flora.—The lake waters of New Zealand have recently tempted two Cambridge men—Messrs. K. Lucas and Hodson—to sound and survey them and secure their fauna and flora. These enterprising explorers have wisely placed for description the whole of the oligochæte fauna obtained by them in the hands of Professor Benham. We desire to know more about all land-forms of animals in Australasia from monotremes and marsupials downwards.

Monotremes and Marsupials.—The extreme interest which attaches to the exploitation of this field of research is shown by the recent discoveries of Dr. J. P. Hill, of Sydney University, that a true allantoic placenta is present in the bandicoot (Perameles), and by the later discovery in collaboration with Professor Wilson that Ornithorhynchus in the early development of the egg shows one most striking evidence of reptilian affinity. A biological examination of the southern part of West Australia, as well as of the north-west corner of New South Wales and the adjoining portion of Queensland, is much needed.

Bird Migration.—Information on this subject as applied to Australasia is at present meagre. More observation is much needed.*

Index, &c.—Another useful type of work is the publication of lists of fauna and flora, such as the "Index Faunæ Zealandiæ," edited by Captain Hutton, and published by the Philosophical Institute of Canterbury.

* Colonel Legge, author of "Birds of Tasmania," &c., has informed me that most Australasian lighthouse-keepers have been asked to help towards recording bird-migrations.

The bringing-together and publishing in well-arranged form useful but scattered papers such as those of Captain T. Broun on the Coleoptera of New Zealand is also much needed.

B.—Botany.

Mr. J. H. Maiden has suggested several useful lines of work.* He dwells specially on the need for systematic botanical surveys of our country, for the conservation of forests, and for the study of the physiographical ecology of plants.†

Dr. Cockayne's work on the ecology of the plants of the Chatham Islands, &c., and his studies in "recapitulation" in the evolution of their seedlings, is a highly suggestive line of research for palæo-geography. Maiden points out Australia's duty in regard to botanical investigation in Australia and Polynesia; also that Germany, through the Royal Gardens in Berlin, subsidises botanists to work up the flora not only of its own oversea dependencies, but also that of Australia. For example, in 1900–01 two German botanists worked for fourteen months in Australia. All honour to them and their country for their zeal in the cause of science. But cannot our Governments in Australasia do more towards defraying the expenses of our own zealous but often impecunious botanists?

The investigation of the relation between the living flora of Australia and that of Cainozoic time is still yielding most interesting results in the hands of Mr. Henry Deane. There is scope for similar work in New Zealand. In the lowly order of bacteria Dr. R. Greig Smith has contributed many important papers to the Linnean Society. His discovery of a new bacillus, *Bacillus levaniformans*, developed in the "gum fermentation of sugar-cane juice," is of considerable economic as well as scientific interest. He has discovered it in sugar from widely distant lands,

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* President's address, Linnean Society of New South Wales, 1902, Pt. 4, pp. 740–804; and Journ. Royal Society New South Wales, Vol. xxi. 62-68.

† Dunedin has set us all a good example in the conservation of native flora by reserving around the city the Town Belt.

in beet as well as in cane sugar.* This bacillus is responsible for the deterioration of raw and refined sugar in bulk, and may also cause acid fermentation of raw-sugar crystals. At last, therefore, we know the agent which causes such loss in the sugar industry, and it is a matter upon which we may congratulate ourselves that this discovery has been made by a worker in the Southern Hemisphere.

Section E.—Geography.

The exploration of the antarctic regions by the German, Swedish, Scotch, and English expeditions has a special interest. The heroic work of exploration, in the rigour of an antarctic climate, by Captain Charles Scott and his brave companions, is one of which the British Empire may be justly proud. Most heartily do we wish them all Godspeed, and a safe and quick return. There is a vast deal to be learned besides mere topography in Antarctica. The study of the present and past flora and fauna of those regions has a more than romantic interest for the bipolar theory of life-development, and for the linking of life-forms in Australasia with those of South America; the question whether Antarctica was the home of the Glossopteris flora of the Australian, African, and Indian coal-measures is not the least interesting of these biological problems. Antarctic explorations are necessarily more or less costly, but nevertheless in the near future it will be our duty to bear a worthy part in the exploration of those regions. But geography, like charity, should begin at home: the real scientific geography of the interior of Australia is at present almost unknown. The work now in course of publication, in which Professor Gregory describes his recent exploration with his Melbourne University students of part of the Lake Eyre basin, is being eagerly looked forward to, and we know that the author of "The Great Rift Valley" will not disap-

* "The Gum Fermentation of Sugar-cane Juice," Proc. Linn. Soc. N.S. Wales, 1901, Vol. xxvi., Pt. 4, pp. 589–625.

point us. The life-history of the New Zealand lakes is another fascinating field of research.*

Oceanography has as yet received very little attention in Australasia. Mention has already been made of the good work that is being done in this direction by Mr. G. H. Halligan. We require information about the under as well as the upper ocean currents. With regard to the study of the tides, we have done as yet little for its advancement in Australasia. The few automatic tide-gauges we have (about eleven on the whole of the Australian coast) are in such positions as to be useful only for local purposes. The proposal to place gauges on Montague and Solitary Islands, so as to record the true tide of the Pacific, undisturbed by local conditions of coast, has been thrown out by every Government for the last ten years on the score of expense; but it is only by gauges in such positions that information likely to affect the tidal theory can be obtained. Mr. Halligan considers that tidal records without concurrent barograph and anemometer records are useless. For example, the pressure of 1 in. of mercury is equal to over 8 in. of tide.† With the limited information at our command several efforts have been made—notably by Mr. R. W. Chapman and Captain A. Inglis, of Adelaide—to trace the course of the tidal wave on the coast, but in Mr. Halligan's opinion the conclusions can be accepted only tentatively, though they will be most valuable to future workers. No complete theory of the tides can possibly be evolved without co-ordinated tidal observations from all parts of the world; and this, too, is a work in which Australasia is called to do its part. The matter of determining the density and temperature of the sea off our coasts has engaged the attention of Mr. T. W. Fowler, M.C.E.‡

* Messrs. Lucas and Hodson found that Lake Manapouri is 1,465 ft. deep and its bottom 600 ft. below sea-level, and Lake Wakatipu 1,200 ft. deep, with its bottom 200 ft. below sea-level.

† Obviously in the case of a tide-gauge station situated near a meteorological observatory the anemometer and barometer observations at the latter can be utilised for the corrections of the tide-gauge records.

‡ Rep. Austr. Assoc. Adv. Sci., Sydney, 1898, Vol. vii., "Australian Oceanography: Densities of Sea-waters," by T. W. Fowler, M.C.E.

Boring the Bed of the Ocean.—Mr. Halligan and I think that it would be possible to put a bore down in the bed of the ocean at a depth of about 100 fathoms, and in such a way as to secure a core of the strata encountered. If the boring at these shallower depths was successful attempts would be made to bore at greater depths.

Section F.—Anthropology and Philology.

Not the least valuable contributions to our volumes have been those in this section. As regards the Australian aborigines, much excellent work has been done by Mr. A. W. Howitt and the Rev. Lorimer Fison. The Royal Society of Sydney this year conferred its Clarke medal on Mr. A. W. Howitt.* By far the most important work on the aborigines that has ever been done is that accomplished by Professor Baldwin Spencer and Mr. Gillen. Only those who have experienced the hardships, perils, and privations of travel in Central Australia can appreciate the splendid self-sacrifice and devotion to science which inspired these men to persevere with the formidable task which they set themselves, and which enabled them to bring their labours at last to so successful an end. Of this work it may be said, "If it were done when 'tis done, then 'twere well it were done quickly." In another few years the civilising of the aboriginal by the white man would have made the work impossible. Baldwin Spencer and Gillen have saved for Australasian science a situation that would otherwise have been irrecoverably lost. Professor Spencer, however, would no doubt be the first to admit that, though much is done, more remains undone. This is a field of research where, as of yore, the harvest is plenteous and the labourers few. Australasia must send forth more labourers into this field. Even in the case of the Maori, though much has already been done by the author of "Maori Art," Hamilton, and "Maori Folk Lore," Rev. W.

* Our Association at the close of the Dunedin Congress awarded Mr. Howitt its Mueller medal.

Colenso, and others, much remains to be done. Much, too, has been done in the study of the Maori language in its relation to other Polynesian languages by Tregear, the author of the "Maori-Polynesian Comparative Dictionary," a work of immense value; yet even Tregear admits that here, too, there are many ways as yet untrod.

Section G 2.—Agriculture.

DROUGHTS AND THEIR CAUSES.

Mr. J. H. Maiden, in an important paper* to the Royal Society of New South Wales, suggested many measures for mitigating the evil of droughts. The determination of the periodicity of droughts, with a view to predicting them, is work urgently needed.

BLESSINGS OF ARIDITY.

An important fact of late brought into prominence by Mr. F. B. Guthrie is that the barren-looking red soils of the western plains of New South Wales, which in dry seasons look like deserts of finely-powdered brickdust, are formed of material which is exceptionally rich in mineral plant-food. For example, these soils contain three times the amount of lime and potash and twice as much phosphoric acid as do the average soils of our fertile coastal plains in Eastern Australia. This, as has been pointed out by Smyth in his "Conquest of the Arid West," is largely to be attributed to the small amount of the rainfall in those regions, which is sufficient to decompose rock-material, and form alkalies and other soluble minerals, but is insufficient to remove them when formed.† Guthrie concludes thus: "From the chemical point of view discussed in this paper, there is no room for doubt that the soils of our arid districts are admirably adapted for cultivation by means of irrigation; abundance of water, properly applied, being the only thing necessary to render

* "Some Lessons of the Drought," read before Royal Society, N.S.W., 4th November, 1903.

† Jour. and Proc. Royal Society of New South Wales, Vol. xxxvii.: "The Chemical Nature of the Soils of New South Wales, with Special Reference to Irrigation," bp F. B. Guthrie, F.I.C., F.C.S.; pp. 57–58.

them extraordinarily fertile; and it is in the establishment of co-operative irrigation colonies such as exist in similar arid districts in other parts of the world, notably in the western States of America, that we may look forward confidently to an expansion of our agricultural resources hitherto undreamed-of." What is true of New South Wales is doubtless true of a very large portion of the interior of Australia. The richness in plant-food of these semi-arid regions explains the fact that on the rare occasions when rain falls over them the desert blossoms like the rose and becomes suddenly a waving prairie of grass and flowers. This is very encouraging for the future, and shows us that even aridity is not without its blessings.

Mr. Guthrie suggests, among problems to be investigated, the following: (1) Irrigation with artesian water, and effect of saline constituents on the growth of plants; (2) soil survey on the lines followed in the United States of America; (3) study of constitution of plants reputed to be poisonous to stock; (4) rust in wheat; (5) study of soil bacteria, and improvements in nitrifying power of soils, &c.

In New Zealand I suppose one of the most important agricultural problems is how to replace the fixed nitrogen and phosphorus annually taken from the New Zealand soil in the shape of wheat, wool, and carcases. This is a problem which will task the energy and ability of your agricultural colleges and directors of agriculture.

Of Sections H. and I. respectively—Engineering and Mining; Social Science and Hygiene—I am not competent to speak, but would just offer two remarks. With regard to engineering, the author of "Our Imperial Heritage" has shown that, inasmuch as electricity is now becoming the great motive-power in the world, nations which can generate it cheaply will have a great advantage over nations which cannot. Electricity is most cheaply generated by water-power. The swift-flowing rivers and waterfalls of New Zealand should in the future be made to generate electricity, increasing thereby the national wealth by supplying cheap power and light.

With reference to hygiene, New Zealand is to be congratulated on the progressive legislation of its Government. What brighter example of this could there be than the recent establishment by the Government of the Waikato Sanatorium for the treatment of consumption? "Consumption" suggests that other great foe of man—cancer. Does not the remarkable discovery that the Röntgen rays will quickly cure rodent ulcer lead us to hope that by means of bacteria-killing radiations of this type even the germ of cancer will eventually be destroyed?

As regards Section J., Mental Science and Education, the work of our Association is capable of a wide expansion, but before discussing it certain other ideals of Australasian science may be roughly outlined. Much has been done already by our Association to promote co-ordination among scientific workers, but more remains. The forces of science must be thoroughly disciplined; the attack on the stronghold of Nature must be a concerted one, and must be pushed home; there must be less of irregular skirmishing and filibustering. Each worker must keep to his own special work, and when it is known that a worker has developed a special aptness for some kind of work, as much of that work as possible should be given him. One worker, for example, has made a special study of the foraminifera, another of eucalypts, another of diptera, and each has become eminent in his special study. Let other workers send to these men for determination their foraminifera, their eucalypts, their diptera. A collector, if he has acquired good material and is not qualified to describe it, should lose no time in forwarding it to the specialist. Too often in the past Australasian science has suffered from the dog-in-the-manger policy of keeping good stuff stored away in cellars because the owner of it could not from want of time, or ability, describe the material himself, and because he grudged to let any one else do it for him. Such action is wholly foreign to the true scientific spirit, which in its earnestness in the advancement of science should be prepared to make any sacrifice so long as thereby the best interests of science are served. Then, too, we aim at better equipment for our laboratories; we long for increased votes for our museums; we need larger and better libraries, endowed in the liberal spirit of that prince of benefactors, Carnegie. But though pure science pays sooner or later, it does not necessarily pay at the time, and the bread-and-butter difficulty has too often checked what otherwise would have been the brilliant career of the young scientist. Too often is it the case that this same bread-and-butter difficulty has made the scientist a Jack-of-all-trades and a master of none. Hence the need for more endowments of research, such as the Macleay Fellowships of Sydney afford. What better use can men who have won wealth through what they have gained by the application of science to Nature make of that wealth than by endowing research? Another way in which science may be advanced is by the subsidising of scientific expeditions. As local scientific societies seldom have funds for this purpose, science has had to rely on private donations. The handsome gifts for this purpose of Mr. W. A. Horn and Sir T. Elder (of South Australia), of Miss Edith Walker (of Sydney), of the Hon. David Syme (of Melbourne), of Professor Baldwin Spencer's father, and of Professor A. Agassiz, and quite recently the assistance given by Captain E. G. Rason, R.N., for the exploration of the New Hebrides, have all been the means of advancing science in Australasia or in the Pacific Islands, and should encourage others to give. But science should not be left in the undignified position of continually crawling around with the hat. If only the public fully realised that science is the life of industry, and safeguard of the people's health, aid would be given cheerfully and ungrudgingly, as parent gives to child.

While the importance of science to national wealth and national health can scarcely be over-estimated, the advance of education should be our grandest ideal. The words of Huxley must not be forgotten, "If the wealth resulting from prosperous industry is to be spent upon the gratification of unworthy desires, if the increasing perfection of manufacturing processes is to be accompanied by an increasing debasement of those who carry them on, I do not see the good of industry and prosperity."*

IV.—DUTY OF THE ASSOCIATION TO SCIENCE-TEACHING.

This Association has not yet put out its strength to secure efficient teaching in science for the people of Australasia, and yet there are few questions of more vital importance. I have already spoken elsewhere on this subject as one of the minor prophets, but, as a prophet has no honour in his own country, I will take the liberty of quoting somewhat extensively from the greater prophets of older countries with regard to the national importance of science-teaching. The importance of science in warfare finds expression in the oft-quoted dictum of Von Moltke, that Sedan was won by the schoolmaster. The Boer war has taught us a lesson which we must take to heart or it will be the worse for us—the lesson that it is useless to oppose light field-artillery to the "long-toms" of Creusot, useless to match mere physical strength and courage against superior military science. Battlefields are no longer won on the playing-fields of Eton. Prussia awoke to the importance of education after Jena, France after Sedan, and it is time the British Empire awoke now. As regards the importance of science-teaching in times of peace, Sir Norman Lockyer in his recent powerful address to the British Association quoted the following from Disraeli: "How much has happened in these fifty years—a period more remarkable than any, I venture to say, in the annals of mankind. I am not thinking of the rise and fall of empires, the change of dynasties, the change of governments. I am thinking about those revolutions of science which have had much more effect than any political causes, which have changed the position and the prospects of mankind more than all the conquests and all the codes and all the legislators that ever lived."† He also quotes this statement

* "Science and Culture, and other Essays," by Prof. Huxley; p. 21. London: Macmillan and Co. 1882.

† "Science," Sept. 25, 1903. British Association address, "The Influence of Brain-power on History."

of Mr. Chamberlain in January, 1901 : "I do not think it is necessary for me to say anything as to the urgency and necessity of scientific training. . . . It is not too much to say that the existence of this country as the great commercial nation depends upon it. . . . It depends very much upon what we are doing now, at the beginning of the twentieth century, whether at its end we shall continue to maintain our supremacy or even equality with our great commercial and manufacturing rivals."* Lord Rosebery has given us the following warning of the danger of neglect of scientific method : "I humbly think that in this country we live a good deal too much from hand to mouth. We do not proceed by scientific method. We go on the principle that things have carried us well so far; that we are a noble nation; that we are pretty numerous; and that we have always muddled out right in the end. But I say this : that we are a people of enormous waste : we waste simply by not pursuing scientific methods. Germany is infinitely more painstaking and scientific than we are. In commerce, in education, and in war we are not abreast of the more advanced nations of the day. And if we want to keep our place we shall have to consider the lessons we have been taught in this respect. Depend upon it, however brilliant you may be, the tortoise of investigation, method, and preparation will always catch up to and overtake the hare which leaves everything to the inspiration of the moment."† How Germany has outstripped us by being "infinitely more paintaking and scientific" is forcibly stated as follows by Professor Dewar :‡ "The consular report estimates that the whole value of German chemical industries is not less than £50,000,000 sterling per annum. These industries have sprung up within the last seventy years, and have received enormous expansion during the last thirty. They are, moreover, very largely founded upon basic discoveries

* "Science," 25th September, 1903, p. 389, inaugural address by Sir Norman Lockyer to British Association.

† Tech. Edu. Rep. Vic. Roy. Com. p. 154. Lord Rosebery at Chatham, 22nd January, 1900.

‡ Address to the Belfast meeting, British Association, 1902.

made by English chemists, but never properly appreciated or scientifically developed in the land of their birth." [He is referring to the manufacture of aniline dyes, perfumes, &c., from coal-tar.] "I must repeat that the fundamental discoveries upon which this gigantic industry is built were made in this country, and were practically developed to a certain extent by their authors. But in spite of the abundance and cheapness of the raw material, and in spite of the evidence that it could be most remuneratively worked up, these men founded no school, and had practically no successors. The colours they made were driven out of the field by newer and better colours made from their stuff by the development of their ideas, but these improved colours were made in Germany and not in England. Now, what is the explanation of this extraordinary and disastrous phenomenon? I give it in a word—want of education. We had the material in abundance when other nations had comparatively little. We had the capital and we had the brains, for we originated the whole thing. But we did not possess the diffused education without which the ideas of men of genius cannot fructify beyond the limited scope of an individual."

In his address to the British Association in 1903 Sir Norman Lockyer drew a comparison between what Britain does for maintaining her sea-power and what she does for maintaining her brain-power. He points out that the British navy is yearly becoming stronger, while the commerce it is designed to guard is yearly decreasing; this involves a constant increase of taxation side by side with a constant decrease of wealth. The remedy he suggests is not to build fewer battleships, but more universities, well equipped and manned, giving education in the broadest and highest sense. He estimates that the building of a university and its upkeep cost as much as those of a first-class battleship—*i.e.*, about £1,000,000 for building and £50,000 per annum for upkeep. Great Britain has only thirteen universities, as compared with the thirty-five combined first-class universities of Germany and the United States of America, her two most formidable commercial rivals. She would therefore need twenty-two extra universities to bring her up to two-power standard in potential brain-power, as she is already up to two-power standard in naval power. But instead of asking for the twenty-two new universities, Sir Norman asks only for eight, and shows, according to the estimates already given, that £8,000,000 would be needed for the building of these universities, and £400,000 yearly for their upkeep. If, therefore, the yearly payments were capitalised at $2\frac{1}{2}$ per cent., a total vote of £24,000,000 would be needed, a sum only slightly in excess of the vote for new warships (£21,500,000) in 1888. The opinion has been expressed that Sir Norman Lockyer has overstated the case, but he points out that in view of Sir Robert Giffen's estimate that in 1901 the United Kingdom "as a going concern" was worth £16,000,000,000, it was not an exorbitant demand to ask £24,000,000—*i.e.*, one 666th—as a vote for higher education. He further points out that £24,000,000 is less than half the amount by which Germany is yearly enriched by having improved upon our chemical industries.

It is not only in the older countries that the importance of science for national prosperity has received the recognition it deserves. Quite recently one of our own Australasian Governors, Sir Herbert Chermside, expressed himself as follows at the Technical College, Brisbane: "Hitherto in the Old World the direction of national affairs has devolved mainly on ex-students from library, cloister, or law chambers, rather than on those from laboratory and lathe. But, already, such a scientist as Lord Kelvin has enunciated that the making of accurate measurements is the high road to scientific discovery, and the day may well be not far distant when the law of the emergence of the fittest may transfer the direction of national interests to scientifically trained intellect, which would form a class of higher moral ascendency than any existing social or industrial one . . . . . What is now to be done is to *act*, meaning thereby to insure a good foundation of general education for the superstructure of a logically succeeding specialised one, to drastically reform dogmatic and didactic tuition with its sterilising effect on the imaginative faculties, to aim at developing the highest qualities of the human intelligence in contradistinction to such hereditary mechanical brains as those of ants and bees."*

The cry that Great Britain in matters of scientific education is behind Germany and America, and that we in Australia are behind Great Britain, has been taken up in Victoria in the excellent report on technical education lately furnished, as well as in the fine report on primary education of the New South Wales Education Commissioners, published a few weeks ago. That Great Britain is behind Germany is freely admitted by standard British publications. Thus, in *Nature*, October 22, 1903, p. 602, we read, "In Britain the total number of students from fifteen years and upwards taking complete day technological courses is 3,873. Probably not more than 10 per cent. could pass the entrance examinations of Charlottenburg." The following shows that while Great Britain is behind Germany in elementary-science teaching, she is ahead of us in Australasia :—†

"Exhibitions by London School Board and Nature-study Exhibition Association indicate progress of practical work in science, especially in physics and biology.

"The School Board has sought to encourage the making of scientific apparatus by the science masters and their scholars out of ordinary and inexpensive materials, as more instructive than the mere manipulation of purchased articles; and the exhibition of what has been thus produced in the schools during the last twelve months shows a very marked advance, both in quantity and quality, over that of the preceding year. The exhibits—651 in number—ranged over botany, chemistry, heat

* Sir Herbert Chermside's speech at the annual distribution of prizes at the Technical College, Brisbane, Queensland (The *Telegraph*, Brisbane. 4th May, 1903).

† British Association, Belfast, 1902. Report of committee on "Teaching of Science in Elementary Schools."

light, hygiene, magnetism and electricity, mathematics, mechanics, natural history, physiography, physiology, sound, and steam. The Board has also entered into arrangements with the custodians of the Royal parks for a weekly supply of cut flowers, leaves, &c., to furnish illustrations of the reading-lessons, as well as material for the scientific study of botany."

"The Nature-study Exhibition Association has been organized for the purpose of creating an interest in biological studies. and of illustrating the most approved methods of arranging school museums and other appliances for teaching. The exhibition consisted of a large collection of objects gathered by children in their own neighbourhood, and of drawings which they had made from the plants and animals themselves, and of manuscript notes as to their development. These illustrations were generally given in their proper colours, and often with the aid of a microscope."

The general conclusion of the Education Commissioners for New South Wales is that in that State there is practically no science-teaching in the primary schools, that there is little science-teaching in the secondary schools, and that, with a few bright exceptions, of an inferior order. As regards the need for teaching science in primary schools, Mr. Knibbs reminds us of the statement of Mr. Sydney Webb about England, "that it is in the class-rooms of her primary schools that the battles of the Empire for commercial prosperity are being already lost."*

Mr. Knibbs further states (*op. cit.*, p. 20): "In order to profit by their opportunities, especially in our young country, it is requisite that the people as a whole should have some idea of the significance of science for daily life and ordinary avocations. For example, a dairyman or agriculturist ought to know something of the meaning of botany, zoology, chemistry, bacteriology, &c., in relation to his chances of success. Therefore he must get elementary instruction in the primary schools about such matters,

* Report of New South Wales Education Commissioners on Primary Education, p. 54.

and clearly the only persons competent to give it would be the persons who have at least been taught by specialists, and who have had opportunities of confirming and applying that knowledge by actual experiment, and who, moreover, enlarge their experience through suitable means. Here it must be pointed out that the consensus of opinion among persons competent to judge is that mere literary attempts to learn science are of small value." And again, p. 37: "Reference may be made to the recognition by Belgium of the value of scientific knowledge to the farming and dairying population, and its influence on education. At the present time Belgium practically supplies her own needs in respect of dairy products, whereas a decade ago her imports were large. This is the result of a suitable education of her people. Scientific instruction in the primary schools is an essential basis for proper subsequent development, either in higher education, or in education for ordinary agricultural, commercial, industrial, or other pursuits. The child properly taught the elements of science has a far more intelligent outlook upon the world and a better understanding of its present activity than he has where the subject is neglected."

If ever science is to diffuse itself through a people it must be largely by means of the primary school. Even in the most elementary stage of science-teaching the great aim should be to make the child discover for himself, and not merely commit to memory explanations given by teacher or text-book. Any science-teaching which does not make the children think, instead of allowing themselves to be filled like little pitchers, is a fond thing vainly invented. Any science-teaching, however elementary, which is not illustrated with experiments profits nothing. Children must be taught to experiment for themselves. Neither elaborate nor costly apparatus is needed for this purpose. The simpler the apparatus the better. Professor Gregory in his admirable lecture lately on "How to teach Geography," and in his school geographies for Victoria, gives useful information on this subject. "Nature Studies in Australia" (by W. Gillies and R. Hall, and "Nature in New Zealand" by J. Drummond, edited by Captain Hutton, are both excellent books calculated to interest children in the natural history of their country and to cultivate healthy habits of observation. For encouraging observation and scientific collecting, and as an aid to experiments, every school should have its own museum. The museums should largely depend for their supply of specimens on those collected by the children. In the Continental schools of Europe the principals of the various industrial establishments make frequent gifts of materials for the school museums. No doubt similar establishments in these austral lands, if properly approached, would do likewise. The value of excursions into the country cannot be over-estimated. "Books in the running brooks" are better than the best of text-books, and secure that realism which is to-day the great aim of teaching. Even mathematics lends itself to this, particularly the teaching of geometry, as Professor Carslaw has recently shown us. *

The New South Wales Education Commissioners also point out that (*op. cit.*, p. 33) Euclid's elements as a means of teaching geometry have for a long time been abandoned in the great majority of European countries, though the system is still retained in England, and quote Professor Sylvester's remarks: † "I would rejoice to see Euclid honourably shelved, or buried 'deeper than did plummet ever sound' out of the schoolboy's reach. . . . The early study of Euclid made me a hater of geometry," and Mr. Knibbs adds (*op. cit.*, p. 34): "French and German treatises on geometry of quite a moderate size teach a great deal more of the subject than can be gleaned from Euclid, and there is no doubt that the abandonment of Euclid's Elements will not only make it possible to handle the subject more interestingly, but also to learn it more thoroughly and comprehensively."

In view of the vast importance of mathematics to science, this Association should use its best efforts to

* The Australian Journal of Education, Vol. i., No. 4. October 1, 1903. Brooks and Co., Sydney. † Address to British Association, 1869.

secure the teaching of mathematics on modern lines, which are not such hard lines on children as the old unaltering lines, and are far more useful.

Then, in the matter of examinations, paper examinations in science, unaccompanied by practical tests, are as vain as teaching science without experiments, and are a direct discouragement to those heuristic methods, the "run and find out for yourself" methods of teaching, which Professors Armstrong and Perkin have so warmly advocated. Periodic inspections should largely take the place of examinations, a reform already adopted in conservative Old England. While science teaching in primary schools must necessarily be of the character of nature study, or *erdkunde*, in the secondary schools distinct branches of science, like chemistry, physics, biology, physiography, &c., can be taught. The same principles apply here as in the primary school teaching of science.

An excellent address on the methods of teaching chemistry in secondary schools was delivered as a university extension lecture by Mr. A. H. S. Lucas to the teachers of New South Wales last year.* He reviews the two methods of teaching chemistry—(1) the old method, in which a text-book is used epitomizing up to date all the chemistry work done in the world, with the results described in their final finished form and logical order, usually not the historic order; (2) the heuristic method, in which the text-book is kept in the background and the pupils are set problems which they have to work out for themselves. Professors Armstrong and Perkin, in England, and Professor Masson, in Melbourne, are advocates of this latter system. Lucas concludes that the result of the contest will be a compromise. He favours the reformers. What is true of the principles of science teaching in secondary schools applies equally to university teaching. The chief need of science teaching at Australasian universities is better-equipped laboratories. The amount which the Australian States expend on their universities and laboratory equipment is small as com-

* *The [illegible]*, [illegible]

pared with that expended by Germany and the United States under equal conditions of population. For example, in Germany the buildings of the new University of Strassburg have already cost more than a million, and the Government annual endowment is £49,000. In New South Wales, the population of which is 1,400,000, the university statutory endowment and lecture votes, with votes for repairs, &c., amount to £13,000 a year; while for scientific apparatus the vote this year is £1,500: total, £14,500. In California, with a population of 1,500,000, the annual income of the university in 1898 was £42,000 from the State Government, £7,200 from the United States Federal Government: total, £49,200 from the Government, which is more than three times as much as Sydney University receives. It might be mentioned that the California University in 1898, had, in addition to the sum mentioned above, £50,000 appropriated by the Government for building professional schools, and also an annual income of £24,000 from private endowments.

What is true of Sydney is more or less true of all the Australasian universities. Speaking of endowments suggests the case of Melbourne University. Is it not a disgrace not only to Victoria, but to the whole Commonwealth of Australia, that a teaching-institution which has done so much for real education and for the advancement of science in this hemisphere should be allowed to be hampered by a debt of £32,000? Cannot this Association do something to arouse public opinion as to the urgency of at once rehabilitating the Melbourne University? For a new racecourse the money would be at once forthcoming.

Horses suggest the subject of sport. It should, I think, be one of the aims of this Association to discover and destroy the microbe of sporting mania. Do not misunderstand me. We should be the last to discourage any healthy sport. But when we worship in the cricket or football fields the wood and the leather, we must remember that they are but idols, and must not let them occupy the chief shrine in our hearts. The following, told me lately by an American professor, will be recognised as not uncharacteristic of our people. He was approaching the shores of Australia at a time when the fate of our Empire hung in the balance. Like his fellow-passengers he was eager to hear what the first news would be as he approached the shores of the great island continent. The pilot-boat approached, and the pilot, through his speaking-trumpet, roared these memorable words, "The Australians have won the first test match." "I calculated then," remarked the professor, "that I had come to a great sporting country." It is not only in Australia that the love of sport has acquired too great an ascendency. The following speech, referring to sport, was lately made by England's Prime Minister, Balfour: "Boys of seventeen or eighteen who have to be educated in the secondary schools do not care a farthing about the world they live in except in so far as it concerns the cricket-field, or the football-field, or the river."* If we go to America we find the same sentiment expressed. In the "commencement" address at the Rose Polytechnic Institute are these words: "But there is a noisy minority who have succeeded apparently in convincing the public and, to a large extent, college authorities, that one of the principal functions of an educational institution is the cultivation of muscle and the conduct of athletic sports. Along with the growth of this minority there has sprung up also a class of less strenuous men, who, taking advantage of the elective system, are pursuing courses of aimless discontinuity involving a minimum of work and a maximum of play. They toil not, except to avoid hard labour; neither do they spin, except yarns of small talk over their pipes and bowls. I need not explain to you that these types of men are well known in natural history. From time immemorial the gladiator and the 'Miss Nancy' have received much of that fleeting attention which the careless crowd bestows on the gaudily-attired tumblers of the circus and on the transparent masks of pretenders. The sporting populace and the sporting alumni go wild with enthusiasm over

* "Science," September 25, 1903, p. 394. † "Science," August 7, 1903.

intercollegiate contests, while the Press, in a fashion similar to that followed in describing prize-fights, devotes much more space to these ephemeral events than it does to all other educational affairs combined. It is no wonder, then, that the light-headed undergraduate attires himself like a stable-boy and affects the manners and vices of a cowboy without aspiring to the virtues of either. He may be excused also for entertaining the hypothesis that colleges are athletic clubs, and that his professors, as suggested by Mr. Dooley, will proceed leisurely to take for him the requisite minimum of formalities leading to a degree."

The creation of a healthier state of public opinion is the chief remedy for excessive love of sport. In Germany, when Virchow passed along the people were wont most reverently to raise their hats—an honour not accorded in that country to the greatest of athletes, and yet Germany is not the least athletic of the nations; but she is, perhaps, the best-educated, and education gives true perspective to the world around us. If we are to create a healthier public opinion with regard to sport, politics, commerce, and all social matters, it must be by education. It is not the part of a patriot to hug himself in smug pessimism, comfortable in the belief that the country is being ruined. We must gird up our loins and act. We believe education can avert the ruin, and that this Association can directly help education. Sir Norman Lockyer has pointed out this: "In Germany there is a Scientific National Council, of about a dozen members, consisting of representatives of the Ministry, the universities, the industries, and agriculture. It reports direct to the Emperor. It does for industrial war what military and so-called Defence Councils do for national armament. It considers everything relating to the use of brain power in peace—from alterations in school regulations and the organization of the universities to railway rates and fiscal schemes, including the adjustment of duties. What this Council advises generally becomes law." He adds, "It should be pretty obvious that a nation so provided must have enormous chances in its favour. It is a question of drilled battalions against an undisciplined army, of the use of the scientific spirit as opposed to the hope of 'muddling through.'" He suggests that in England a scientific council might be appointed as a committee of the Privy Council.

I beg to suggest that this Association appoint an influential Research Committee to inquire into science-teaching, and how to make it effective in primary and secondary schools, colleges, and universities. Such a committee might also approach the various Governments of Australasia on the subject of the formation of Scientific Boards of Advice. Such a work, if it can be successfully carried out, would be worthy of our best effort, and there is no reason why it should not succeed as well as the British Association, which has so successfully helped to reform the teaching of mathematics in Great Britain. We can but try.

A few words, in conclusion, about what seems to be the ideal of science. Science expects every man in this world to learn in the simple way that a child learns the great lessons of the universe; she wants him to be free as the air in his interpretation of what he sees and hears in the world of Nature around him, and she wants the simple child-habit of learning by experiment to follow him from childhood to boyhood, from boyhood to manhood. She wants him to learn well that he may live well; to learn by experiment rather than wholly through the experience of others, so that he may be self-reliant and think for himself. Thinking of this kind brings discovery, and the discoveries of science uplift humanity. Does not science uplift humanity? Has she not taught men to be fearless in the pursuit of truth—taught them to sacrifice all for the truth? Year by year the devotees of science grow at a rate far faster than grows the population of the world. Science by her rigid and unswerving pursuit of truth is drawing to herself, not only her own votaries, but men of every shade of thought who love the truth. Such is the work of Science, and if she were doing no other work than this, would not her glory be greater than "glory of warrior, glory of orator, glory of song"?

PROCEEDINGS OF THE SECTIONS.

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Section A.

ASTRONOMY, MATHEMATICS, AND PHYSICS.

PRESIDENTIAL ADDRESS.

By Professor W. H. Bragg, M.A., Adelaide.

(Delivered 7th January, 1904.)

ON SOME RECENT ADVANCES IN THE THEORY OF THE IONIZATION OF GASES.

I propose to speak to you this morning concerning some recent advances in the theory of the ionization of gases. The phenomenon itself furnishes one of the principal methods by which the strange new properties of radio-active substances are made manifest and studied. For this reason its interest, always great, has been doubled. Many of the most skilful experimenters that physical science possesses are devoting their energies to it, and in consequence our knowledge of its laws grows rapidly. Some great principles are beginning to take definite shape, and as they do so they suggest new lines of advance; at the same time they help us to co-ordinate masses of facts whose connections with each other have been hitherto unknown. When we consider the importance of these laws, the extent of their bearing on all branches of science, their own intrinsic beauty, and the beauty also of the experiments which illustrate them, we can understand the fascination experienced by all students of this new subject.

Let me begin by stating briefly a few main facts and principles. When gases are subjected to certain influences, such as Röntgen rays or the radiation from radio-active substances, they acquire the power of conducting electricity. But this power has curious limitations. In the case of an ordinary conductor, such as a metal wire, the current is simply proportional to the potential gradient, so long as the temperature of the conductor is maintained constant. In the case of the conducting gas, on the other hand, the current does indeed increase as the electro-motive force is made greater, but it tends to a limit. When this stage has been reached, the electro-motive force may be very largely increased without any corresponding increase of the current. Yet, if the in-

crease of the electro-motive force is sufficient, again a new state of things sets in, and we find the current increasing faster than the electro-motive force. Finally a stage is reached in which the Röntgen rays or the radio-active substances are no longer necessary: the current across the gas can be maintained by the electro-motive force acting alone, and the phenomenon is now that of the well-known electric discharge.

All these things are readily explained on the hypothesis that the conduction of electricity across a gas is effected by the motion of charged carriers, or ions. The neutral molecule or the neutral atom of the gas is divided, through the influence of the Röntgen rays or other ionizing agency, into two parts, one carrying a positive the other an equal negative charge. Under the guidance of the acting electro-motive force these ions begin to move as soon as they come into existence, the negative going up the lines of force to the positive electrode, the other in the opposite direction to the negative. Since the number of ions so formed must depend on the magnitude of the ionizing influence, it is plain that so long as the electro-motive force is enough to take all the ions to the electrodes no further increase of the force will have any effect. In order to understand why a certain electro-motive force is necessary for the production of the full current which uses all the ions, we must take into account the fact that these ions always tend to recombine. In fact, if a certain volume of gas were subjected to Röntgen rays it would not be possible for the number of ions formed to exceed a certain value, no matter how long the ionizing influence was at work, even if there were no electro-motive force to drive them out of the gas as fast as they were formed. At this value the number of new ions formed in each second would be equal to the number that in the same time recombine and become neutral molecules or atoms. When, therefore, the electro-motive force acts on the gas which is being ionized, and we wish to measure the full amount of the ionization, the force must be so great that the ions are moved up to the electrodes before the recombinations are numerous enough to make any serious difference to the current.

This theory sufficiently explains the phenomena that are shown by a gas conducting under moderate electro-motive forces, such as a few hundred volts per centimetre, in air at atmospheric pressure. It will be better to defer for the moment the consideration of the effects of large forces, when, as has been described above, the current rises past the value which it maintains unaltered through a great range of moderate forces. The currents in these experiments are very small, and it is usual to employ delicate electrometers to measure them.

Questions of great interest at once arise. Of what nature are these ions? How large are they compared to the molecules of the gas in which they are formed? What is the charge on each ion? We know that the molecules of a gas are in rapid motion; what is the average speed of the ion?

What we know of the answers to these questions we owe in great measure to the brilliant experimental investigations carried on at the Cavendish Laboratory at Cambridge under the directorship of J. J. Thomson. One of the names best known in connection with these researches, and with other great researches to which they have led, is that of E. Rutherford, who, having won an "1851 Exhibition" scholarship, left this Colony of New Zealand in 1896 to pursue his studies at Cambridge. It is a happy coincidence, and I realise the fact with great satisfaction, that, in speaking to you of a subject which owes so much to him, I am addressing his own friends and kindred.

In the first place, the charge that the ion carries has been determined by J. J. Thomson, Townsend, H. A. Wilson, and others. Their experimental researches, all most ingenious and beautiful, have shown that the ionic charge is a constant quantity. No matter what the gas in which the ion is formed, nor what its state, nor what the agency that produces it, the charge is the same, and is very nearly $1{\cdot}1 \times 10^{-20}$ in electromagnetic units. This remarkable fact is, of course, the foundation of the atomic theory of electricity. I do not propose to describe the investigations which have led to this result: a comprehensive account is to be found in Sir Oliver Lodge's address to the Institute of Electrical Engineers (Proc. Inst. E.E., Feb., 1903).

As to the size of the ion, the work of Zeleny, Rutherford, Townsend, and others has made clear the surprising fact that it is much greater than that of the molecule. Since the ions are formed by the partition of molecules, it might at first appear that there was here an exception to the axiom, "The part is not greater than the whole." There is, however, a simple explanation to be given. Each of the two portions of the atom or molecule, soon after its separation, becomes the centre of a cluster of molecules which gather round the attracting electric charge. Thus the ions are really molecule-clusters. These clusters move very slowly through the gas, even if urged by an electro-motive force, and it is by the slowness of their diffusion that their bulk is determined. Townsend, for example (Phil. Trans., 193, 1899), caused air which had just been ionized by X rays to flow uniformly along a metal tube. The ions that diffused to the sides gave up their charges and became neutral, so that the gas on emergence from the tube contained fewer ions than when it entered. The loss depended on the speed of the current of air, on the dimensions of the tube, and on the "coefficient of diffusion," which term was employed in the usual sense, as defining the rate at which the molecules of one gas diffuse into those of another. Townsend thus obtained the following coefficients:—

		Positive Ions.	Negative Ions.	Ratio of Positive to Negative.
Dry	Air ...	·028	·043	1·54
	O ...	·025	·0396	1·58
	CO_2 ...	·023	·026	1·13
	H ...	·123	·190	1·54
Wet	Air ...	·032	035	1·09
	O ...	·0288	·0358	1·24
	CO_2 ...	·0245	·0255	1·04
	H ...	·128	·142	1·11

It will be noticed that the negative ion diffuses faster than the positive and must therefore be smaller, and that for some unknown reason the difference between the two is much less when the gas is wet.

Now, let us compare these with the rates of diffusion of gases into each other, as shown by the following table:—

	Air.	CO_2.	H.
O	...	·18	·721
CO_2	·142	...	·555
Ether	·077	·055	·29
Alcohol	·101	·068	·378
Water	·198	·132	·687

It is plain from these figures that the ions move sluggishly and must be large things compared to ordinary molecules. Indeed, it has been shown by Townsend (from whose paper these figures and arguments are taken) that if we employ Maxwell's formula for the coefficient of interdiffusion of two gases in terms of the radii of the molecules we find the radius of an ion to be $9{\cdot}2 \times 10^{-8}$, whereas the diameter of the gas-molecules is about 2×10^{-8}. Again, if we employ the experimental law $k \times \sqrt{(\rho_1\rho_2)}$ = constant, where k is the coefficient of interdiffusion of two gases whose densities are ρ_1 and ρ_2, we find that the mass of the ion is thirty or forty times that of the oxygen-molecule, and is nearly the same no matter what gas it is formed in.

Moreover, various ionizing agencies produce ions of the same size. Townsend has shown that the ions due to the action of X rays are very similar to those produced by the radiation from radio-active substances, or by the electric discharge from points, or the action of ultra-violet light on a zinc plate.

Zeleny (Phil. Trans., 195) measured the actual rate at which the ions move through the gas under the influence of electro-motive force. He found the velocities in centimetres per second under an electro-motive force of one volt per centimetre to be as follows:—

		Positive Ion.	Negative Ion.	Ratio of Velocities.
Dry	Air ...	1·36	1·87	1·375
	O ...	1·36	1·80	1·32
	CO_2 ...	·76	·81	1·18
	H ...	6·70	7·95	1·19
Moist	Air ...	1·37	1·51	1·10
	O ...	1·29	1·52	1·18
	CO_2 ..	·82	·75	·915
	H ...	5·30	5·60	1·05

These results correspond very closely with those of Townsend in that they show that the velocities of the various ions bear the same proportions to each other as the coefficients of diffusion. Each set shows the same curious effect of water in tending to equalise the sizes, and therefore the speeds, of the two kinds of ions.

NOTE.—The coefficient of diffusion k and the speed u under E.M.F. equal to X are connected by the relation

$$u = \frac{ne\text{XK}}{p} \; (loc.\ cit.),$$

where u is the number of ions in a cubic cm., p is the pressure they exert, and e is the ionic charge.

If we assume the law of Avogadro to hold for these ions, then we may replace n/p by N/P, where N is the number of molecules in a square cm. of the gas and P is the gas-pressure. Thus u = NeXK/P. If we take u from Zeleny's table—for instance, 1·36, the value for the ion in dry air—then we must put K equal to ·028, as given in Townsend's table; also X = one volt, or 1/300 E.S. unit, and P = 10^6.

Hence, as Townsend has shown—

$$\text{N}e = \frac{1{\cdot}36 \times 300 \times 10^6}{{\cdot}028} = 1{\cdot}46 \times 10^{10}.$$

The other possible substitutions give very similar values. The value of Ne in electrolysis is $1{\cdot}23 \times 10^{10}$.

We have now got so far as to see that various ionizing agencies produce ions in gases which are of the nature of molecule-clusters, of comparatively great bulk and sluggish movement; also, under the circumstances we have considered, these ions, however and wherever produced, carry the same charge and are approximately of the same size. Now, it is probable—we may say it is certain—that the former statement is true under all circumstances and the latter is not. No known experiment shows us an ion of different charge; but there are causes, not yet considered by us, which affect the size of the cluster. McClung has shown (Proc. Camb. Phil. Soc., October, 1903, p. 152) that X ray ions in air recombine very much more rapidly at high temperatures than at low; and Richardson (*loc. cit.*) shows that the great difference can only be explained by supposing that the clusters become smaller as the temperature rises. In this way the ions become more lively, and have greater chances of recombining. It would seem that, as the rolling stone gathers no moss, so the ion, urged to more rapid motion by rise of temperature, loses some of its clustering molecules in the greater frequency and violence of its collisions. Richardson quotes also a statement of Langerin, that at low pressures the ions, especially the negatives, are quicker in their movements, and this implies a smaller bulk. At moderate pressures—from three atmospheres down to an eighth of an atmosphere —the rate of recombination is independent of the pressure, as McClung has shown (Phil. Mag., March, 1902) ; so that the cluster is of constant size throughout this range.

In some cases there are found clusters of much greater size than those described above. Townsend (Proc. Camb. Phil. Soc., ix., p. 358, 1897) has shown that such clusters exist in gases newly prepared by electrolysis. For example, in the hydrogen given off in the electrolysis of dilute sulphuric acid there are clusters having a diameter of $4{\cdot}5 \times 10^{-7}$ c.m. ; in the oxygen, of $1{\cdot}2 \times 10^{-6}$. The gases were perfectly dry. Such clusters are to ordinary molecules somewhat as cricket-balls are to small shot. They have difficulty in passing through an ordinary porous pot. If water is made to settle on them by an adiabatic expansion of air saturated with water-vapour their diameter may grow to nearly 10^{-4} cm. The clusters are then so large that if the containing gas is made to flow along a horizontal tube numbers of them fall to the side under gravity and are thus removed from the gas. The diameter of such a cluster is many thousands of times as great as that of an ordinary molecule ; and, as we shall see later, it is in some cases nearly a thousand million times greater than the part which was broken from the molecule and is the kernel and cause of the whole affair.

These electrolysis clusters are curiously stable—much more so than the clusters produced by X rays. The dry gas containing them may be bubbled through water so that the clusters grow to the larger size, and be dried again by passing through sulphuric acid so that the clusters become their ordinary size, and yet 80 per cent. of the original electrification will remain.

Again, the ions which are formed in the neighbourhood of the electric arc and of incandescent metals are of sizes which depend on the circumstances of formation, as has been shown by McLelland (Camb. Phil. Soc., x., p. 241). Velocities, under an E.M.F. of one volt per cm., which varied from ·015 cm. per second to ·33 cm. per second—these values may be compared with Zeleny's velocities of X ray ions, which average about 1·5 cm. per second. Under the same electro-motive force the heavy electrolytic clusters would have a velocity of less than ·001 cm. per second. It is remarkable that, although the ions vary in size with the circumstances under which they are formed, yet the negative ion is always some 20 per cent. more mobile than the positive.

As I have already said, recombination of ions goes on continually in an ionized gas. A positive collides with a negative, the chances of collision being greatly increased by their mutual attraction, and sometimes the two become permanently attached to each other. According to Langerin (P.C.R., 134, p. 414) union happens in one out of every four collisions at ordinary pressures and temperatures. The attendant molecules presumably drop away from the active kernels, just as the iron-filings which are attached, some to the north pole of one magnet and some to the south pole of another, drop away when the two poles are brought close together. If there are n ions present in each cc. of the gas, $n/2$ of each kind, then the rate of recombination must be proportional to n^2; for if the number of ions were doubled there would, we may say, be twice as many positives to meet and twice as many negatives to be met, and so there would be four times as many successful encounters. We may therefore, as Rutherford has shown (Phil. Mag., Nov., 1897), put $dn/dt = -an^2$, where a is a coefficient of recombination. McClung (Phil. Mag., vol. iii., p. 305, 1902) finds for a the value $3384e$, where e is the ionic charge. Using the most recent and best determination of e—viz., $3{\cdot}3 \times 10^{-10}$ in electro-static units—we find that $a = 1{\cdot}1 \times 10^{-6}$. The value for a is the same in CO_2 as in air, but in H it is only $\cdot 96 \times 10^{-6}$. I have already said that McClung found it to be constant over a wide range of moderate pressures. If N be the number of ions at any time, and n the number t seconds later, then, since $dn/dt = -an^2$, we have

$$\frac{1}{n} - \frac{1}{N} = at.$$

Thus, if $n = N/2$, $t = 1/Na$, and we see that the time that elapses before half the ions recombine depends on the original number. To give some idea of the quantities involved it may be said that under ordinary circumstances the conducting-power of air ionized by X rays disappears in one or two tenths of a second. If ionized air is passed through a glass-wool plug the ions all discharge themselves by diffusion to the walls of the channels through which they pass.

Ionized air blown against an insulated conductor generally imparts a charge to it. The sign and amount of the charge vary with circumstances in a manner which at first sight appears almost capricious. Villari, who experimented much in this direction, came finally to the conclusion "that Röntgenised air passing quickly and lightly over metallic surfaces charges them negatively, and that passing slowly and with more pressure it charges them positively" (Rapports Congrès, Paris, 1900, vol. iii., p. 163). But it has been shown by Simpson (Phil. Mag., Nov., 1903) and also by Zeleny (Phys. Zeit., Oct. 1, 1903) that all the varied effects can be explained by the difference in the mobilities of the positive and negative ions. Suppose ionized air to be passed through a long tube, and let the entering air possess equal numbers of the two kinds. Near the ingress an excess of negatives will discharge themselves to the walls of the tube: further on the numbers will be equal: further still the positives will be in excess, and the more so, relatively, because recombinations have been taking place all the time. Thus, one end of the tube will acquire a negative the other a positive charge. The position of the dividing line will depend on the velocity of the air. Thus, if the air moves slowly and "with pressure" the negative ions are early removed, and surfaces which the gas encounters acquire a positive charge. On the other hand, surfaces over which air passes immediately after its ionization acquire a negative charge. The latter fact, first shown by Zeleny (Phil. Mag., 46, p. 120, 1898), has been used by Geitel to explain the negative charge on the earth's surface as being due to the absorption of more negative than positive ions from the atmosphere. But Simpson points out that it is only when ionized air is passed in a stream over a conductor that the latter acquires a charge, which, as we have seen, may be of either sign, according as to which ion is in excess. A conductor surrounded by ionized air in which there are equal numbers of positive and negative ions acquires no charge, through the inequality in the speeds of the two ions.

A very ingenious and instructive experiment is described by Simpson. Röntgen rays are projected into a box of the form of the boxes used to produce smoke rings. The back of the box being struck in the usual way, a vortex ring of ionized air is shot out into the air of the room. When it is received in a gauze cage connected to an electrometer a positive charge is registered. The negative ions have diffused away faster than the positive. But the cage must not be too far away: if the ring takes a fifth of a second to reach it the charge is gone. But if the box is filled with smoke the electrometer registers a negative charge. In this case material particles are mixed with the ionized air of the ring, and as the ions diffuse through the particles on their way to the outside the more mobile negatives discharge themselves to the particles in greater number than the positives do. The ring thus finally acquires a negative charge.

So far, then, we see that in certain cases of the ionization of gases we have to deal with ions of great size. Whatever may be the size of the parts into which the molecule or atom is divided initially, each part at once grows, by the attachment of surrounding molecules, into molecule-clusters. Thus, experimental investigation of the behaviour of these large ions gives no information respecting the nature of the molecular or atomic subdivision. If we are to obtain such information we must seize upon the parts before clusters have had time to form. Since this is usually a rapid process we must employ such conditions as delay the formation. These are readily found: *the parts must at once be set in motion with high velocities.* I have, indeed, already said that according to McClung's experiments the cluster diminishes as the speed increases. Now, when the parts are endowed with speeds of the order of one-hundredth of the velocity of light and more they collect no molecules—the stone is rolling too fast to gather any moss at all.

That this theory is correct is shown in many ways: most clearly, perhaps, in a series of beautiful experiments which we owe to Townsend (Phil. Mag., vol. iii.).

One wall of a chamber within which ionization is to be produced consists of a quartz plate. The inner surface of the quartz is silvered so as to make it a conductor, but the silvering is ruled with many lines so that ultra-violet light may pass through it. Within the chamber is a zinc plate on which the light falls. The chamber may be exhausted to any degree, and may be filled with different gases. The silvered surface of the quartz is connected to the positive pole of a battery whose other pole is to earth; the zinc is carefully insulated and connected to one pair of quadrants of an electrometer whose other pair is earthed. Under the influence of the ultra-violet light negative ions issue from the zinc plate and travel up the potential gradient to the positive plate. These ions have the same mass and charge as the corpuscles of the cathode stream, and therefore, being in all essentials identical with them, are likewise called electrons. The moving ions constitute a current, whose value is shown by the rate of leak of the electrometer. Now, if they were the only ions present the current could never exceed a certain value. Increase of electro-motive force could only hurry them across the chamber at a quicker rate; it could not add to their number, since the latter is determined by the intensity of the ultra-violet light. But it is found that, provided the force is great enough, the current does exceed the value which it has for a wide range of moderate forces. And, further, when this is the case the current is increased by increasing the distance between the plates, so long as the volts per centimetre remain the same. New ions are produced, therefore; but where?

Not at the surface of the zinc, because the surface is under precisely the same conditions as before, even to the amount of potential gradient in the air near its surface. The new ions must come from the gas, and the only agents that could produce them are those ions of whose existence we are already aware. Hence, Townsend concludes that the old ions produce new ions by collision. But there is more than this. If the new ions were simply due to those that came from the zinc plate we should indeed expect that the current would increase with increasing distance between the plates, the potential gradient being, of course, a constant; but we should expect a linear or simple-interest law. Let N_0 be the original number produced by the light in each second, α the number of new ions each of these makes in 1 cm., and d the distance between the plates: then we should have the current $N = N_0 + \alpha d N_0$. But it is found that the law is of the exponential or compound-interest form: $N = N_0 e^{\alpha d}$. This implies that as we follow the stream of ions on their way across the chamber we find the increase always proportional to the number in the stream, whether these came from the zinc or not. Thus, each new ion is as capable of generating other new ions as an ion that came from the zinc, and is presumably identical with it. All is therefore explained if we suppose that the zinc ion moves out into the chamber and on occasion gathers enough way to generate a new pair of ions by collision with a gas-molecule. Every time this happens the new negative ion joins the stream of moving electrons, the members of which are all like itself, and so the stream swells as it flows.

An analogy may make matters clearer. Imagine two walls built on a mountain-side, each at a uniform level, but one higher than the other. Let the ground between be strewn with stones, which would, if uprooted from their beds, run down the slope. Let other stones be set rolling from the upper wall. If the slope of the mountain is great enough, and if the rolling stones have had on the average a sufficiently clear run, when they strike the fixed ones they will start many of them into motion, and the stream will grow as it descends. Plainly, also, the greater the distance between the walls the greater the avalanche will finally become. The analogy is fairly complete, though, of course, there is nothing in it to represent the stream of positive ions flowing the opposite way to the negative.

Such a stream of electrons moves through the gas in much the same way as any one gas diffuses into another. That is to say, the path of any one electron is highly irregular, interrupted by many collisions, but directed, on the whole, in one direction—that of the impelling electro-motive force. In such a case the electron acquires an average velocity proportional simply to the force. The stream does not gather velocity as it goes: it increases in volume only. The number of new ions made in a distance δx is proportional therefore to $\alpha N \delta x$, where α is a constant depending on the average velocity. Hence we get the law $N = N_0 e^{\alpha d}$. This law has been found to be well fulfilled over a large range of electrical forces, of gas-pressures, and of distances between the plates, so that we may consider the theory of the production of ions by collision to be established.

Here, then, we catch a glimpse of the nature and properties of the portions into which the gas-molecule is divided by ionization. The negative portion, at least, hurries away too quickly to gather a train of molecules. Yet, no doubt, even where the effects are such as have been described above, some clusters are formed. Some ions are rendered unable to produce more, in consequence of attachment to heavy molecules. Yet the number of such must be small, because it is possible to neglect them and yet arrive at a satisfactory formula. For suppose that every collision is successful where the speed exceeds a certain value, and that when a collision is unsuccessful the ion is simply stopped for the moment and then resumes its onward path up the potential gradient. Suppose also that when a collision is successful the old negative ion and the new start off together from rest, the positive moving the other way. Lastly, suppose that no ion is rendered ineffective by association with molecules that clog its motion. It is, of course, possible that not one of these suppositions is exactly correct. Let c be the distance which an electron must move up the potential gradient of X volts per centimetre in order that it may have enough energy to make a successful collision. Such an electron actually moves through Xc volts, and we may for the moment assume this to be a constant E.

Let the number of ions which cross a plane parallel to the two plates and at a distance x from the negative one be denoted by N. Of these Ne^{-kc} have come from a distance greater than c, if k is the reciprocal of the mean free path of the electron in the gas. All these have enough energy to make successful collisions. But only the proportion $1 - e^{-k\delta x}$ will actually make collisions in the space between the planes x and $x + \delta n$. Thus, the number of new ions produced in this space is $Ne^{-kc}(1-e^{-k\delta x})$ or $Ne^{kc}k\delta x$. Thus, we find that the quantity we have already denoted by α is equal to ke^{-kc} or $ke^{-kE/X}$.

Now, Townsend found that the curve in which he plotted the relation between α and X at constant pressure satisfied this formula very well for all the larger values of X. At a pressure of 1 mm. the numerical relation proved to be $\alpha = 15{\cdot}2 \cdot e^{-15{\cdot}2 \times 25/X}$.

On the simple hypothesis which has been used in obtaining this formula we must interpret the result so :—

(1.) 25 volts are necessary for a successful collision.

(2.) The free path of the electron in the gas is 1/15·2.

But this formula for α represented only the upper part of the curve with accuracy. Townsend therefore (Phil. Mag., April, 1903) extended his hypothesis by supposing that there is no exact value for the number of volts necessary to make collision ; and, finding that the curve for α could be well expressed throughout its entire length by

$$\alpha = \cdot 118 \times k(e^{-10k/X} - e^{-20k/X}) + \cdot 349k(e^{-20k/X} - e^{-30k/X}) + ke^{-30k/X}$$

he interpreted the result as follows :—

(1.) A collision is sure to be successful if the electron has fallen through 30 volts ; ·349 is the chance of success if the electron has fallen through from 20 to 30 volts ; and ·118 if the fall is between 10 and 20 volts.

(2.) The free path of the electron in the gas is 1/15·2. The latter result leads to a very interesting conclusion. The free path of an air-molecule in air at 1 mm. pressure is about $7 \cdot 84 \times 10^{-2}$ mm. This assumes that all the molecules are in motion ; and the free path of the molecule amongst the others at rest is $7 \cdot 84 \times 10^{-2} \times \sqrt{2}$ mm., or ·11 mm. But the free path of the electron amongst the air-molecules is 1/15·2 or ·66 m.—that is to say, six times as great. This fits in very well with the idea that the electron is very small. A particle of dimensions small compared to those of an air-molecule would have a free path of ·44 mm. This explanation is, so far, insufficient ; but if we also suppose that the electron can to some extent penetrate the domain of a molecule we can explain the whole difference. We shall see later that this penetration does in all probability occur.

As regards the former result, we see that a collision is sometimes successful when the electron has fallen through less than 10 volts—that is to say, when it has energy less than $10 \times 10^{8} \times 1 \cdot 1 \times 10^{-20}$ or $1 \cdot 1 \times 10^{-11}$ ergs. This does not imply that the energy necessary to tear an electron from the atom is $1 \cdot 1 \times 10^{-11}$ ergs. To make such a deduction it would be necessary to suppose (a) that the whole of the energy of the moving electron is absorbed in the collision, (b) that the whole of this absorbed energy goes in the separation of the new electron, (c) that no "trigger action" takes place, no molecular energy is set free by the alteration of conditions. The known existence of radio-active substances makes it necessary to suppose that "trigger action" is a possibility in the case of ordinary substances.

We should not, therefore, expect to find any precise value for the energy of ionization of a solitary atom. But we might expect to find a statistical average of the energy spent in producing a number of ions. It will be convenient to defer this question for the moment.

On a certain simple hypothesis we were able to obtain a formula $\alpha = ke^{-kE/X}$. Since k is the reciprocal of the free path and is therefore proportional to the pressure, we see that α/p is a function of X/p. It is easy to see that this functional relation should be satisfied in any relation which we might obtain between the three quantities α, p, and X, even if we made no such restrictions as were necessary to obtain the simple formula we have discussed. For if we consider again the electron-stream flowing through the gas, and making new ions at a rate depending on the energy of its collisions, and if, as an example, we consider what would happen if both p and X were doubled, we see (1) that collisions in a given space would be twice as frequent, (2) that though each path is only half as long as before, yet it is accomplished under twice as great an electric force, so that the total number of volts the electron moves through in each path is the same. The same proportion of collisions will therefore be successful, and so α will be doubled as well as p and X. Hence on general considerations α/p should be a function of X/p. Townsend found this to be experimentally verified, and was able to represent the relations between the three quantities by a single curve, in which the co-ordinates were α/p and X/p.

So far we have only considered the negative ions to be capable of producing new ions by collision, and the hypothesis is justified by results already described. There is, indeed, a well-known phenomenon (see Kirkby—Phil. Mag., vol. iii., p. 212) which can only be explained on this supposition. Imagine a metal tube, say 2 cm. in radius, to have a thin wire stretched along its axis. Let the space between wire and tube be ionized by X rays, and let enough E.M.F. be applied to drive the ions to the sides. Let the current be measured in the usual way by an electrometer. If the E.M.F. is not too great, and no ions are produced by collision, the current is the same no matter whether the current runs from wire to tube or *vice versâ*. But with large electro-motive forces, when ionization by collision sets in, the current is greater when the wire is positive and the tube negative than when the wire is negative and the tube positive. The explanation is simple. The field of force is not uniform, and is stronger near the wire. Suppose, for example, that within 1 cm. of the wire the field is sufficient to generate the requisite amount of energy in the ions, and outside that limit it is not. When the wire is positive all the negative ions generated pass through this stronger portion of the field; when it is negative only a quarter of them do. There will be a larger current in the former case.

But we might surely expect that positive ions would sometimes produce ionization. It is plain that they do not do so under such circumstances as we have considered, because we have not found it necessary to assume this in order to explain the facts. Nevertheless, we might suppose that positive ions could produce ions under still greater potential gradient than those employed in the experiments described above. This Townsend has found to be the case (Phil. Mag., Nov., 1903). He has shown that his theory can be extended so as to take account of this additional fact, and that, so improved, it gives a satisfactory account of the experimental results from those obtained under the smallest potential gradients to those obtained when the E.M.F. is enough to maintain a continuous discharge. The latter phenomenon depends upon and is the result of the production of ions through the collisions of both positives and negatives with neutral atoms. In such cases as we have already considered the current was initiated by the Röntgen rays, or the ultra-violet light. It was increased by the effects of collisions, but if the first agency ceased its operations the current ceased also. In order that an electro-motive force may be able to maintain a discharge without the assistance of any external ionizing agency, both positives and negatives must be able to ionize, so that each kind may be produced throughout the whole discharge-space, and neither stream may fail.

The improved formula is

$$n = n_0 \frac{(\alpha - \beta)e^{(\alpha - \beta)d}}{\alpha - \beta e^{(\alpha - \beta)d}}$$

where α is similar to the constant used on the former hypothesis, and β is the constant which is for the positives the same as α for the negatives.

This formula gives excellent results. For instance, in a certain set of experiments, where the E.X.F. was 350 volts per cm. and the pressure 1 mm., Townsend found the following current-values for different values of d :—

d (in mm.) =	0	2	4	6	8	10	11
Current =		2·86	8·3	24·2	81	373	2250
n (from formula)		2·87	8·3	24·6	80	380	2150

the values adopted for α and β being 5·25 and ·0141.

Further, n is infinite if $\alpha = \beta e^{(\alpha - \beta)d}$; and this equation is satisfied if $d = 11·3$ mm. When Townsend separated the plates to this distance he found that a permanent discharge set in which filled the space with glowlight, and continued when the external ionizing agency ceased to act.

Since β is so small, the positive ion is far less successful than the negative in producing new ions by collision. Townsend estimates that in air the positive must move through about 70 volts, whereas he showed that the negative was successful about once in eight times at a potential between 10 and 20. This is not perhaps surprising, for the collision of the positive is rather with the molecule as a whole, whilst that of the very small negative must be, immediately at all events, with the parts of the molecule. A stone thrown at a cherry-tree might knock off a cherry with a very small expenditure of energy: it would require a much heavier blow to so jar the tree that the cherry was shaken off.

We have now considered examples of slow-moving ions or molecule-clusters, and of quicker-moving ions that are able to produce others by collision. It remains only to consider the high-speed ions of the cathode rays and of radio-active substances. These move with velocities that fall little short, in some cases, of that of light itself.

That they are ions of the same nature as those that spring from zinc when ultra-violet light shines upon it is shown by the fact that they are like the latter both in charge and mass. The latter quantities have in their case been determined by Becquerel, Kaufmann, and others. The velocity alone is a variable, and, as we shall see, difference in velocity is all that is required to explain difference in behaviour.

The velocity of the electron of the cathode ray depends upon the total fall of potential to which its motion is due, and is, of course, proportional to the square root of that fall. For example, Seitz (Ann. der Phys., May, 1902) found the following values, amongst others:—

(1.) E.M.F.	(2.) $10^7 \times e/m$	(3.) $v \times 10^{-10}$	(4.) $\sqrt{(1)}$	$\sqrt{(3)}/(4)$.
8490	1·90	·572	92	·0623
11040	1·85	·640	105	·0635
12900	1·90	·700	114	·0632
15110	1·85	·748	112·5	·0612

Generally speaking, the velocity of the cathode-ray electron is about $\cdot 5 \times 10^{-10}$, this being also an average value of the electron when it is allowed to pass through a thin aluminium window placed in the wall of the tube and so emerge into the open. The electrons projected by radio-active substances move nearly ten times as fast. For example, Kaufmann (*Beiblatter zu den Annalen der Physik*, Feb., 1902) found velocities varying from $2{\cdot}36 \times 10^{10}$ to $2{\cdot}83 \times 10^{10}$, and later (C.R., Oct. 13, 1902) determined, with better material, the relations between mass, charge, and velocity in the case of electrons moving with various speeds approximating to that of light, and found that they satisfied the formula—

$$m = \frac{3m_0}{4\beta^2}\left[\frac{1+\beta^2}{2\beta} \cdot \log\frac{1+\beta}{1-\beta} - 1\right]$$

where β = ratio of speed of electron to speed of light. Kauffmann does not state in the paper quoted the actual values he obtained, but the formula gives the following :—

Speed $\times 10^{-10}$	...	$e/m. \times 10^{-7}$
2·8	...	·90
2·5	...	1·19
2	...	1·46
1·5	...	1·64
1	...	1·74
·75	...	1·79
Low speed	...	1·84

This formula was given by Abraham.

These results were considered by Kaufmann to establish the proposition that the mass of the electron is an electro-magnetic phenomenon, and that the apparent increase in mass as the speed increases is just what electro-magnetic theory predicts. Since $e = 1·1 \times 10^{-20}$, it follows that the mass of the electron is $·6 \times 10^{-27}$, unless the speed approaches that of light.

The most striking properties of the high-speed electron are (1) its great power of penetration, (2) the dependence of the penetration into any body upon the actual density of that body, not its composition or state. As an instance of the former, Rutherford found that in a certain case half the β radiative which entered a plate of aluminium ·05 cm. thick emerged on the other side. The density of aluminium is 2,000 times the density of air; and so it would follow from the second property that the aluminium plate is equivalent to 2,000 × ·05 cm., or 100 cm. of air at atmospheric pressure, or 760 metres of air at a pressure of 1 mm. The electron of the β ray can therefore easily penetrate this mass, and, what is most remarkable, still maintain its rectilinear motion. If an object is placed on one side of a thin aluminium screen a shadow of it can be cast on the other. The electron that just skirts the edge of the object must pass with unappreciable deviation through the screen. There is a sort of penumbra, as Becquerel has shown, but the general character of the motion is unmistakable. It is perhaps right to add that in a magnetic field the shadow is deflected as it should be, and in the fashion we are accustomed to see in respect to the cathode rays.

But if we draw a straight line through 760 metres of air at 1 mm. pressure it passes through 760 × 100/·044 molecules—nearly two millions, that is to say. The electron must do the same, or push them all out of its way. It could not do the latter unless it was enormous compared to the molecule. We know it to be very small. But if a small body encounter another even as small as itself it is in all probability appreciably deflected. Hence the electron must often pierce two million molecules and yet experience nothing of the nature of a collision. It follows that the molecule is something in which the—so to speak—unoccupied spaces are the greater part. This is, of course, in accordance with the conception that each atom is built up of electrons, which are themselves small compared to the atom of which they are component parts. Let us, then, consider the problem in the following way: The β-ray electron is projected into a body consisting of electrons, which are, indeed, grouped into certain systems called atoms, but this fact is immaterial. The electron has a half-chance of penetrating ·05 cm. The number of electrons in a cubic centimetre of the body is equal to the density of the body divided by the mass of an electron. The density of aluminium is 2·6. Since e/m is about $1{\cdot}84 \times 10^7$, and e is $1{\cdot}1 \times 10^{-20}$, we may take m to be $\cdot 6 \times 10^{-27}$. Hence the number of electrons in a cubic centimetre of aluminium is $4{\cdot}4 \times 10^{27}$. According to the kinetic theory of gases, if l is the free path half the paths are greater than d, where $e^{-d/l} = 1/2$, or $l = d/{\cdot}7$. In this case, therefore, the free path is ·07 cm. But if σ be the radius of the sphere of action at a collision, the free path of a particle amongst others whose motion is small compared to its own is $1/\pi\sigma^2 N$, where N is the number of particles in a cubic centimetre. Hence in this case

$$\cdot 07 = 1/\pi\sigma^2 \times 4{\cdot}4 \times 10^{27};$$

from which it follows that σ is about $\cdot 32 \times 10^{-13}$.

On the supposition that the mass of the electron is an electro-magnetic phenomenon, we should have the radius of it equal to $2e^2/3m$, or $\cdot 7 \times 10^{-13}$.

The argument contains too many approximations in both fact and deduction to make it possible to draw exact conclusions from the near equality of these two results. We can, however, clearly see that the power of penetration of the flying electron is just of the order that we should expect when we suppose that the atom is built up of electrons of such a size and spaced in such a way as is consistent with what electro-magnetic theory demands.

Two new questions present themselves for immediate answer: (1.) Are we not neglecting in this argument the electric action between electron and electron? (2.) How is it that penetration varies with speed, as has been found to be the case? (*E.g.*, the Lenard ray, with velocity $\cdot 5 \times 10^{10}$, only penetrates a centimetre or two of air at atmospheric pressure.)

The answer to the one of these questions is the answer to the other. We *ought* to take into consideration the electric action; and if we do so we find that the slower the electron moves the more liable it is to suffer deflection from its path. Indeed, the encounter between two electrons can hardly be called a collision in the ordinary sense. Suppose, for example, one to be fixed and the other projected directly towards it with a velocity v. Let d be the distance of closest approach. When this is reached the kinetic energy of the system has become potential. The measure of the former is $mv^2/2$, of the latter e^2/d where e is in electro-static units, or V^2e^2/d where e is in electro-magnetic units, V being the velocity of light. Putting for m its value $2e^2/3a$ (e in E.M. units), we have the equation

$$V^2e^2/d = e^2v^2/3a.$$

$$\text{Hence } d = \frac{V^2}{v^2} \cdot 3a.$$

We can hardly apply this simple result to an electron moving with a speed nearly equal to that of light, because the value adopted for the mass in terms of e and a is incorrect at such a speed. Nevertheless, the result shows that closeness of approach depends on speed, and that slow-moving electrons cannot get near to each other.

We may look at the problem from another point of view, also very simple. Imagine an electron flying at a speed v *past* a similar electron, and let the distance of nearest approach be d. Let d be so great that the moving electron is not seriously deflected from its course. Now, if we sum up the effect of the moving electron on the other which is at rest, but free to move, we may most conveniently do so by the following consideration: The total influence of the moving body on the other is equal to the influence that would be exerted by a linear distribution of electricity along the path, the amount of electricity per unit of length being equal to the moving charge, and the influence being allowed to act for a time equal to that which the moving charge takes to pass over 1 cm. The law of repulsion between two charges like these is presumably that of the inverse square; but for the sake of generality suppose that the repulsion exerted between the linear distribution and the electron which was at rest is simply a function of the distance d—say, $f(d)$. Then, the momentum imparted to the electron which was at rest is $f(d)/v$, and its direction will be that of d. The other will acquire the same momentum in exactly the opposite direction. It will therefore acquire a velocity $f(d)/mv$ in a direction at right angles to its original direction—that is to say, it will be deflected through an angle $f(d)/mv^2$. It is also to be observed that the one electron has gained, the other lost, an amount of energy equal to $[f(d)]^2/2mv^2$. When v is large this is very small unless the approach is a close one. If the electron which is originally at rest be supposed fixed, the moving electron loses no energy, but undergoes the same change of direction.

Arguments of the same character as this have been used by Sutherland to explain, in the kinetic theory of gases, the apparent diminution of the sphere of action with rising temperature.

Now, it is clear that in at least one respect the hypothesis is too simple. The atom contains a number of similar electrons distributed irregularly and sparsely. But we cannot take account of all these electrons as negative charges and forget the compensating positive. There does not seem to be any evidence on which to found any ideas as to the place of the positive charge or its relation to the negative. There is but the negative statement that the positive electron, if it exists, has never yet been detected. All positive ions are at least as large as molecules, so far as we know them. If the positive charge of the atom is an aggregate of small positive electrons, corresponding to the condition of things which we are assuming for the negative, then it would seem probable that positive electrons would be detached just as negative electrons are. For this reason I cannot see that there is justification for the view that Lenard puts forward in the current number of the *Annalen der Physik* (No. 12, 1903). He assumes that each negative is attached to a corresponding positive, the pair forming a doublet, which he terms a "dynamid." The atom is an assemblage of dynamids. It seems to me also that this view is too precise. It is sufficient to suppose, and I believe the suppositions are justified by what I have said above, that—(1) the atom contains a number of similar electrons, whose negative charges are counterbalanced, so far as space exterior to the atom is concerned, by an equal quantity of positive electricity distributed somehow and somewhere in the atom; (2) an electron moving with sufficient speed can pass through the atom, and if it passes near to one of the electrons of the atom it is deflected through an angle inversely proportional to its own energy. The relation between the amount of deflection and the closeness of approach cannot be calculated.

If the electron in the atom is capable of motion, which must be the case to some extent, the moving electron must lose energy, to an extent which is the more, the less it possesses. Let us proceed on this basis. The proportionality between the deflection of the high-speed electron and the inverse of the energy has been experimentally verified by Kaufmann (Ann. d. Phys., Sept., 1899). Now, imagine a jet of moving electrons projected into space where there is matter —into the air, for example. Some will go far without serious encounter with the electrons of the matter; some will at an early date be deflected from their original deflections. The general effect will be that of a stream whose borders gradually become ill defined; it weakens as it goes, it is bordered by a haze of scattered electrons, and at a certain distance from the start all definition is gone, and the force of the stream is spent. These characteristics are exactly shown in the drawings which Lenard made (Annalen der Physik, 1894), by which he exhibited the results of his first great experiments in this direction. It is now possible to see more clearly the all-important relation between speed and penetration.

When the speed of the electron is very great the consequences of its passage through the atom are small, unless it happens to go quite close to one of the atom electrons. If, therefore, it goes close enough to one of these so as to be affected by it, it is not likely to go close enough to any other. It is improbable that it should be affected by two electrons at once; consequently the chance of its experiencing an appreciable deflection in going through an atom depends only on the number of electrons in the atom, and not at all on their arrangement. It is purely an electronic, not an atomic, effect. Hence, if a stream of electrons of sufficient speed enters a substance, their subsequent history depends only on the number of electrons to the cubic centimetre in the body—that is to say, upon the density. The high-speed electron regards matter as a collection of electrons, and pays no attention to their atomic grouping. For electrons of slower and slower speeds the grouping is of more importance. This is beautifully shown in the paper of Lenard's to which I have already referred (Ann. d. Phys., No. 12, 1903). He has examined the scattering of electron-streams of speeds varying from those just short of the speed of light to speeds that can be generated by the fall of the electron through six volts, or about $1 \cdot 5 \times 10^8$ cm. per second. At high speeds density is the determining factor; at the low speeds the molecular cross-section seems rather to be influential. The former truth has been proved in several ways and by various observers. I shall have occasion to refer to some interesting examples of it in a little while; but before doing so it is necessary to consider the ionizing properties of the β and the cathode rays.

It is well known that these rays ionize gases through which they pass. The laws which govern the phenomenon are very clearly shown in some experimental investigations due to Durack (Phil. Mag., May, 1903).

The β radiation from some radio-active material passes through a thin aluminium plate into an ionization chamber of which the plate forms one wall. The opposite wall is a parallel metal plate, insulated and connected to one pair of quadrants of an electrometer whose other pair is to earth. If the chamber is highly exhausted the electrometer shows a steady leak. This is due to the gradual accumulation of negative electricity, the sum of the negative charges brought by the flying electrons which constitute the β radiation. Let the number arriving each second be N and the charge on each be e: then the leak shows a current Ne. The leak is not altered if a moderate electric field is imposed upon the space between the plates; not even if the direction of the field is against the electrons—*i.e.*, if the plate on which they fall is negative—is any effect made on their flight. It would take many thousands of volts to turn them back, so great is their speed. Now, if some air is admitted to the chamber the current is altered, because the electrons ionize the gas through which they pass. The effect is very simply estimated, because the electrons in this short flight are not stopped or turned aside to any appreciable degree. Consequently each electron as it crosses the space between the plates makes new ions, whose number is proportional to d, the distance between the plates, and to p, the pressure of the gas. (It may be pointed out that it is only necessary to count the ions of one sign; we are here counting negatives only.) Suppose the number of new negative is Nαpd. Let an electro-motive force be imposed so as to drive these new ions to one of the plate electrodes; the force must, of course, be less than would be sufficient to bring about the production of new ions by collision. If the new ions are sent in the same direction as the β electrons which produced them the current is Ne + Nαpde. If the other way, it is Ne − Nαpde. Hence the double observation gives Ne and α. For the constant α Durack found the value 1/6, the pressure being 1 mm. of mercury; and all experiments were consistent with each other and with the theory.

The interpretation of this result is that the electron of the β ray makes one new electron in every 6 cm. of its path in air at 1 mm. pressure. In air at atmospheric pressure it makes nearly 130 per centimetre.

Now, the electron passes through 6/·044, or about 135 molecules, in a flight of 6 cm. in air at 1 mm. pressure. Hence the electron passes through many molecules without forming new ions: in 135 transits only one is successful.

Durack also carried out (Phil. Mag., 4, p. 29, 1902) a similar experiment in the case of Lenard rays. These slower-moving electrons make more ions in a given distance than the fast ones: they each make on the average one new one in 2·3 cm. The average speed of his Lenard rays was 4×10^9.

Now, we saw above that the energy imparted to an electron at rest by one which flew by was less the higher the speed, except, of course, Townsend's results, which I have described above. These related to very slow electrons.

Therefore we should expect to find this greater ionizing power of the slower ray. As far as I know, these are the only sets of experiments which link ionizing power and velocity. It seems very desirable that we should possess a more complete knowledge of the relation between the two quantities over a wide range of velocities—such a range as Lenard worked over in connecting velocity and dispersion.

In making a new ion, in tearing an electron from the atom to which it belongs, the moving electron must spend some of its energy. Hence the speed of the electron must gradually decrease as it goes. The question therefore arises, Can we make any attempt to estimate this decrease?

It would seem that so simple a matter could easily be settled by experiment, yet such evidence as exists is very contradictory. In Lenard's early experiments on absorption he found no evidence of any effect of this kind. Becquerel made careful attempts to find it, using aluminium sheet 1 mm. thick, and failed. On the other hand, Des Condres (Phys. Zeit., Nov. 15, 1902) found that rays proceeding with half the velocity of light suffered a 10-per-cent. reduction of speed in going through ·01 mm. of aluminium. One result, which is noted by several observers, is clearly in accordance with our hypothesis. The results obtained, for example, by H. Starke (Ber. d. Deut. Phys. Ges., No. 11903) show that a bundle of rays which was of uniform speed before entering an aluminium sheet was heterogeneous after emergence, and could be drawn out into a sort of velocity-spectrum by either an electric or magnetic field. This ought to be the case, because some electrons would have encounters of various kinds in going through the sheet and be diverted in different directions with various speeds. Starke found that e/m remained the same, but that some of the electrons suffered considerable reduction of speed. Let us now consider what indirect evidence we have. The β ray, of speed $2{\cdot}3 \times 10^{10}$, makes, according to Durack, ·16 new ions per centimetre in air at 1 mm. pressure. It can penetrate, say, 760 metres of air at this pressure. It therefore makes at least about 13,000 new ions, and probably more, because as it slows down it is more successful. Now, the energy of such a ray is not far from $2{\cdot}2 \times 10^{-7}$ ergs. Hence if it spent all its energy on ionization the energy per ion would be $2{\cdot}2 \times 18^{-7} \div 13000$, or $1{\cdot}7 \times 10^{-11}$ ergs. Such an amount of energy would be generated by an electron in falling through about fifteen volts ($15 \times 10^8 \times 1{\cdot}1 \times 10^{-20} = 1{\cdot}65 \times 10^{-11}$). This should be a superior limit to the average energy required to ionize the molecule, but the data are too uncertain to make the result a determination which can claim any degree of precision. Townsend's experiments showed, it will be remembered, that ions could be produced with some regularity at a fall of ten volts; indeed, he considered it probable that they were produced occasionally at a fall of five volts (Phil. Mag., Sept., 1903). On the other hand, Stark estimates the necessary fall at fifty volts; in the neighbourhood of a metal there is, according to his arguments, a catalytic action, so that the necessary fall is less. Stark's value appears to be inconsistent with the penetrating-power of the rays.

If we, for the moment, assume fifteen volts to be the ionizing potential of the electron, then in going through 20 cm. of air at 760 mm., whose stopping-power is equal to that of ·01 cm. of aluminium, one-fifth of the electron's energy would be spent in ionization, and the velocity would be reduced by one-tenth. A greater or less value of the ionizing potential would lead to a greater or less value of the loss of speed. The failure of some experimenters to find the expected loss of speed is therefore easily explained, because they looked for it in the case of rays which had passed through only a few centimetres of air, in which case it would be very small.

On the whole it would appear that the majority of the experimental results are satisfied on the hypothesis that the ionizing potential is somewhat less than fifteen volts. We should then understand the failure of many careful attempts to find the loss of velocity on penetration. At the same time we should be able to explain the fact, which has so often excited comment, that the radiation does not decrease according to an exponential law when it penetrates, but at a faster rate. As Seitz puts it (Ann. d. Phys., 6, p. 2), "The absorption coefficient grows with the thickness of the window (through which it passes)." In other words, if a screen of a certain thickness intercepts one-tenth of the incident radiation, a second screen of the same thickness will intercept more than one-tenth of what is left. The velocity is less—though perhaps but a little less—on entering the second screen, and therefore there is more deflection of the stream, as well as more energy used up in ionization. For it must be remembered that the slower the electrons go the more new electrons they set free in a centimetre.

It is plain that no simple formula can express the amount of radiation which penetrates to different distances in a given case. The exponential law is not applicable to this kind of radiation, and can only be used as a first approximation. No empirical law has yet been found, nor are there sufficient data from which to calculate. It is plain, also, that different formulæ would be required to express two totally different things—(1) the number of electrons that pierce a given screen; (2) the energy that pierces a given screen. "Amount of radiation" is not a term with definite meaning.

We do not, however, need the exact formula in order to be able to understand the general results of experiment and to explain some apparent inconsistencies.

Consider, for example, Lenard's original experiment. Cathode rays were made to pass through a small, very thin window of aluminium placed in the wall of the vacuum tube and to emerge into the open. From the window they radiated as from a centre, reminding us of the spreading of the parts of an explosive bullet from the point at which it strikes. At a short distance from the window was a screen with a small aperture whose object was to limit the radiation to a narrow pencil. On the other side was a phosphorescent screen which could be placed at various distances. Lenard introduced various gases, at various pressures, between the window and the screen. The latter he so placed that the illuminated spot was in each different experiment just visible. He then calculated the coefficient of absorption on the supposition that the strength of the radiation was connected with the distance from the window (r) by the relation $J = J_0 e^{-ar}/r^2$. J_0 was a constant, a the coefficient of absorption. The factor $1/r^2$ took into account the divergence of the radiation from a centre, and the factor e^{-ar} was introduced on analogy with the usual form of absorption equations. We see, however, that the exponential factor would be directly due to the scattering of the flying electrons from the narrow pencil—a process which would depend on the chances of encounters, and be at any time proportional in amount to the number of electrons still left in the original path. Presuming that Lenard really observed the energy of the stream, not the number of the electrons, it will be seen that he took no account of any decline in speed of the electrons as they flew. Seitz, as I have said, found that there *was* an increase of absorption co-efficient with distance, and that Lenard's law was only a first approximation.

Now, compare this with an experiment due to Durack (Phil. Mag., 4, p. 29). The radiation from the window of a Lenard tube was allowed to enter through a small opening into a little ionization-chamber, whose opposite walls were insulated from each other. An electro-motive force could therefore be put upon the space in the chamber, so that the ions formed could be collected and measured. The experiment was, in fact, similar to the one in which the same worker determined the ionizing properties of the β electron. Durack in this way measured the number of the new electrons produced by each Lenard-ray electron which entered the chamber. He found the effect measured to be simply proportional to the inverse square of the distance from the window. There was no exponential factor in the formula which expressed his results. But, then, Durack used no opening to limit his rays to a pencil; and since there was no single pencil used there could be no scattering which would affect the result. An analogy may make the matter clear. Suppose an observer to measure the intensity of sound at various distances from its source, he would, if there were no disturbing reflections, find the law to be that of the inverse square. But if he placed a screen between himself and the source, and limited the sound to such as passed through an opening in the screen, he would find that the intensity would fade away as his distance from the source increased at a rate much greater than that of the inverse square. For the energy of the sound would diverge after passing through the aperture and the central "pencil" would be weakened.

The formula of Durack took no account of any lessening of velocity and diminution of speed. This was as it should be, for he measured the number of the electrons, not their energy.

Let me draw your attention to one more example—one of the beautiful experiments which Becquerel has made. He placed a tiny quantity of a radium compound in a leaden cup on the sensitive side of a photographic plate. So placed it could exert no action on the plate. But a magnetic field is brought to bear, with its lines parallel to the surface of the plate. The paths of the electrons are now curved; and in particular the paths which are in a plane passing through the radio-active material and perpendicular to the lines of force are circles of different sizes. If v is the velocity of any electron, H the strength of the field, ρ the radius of the circle it describes, then $H\rho = mv/e$. The circles vary much in size, because radium sends out electrons with a wide range of velocities. The slower electrons strike the plate again close to the cup; the swifter ones take wider sweeps. In fact, Becquerel arranged the electrons in what might be termed a speed-spectrum. He then found that if he placed sheets of various material on the photographic plate certain slower rays were unable to get through in sufficient force to affect the plate. The plate would only allow to pass those electrons having more than a certain critical speed, which depended on the sheet. He gives the figures in the first and third columns of the following table (Congrès Inter. de Phys., Paris, 1900, vol. iii., p. 68):—

Substance.	(1.) Thickness (mm.).	(2.) $\sqrt{\text{Thickness} \times \text{Density}}$.	(3.) $H\rho$ for Rays that just get through.	(4.) Ratio = $\frac{(3)}{(2)}$.
Black paper ...	·065	...	650	...
Aluminium ...	·010	·16	350	2200
" ...	·100	·56	1000	1800
" ...	·200	·72	1480	2100
Mica ...	·025	·264	520	2000
Glass ...	·155	...	1130	...
Platinum ...	·030	·80	1310	1600
Copper ...	·085	·86	1740	2000
Lead ...	·130	1·2	2610	2200

Now, if we multiply the thickness of each substance by its density we obtain a measure of the crowd of electrons belonging to the plate which the moving electron has to force its way through. If we take the square root of this product we obtain the figures of the second column. If we divide the figures of the third column by those of the second we obtain those of the fourth, which it will be seen are nearly the same. Thus, we find that the stopping-power, as we may term thickness × density, is proportional to $(H\rho)^2$—*i.e.*, to the energy of the penetrating electron.

This is what we might expect, for if a projected stream had just enough energy to get through a plate of given thickness in sufficient quantity to affect a plate beyond, then as a first approximation electrons with doubled energy would just get through a double plate. For there are two causes which weaken the ionic stream, scattering and consumption of energy in ionization. As regards the former, the scattering at any encounter is half in the second case what it is in the first, since it is inversely proportional to the energy; but to make up for this there are twice as many encounters. As regards the latter, there are twice as many acts of ionization, and twice as much energy to spend on them.

The electrons that just get through ·1 mm. of aluminium have, it may be shown, a velocity of about $1{\cdot}8 \times 10^{10}$.

Becquerel found that when an aluminium sheet was laid on the cup containing the radio-active substance there was apparently no absorption. The spectrum was complete. This should clearly be the case: the completeness of the spectrum requires only that there should be rays of all sorts of speed starting from the common origin. This would still be the case when the aluminium lay on the cup: it would do no more than take off a little of the speed of all the rays, and there would still be a complete range. When the aluminium was on the photographic plate, and the rays, now arranged according to speed, had to pass through it, a certain number were wholly intercepted.

It was shown by Becquerel that "secondary" radiation was produced when the primary passed through an absorbing substance. We should, indeed, expect to find evidence of the existence of electrons which had been quite swung round by very close encounters with electrons of the absorbing body, and had left the body in various directions. Becquerel showed that they had approximately the same deviation in a magnetic field as the primary rays; he showed that they were more in evidence when the primary rays were more absorbed—that the secondary produced tertiary, and so on. All of this fits in naturally with the conceptions which I have tried to explain.

The Röntgen rays afford an exception to the rule that penetration and ionizing effects depend only on the density of the substance penetrated. The absorption of the rays in the gas is proportional to the ionization produced, but neither is proportional to density. J. J. Thomson has shown, for example (Camb. Phil. Soc. Proc., vol. x., p. 10), that ionizations produced by the same rays in hydrogen and nitrogen are as 33 to 89. The explanation of the difference appears to be that the Röntgen rays act on the molecule as a whole, the separation of the electron being a secondary effect. The effect is, however, independent of molecular composition, so that the effect on N_2O, for example, is the sum of the effect as on N_2 and half the effect on O_2.

It is also an interesting and remarkable fact that the secondary radiation which is produced when Röntgen rays pass through a gas is very nearly, except in the case of hydrogen, proportional to the density. Barkla (Phil. Mag., June, 1903) gives the following figures :—

Gas.	Relative Intensity of Secondary Radiation.	Density of Gas.	Ionization (J. J. Thomson).
Air	1	– 1	·1
Hydrogen	·17	·07	·33
Sulphuretted hydrogen	1·075	1·18	·6
Carbon dioxide ...	1·45	1·53	1·4
Sulphur dioxide ...	2·11	2·19	6·4

It has been recently shown by McClung (Proc. Camb. Phil. Soc., vol. xii., p. 191, 1903) that from 14° C. to 200° C. the ionization produced by Röntgen rays is independent of the temperature. So also Patterson (Phil. Mag., August, 1903) has shown that the ionization of air by radio-active processes is independent of the temperature from 0° C. to 450° C. In this we find a parallel to the striking peculiarity of the radio-active phenomena, which appears to be unaffected by heat or cold, or, indeed, any physical or chemical influences. Patterson's experiments related to the measurement of the ionizing effects produced by the small amount of radiation that appears to be given off by all bodies. These effects have been but recently discovered. It has been shown by several workers that when one metal is entirely enclosed within another there is a slow ionization of the space between them which finally brings the two metals to a difference of potential equal to the Volta effect; and Strutt (*Nature*, 67, p. 369, 1903) and McLennan and Burton (*Nature*, 67, p. 391) have shown that the rate of ionization varies with the nature of the metals, and is due to their being slightly radioactive. Patterson showed that at 450° C. there was a considerable increase in the ionization; but it is not certain whether ionization is easier to produce at this temperature or the walls of the chamber become more radio-active.

This point belongs to another very interesting branch of the subject, the production of ions in gases which are in contact with hot metals. There is not time to touch upon it now.

It is very interesting to compare the penetrating and ionizing powers of the α and the γ rays with those of the β ray. The α rays, it will be remembered, consist of positively charged bodies of ordinary molecular size. Rutherford has shown (Phil. Mag., Feb., 1903) that the ratio of charge to mass is 6×10^3, and this result was confirmed by des Coudres (Phys. Zeit., June 1, 1903), who found $e/m = 6 \cdot 4 \times 10^3$. Since the ratio of charge to mass in the case of the electrolysis of hydrogen is nearly 10^4, it follows that the mass of the α particle is about twice the size of the hydrogen-atom. The velocity of the α ray is much less than that of the β ray. Rutherford found the value $2 \cdot 5 \times 10^9$; des Coudres, $1 \cdot 65 \times 10^9$. Both measurements refer to the radiation from radium. In atmospheric air the penetration extends to but two or three centimetres. Curie found that beyond 4 cm. it was unappreciable. The α rays have therefore been often termed the easily absorbed rays. Yet it is true for these rays, as well as for the β rays, that the degrees to which they penetrate various substances depend only on the densities of those substances. Rutherford has proved this for substances as widely different as air and aluminium. Consequently the immediate cause of the absorption must be electronic rather than atomic. Again, small as the penetration is, it is far greater than the free path of the ion. The free path of an air-molecule amongst its fellows is about 10^{-5} cm., whereas the α ray penetrates more than a hundred thousand times as much as this and yet moves in a straight line. We can only suppose that the particle of the α ray consists of thousands of electrons, like any other atom, and that at the high speed which we know it to possess it sweeps through other atoms, just as one solar system might sweep through another. If its velocity were small it would be repelled on encounter with another atom, in the same fashion as occurs continually in the encounters of gas-molecules, as treated in the kinetic theory. But at the high speed which it possesses when it leaves the parent body it breaks down the defence of any molecule it encounters and passes through, tearing away in at least some cases an electron as it does so. Perhaps it tears away more than one; there are not, I think, any experimental results to decide the question. We need an investigation similar to those which Durack carried out in the case of the β and Lenard rays; and it is conceivable that it might be discovered that the α ray made more ions in a centimetre than the number of its collisions in the same distance.

As, then, the α particle goes on its way it ionizes the gas through which it passes, and in this way, as well as in the action of its own electrons on those which they pass by without tearing from their places, the energy of the radiation must be spent. Now, it is to be observed that the β ray is turned from its path on a near encounter with a similar electron, and such scatterings are mainly responsible for the failure of a projected stream to reach the distance which it might do if the consumption of energy in ionization were the only thing that stopped it. Hence, in certain conditions such as Lenard employed in his original experiments the exponential law was required to express the results. But in the case of the α ray we could hardly expect that a close collision between an electron of the α particle and an electron of the gas-molecule through which the particle is passing would have much effect in turning the α particle to one side. Scattering must be a less important cause, and gradual stoppage through expenditure of energy must be a more important cause, of the absorption of the α radiation. This is confirmed by two curious results. One is described by M. and Mme. Curie (Congrés Inter. de Phys., Paris, 1900, vol. iii., p. 102). The space between two parallel horizontal plates forms an ionizing-chamber open to the air. At a little distance below the lower plate is some radio-active material. The α radiation streams through an aperture in the lower plate and ionizes the air in the experimental space. If the distance of the active material from the lower plate is more than 4 cm. there is no effect, no α ray passes through the aperture and there is no ionization. When the distance is gradually diminished the appearance of the rays in the chamber is comparatively sudden, so that "for a small diminution of the distance the current, which was very feeble, becomes considerable." This is exactly what we should expect. If the α particles are stopped through sheer expenditure of energy, and if they all start with the same speed, they must all come to a stop at the same distance. Thus, as the active material is gradually raised the time arrives when the α rays begin to make their way into the ionizing-chamber; and, of course, the number of ions produced, and therefore the current measured, is proportional to the number of α particles and to the distance they penetrate. The appearance of ions in the ionizing-chamber will be comparatively sudden, and the current will rise steadily as the active material is raised. Again, a sheet of aluminium ·01 mm. thick is equivalent to air at atmospheric pressure 2 cm. thick ($2000 \times \cdot 01$ mm. $= 2$ cm.). When such a sheet was placed in such a way that the α rays had to go through it the material had to be raised about 2 cm. to produce the same effect in the ionizing-chamber; when two sheets, the distance had to be diminished by 4 cm.

Again, in a certain case one sheet was found to transmit only 25 per cent. of the radiation—that is to say, the current was reduced to that fraction of the original value. But a second sheet of the same thickness reduced it to ·7 per cent. Thus, the first sheet allowed one-quarter of what entered it to pass through, but the second only about one thirty-fifth. As the phenomenon was described by the earlier investigators the absorbing-power of a plate increases with its distance from the source of radiation. But we see that this startling result is due to the wrong supposition that the exponential law is applicable, and that there is such a thing as an absorption-coefficient. It cannot be correct to say that the amount of the radiation which penetrates a distance x is proportional to the expression e^{-ax}: it must rather be proper to say that—

(1.) The number of α particles penetrating a given distance does not alter much with that distance until a certain critical value is passed, when there is a rapid fall.

(2.) The energy of the α particles penetrating a given distance gradually decreases as the distance is increased, and dies out at the same critical value.

These statements are the expression of what we should expect if ionization, consuming energy, were alone responsible for the absorption of the radiation. And it appears that this must be an important cause in the case of α rays, since the latter do behave to a marked degree in the way described. In the case of β rays there is something of this effect, showing that the rays do lose energy on their way; but the absorption of the β rays is mainly due to scattering.

The second of the two curious results is that there is no secondary radiation from α rays, as Becquerel has shown (C.R., cxxxii.); and this agrees with our idea that the α rays are not stopped by scattering. They are not turned to right and left as they pass through a substance in the manner of the β rays.

Lastly, there is the highly penetrating γ radiation, which cannot be deviated by electric or magnetic fields. It only falls to half-value in passing through 8 cm. of aluminium (Rutherford, Phil. Mag., Feb., 1903). Its ionizing powers are proportional, as in the case of the β rays, simply to the density of the substance penetrated, as has been shown by Strutt (*Nature*, August, 1903). The following values are taken from Strutt's table:—

		Ionization by			
	Density.	α	β	γ	x Rays.
H	·0693	·226	·157	.169	·114
Air ...	1·00	1·00	1·00	1·00	1·00
O	1·11	1·16	1·21	1·17	1·39
CO_2 ...	1·53	1·54	1·57	1·53	1·60
Cyanogen ...	1·86	1·94	1·86	1·71	1·05
Chloroform ...	4·32	4·44	4·89	4·88	31·9

In each column the ionization of air is taken as unity, and hydrogen is, as usual, out of line with other substances. It was generally supposed that the γ rays are Röntgen rays, but the differences between the last two columns are against this idea. The enormous penetrating-power, even compared with β rays, is against a corpuscular nature, as is also their non-deviation by magnetic or electric force. If they are waves, the only possible supposition would seem to be that they are waves so small as to be unable to act as a whole molecule or atom at once. To them as well as to the high-speed electron matter is but a collection of electrons, and grouping into atoms goes for nothing. The γ rays have such penetrative powers that they act with difficulty on a photographic plate, since they spend so little energy in passing through it. The secondary radiation which is aroused by their passage through a gas is, however, easily absorbed. From this cause arises the very curious effect observed by Becquerel. A metal screen being laid on the surface of a photographic plate, and γ radiation being allowed to pass through (it is easy to screen off α and β rays, since they are so much more easily absorbed), it is found that the densest action is under the metal where one would have expected the screen to have shielded the plate. The explanation is that secondary radiation has been excited in the metal screen, and this has more effect on the plate than the original γ radiation.

There is much more that might be said, but this address is long enough. I hope I have added something to your interest in a very wonderful subject.

No. 1.—ON THE GEOMETRY OF AN AXIS OF HOMOLOGY.

PART II.

By EVELYN G. HOGG, M.A., Christ's College, Christchurch.

(The following paper is a continuation of one read before the A.A.A.S. at its Hobart meeting, 1902, and published in the volume of Proceedings of that meeting.)*

§ 1. Let three lines be taken, L′, L″, L‴, where

$$L' = l_1\alpha + m_1\beta + n_1\gamma = 0;$$
$$L'' = l_2\alpha + m_2\beta + n_2\gamma = 0;$$
$$L''' = l_3\alpha + m_3\beta + n_3\gamma = 0;$$

and let the triangle formed by these lines be called Δ_0.

The axis of homology of any point O $(\alpha_0\beta_0\gamma_0)$ with respect to Δ_0 will be

$$\frac{L'}{L'_0} + \frac{L''}{L''_0} + \frac{L'''}{L'''_0} = 0, \qquad \text{(i.)}$$

where $L'_0 = l_1\alpha_0 + m_1\beta_0 + n_1\gamma_0$.

The axes of homology with respect to Δ_0 of points on (i.) will envelop the conic

$$\sqrt{\frac{L'}{L'_0}} + \sqrt{\frac{L''}{L''_0}} + \sqrt{\frac{L'''}{L'''_0}} = 0. \qquad \text{(ii.)}$$

The locus of points whose axes of homology with respect to Δ_0 pass through $\alpha_0\beta_0\gamma_0$ is the conic

$$\frac{L'_0}{L'} + \frac{L''_0}{L''} + \frac{L'''_0}{L'''} = 0. \qquad \text{(iii.)}$$

§ 2. To find the equation of the pair of tangents from any point $\alpha_1\beta_1\gamma_1$ to the conic

$$\sqrt{\frac{L'}{L'_0}} + \sqrt{\frac{L''}{L''_0}} + \sqrt{\frac{L'''}{L'''_0}} = 0,$$

take the conic

$$\frac{L'_1}{L'} + \frac{L''_1}{L''} + \frac{L'''_1}{L'''} = 0.$$

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* Proc. A.A.A.S. (Hobart), 1902, pp. 72, *et seq.*

The axis of homology with respect to Δ_0 of any point on this conic will pass through $\alpha_1\beta_1\gamma_1$; hence the required tangents will be the axes of the two points in which this conic meets the line (i.).

Let $\alpha_2\beta_2\gamma_2$ be the co-ordinates of one of these points of intersection. Then

$$\frac{L'}{L'_2}+\frac{L''}{L''_2}+\frac{L'''}{L'''_2}=0;$$

$$\frac{L'_1}{L'_2}+\frac{L''_1}{L''_2}+\frac{L'''_1}{L'''_2}=0;$$

$$\text{and } \frac{L'_2}{L'_0}+\frac{L''_2}{L''_0}+\frac{L'''_2}{L'''_0}=0.$$

Eliminating L'_2, L''_2, L'''_2 from the above relations, the equation of the pair of tangents required takes the form

$$\frac{1}{L'_0\,(L''\,L'''_1-L'''\,L''_1)}+\frac{1}{L''_0\,(L'''\,L'_1-L'\,L'''_1)}$$
$$+\frac{1}{L'''_0\,(L'\,L''_1-L''\,L'_1)}=0.$$

The equation of the fourth common tangent to the two conics

$$\sqrt{\frac{L'}{L'_1}}+\sqrt{\frac{L''}{L''_1}}+\sqrt{\frac{L'''}{L'''_1}}=0,$$

$$\sqrt{\frac{L'}{L'_2}}+\sqrt{\frac{L''}{L''_2}}+\sqrt{\frac{L'''}{L'''_2}}=0,$$

inscribed in the triangle Δ_0, is

$$\frac{L'}{L'_1\,L'_2\,(L''_1\,L'''_2-L''_2\,L'''_1)}+\frac{L''}{L''_1\,L''_2\,(L'''_1\,L'_2-L'''_2\,L'_1)}$$
$$+\frac{L'''}{L'''_1\,L'''_2\,(L'_1\,L''_2-L'_2\,L''_1)}=0.$$

§ 3. If the triangle with respect to which the axes of homology be taken be the triangle of reference Δ, the equations (i.), (ii.), and (iii.) reduce respectively to

$$L_0=\frac{\alpha}{\alpha_0}+\frac{\beta}{\beta_0}+\frac{\gamma}{\gamma_0}=0;$$

$$S_0=\frac{\beta\gamma}{\beta_0\gamma_0}+\frac{\gamma\alpha}{\gamma_0\alpha_0}+\frac{\alpha\beta}{\alpha_0\beta_0}=0;$$

$$S_0'=\sqrt{\frac{\alpha}{\alpha_0}}+\sqrt{\frac{\beta}{\beta_0}}+\sqrt{\frac{\gamma}{\gamma_0}}=0.$$

S_o' when expanded may be written in the form $L_o^2 - 4S_o$, showing that S_o and S_o' have double contact with each other along the line $L_o = 0$.

The axis with respect to Δ of any point $\alpha_1\beta_1\gamma_1$ on L_o will touch S_o' at the point $\left(\frac{\alpha_1^2}{\alpha_o}, \frac{\beta_1^2}{\beta_o}, \frac{\gamma_1^2}{\gamma_o}\right)$.

§ 4. Let the triangle formed by the lines

$$\frac{\beta}{\beta_o} + \frac{\gamma}{\gamma_o} = 0, \quad \frac{\gamma}{\gamma_o} + \frac{\alpha}{\alpha_o} = 0, \quad \frac{\alpha}{\alpha_o} + \frac{\beta}{\beta_o} = 0 \quad \text{be } \Delta_1.$$

The axis of homology of $\alpha_o\beta_o\gamma_o$ with respect to Δ_1 is $L_o = 0$.

The axis of homology of any point $\alpha_1\beta_1\gamma_1$ on $L_o = 0$ with respect to Δ_1 is

$$\frac{\alpha}{\alpha_o}\left(\frac{\beta_o}{\beta_1} + \frac{\gamma_o}{\gamma_1}\right) + \frac{\beta}{\beta_o}\left(\frac{\gamma_o}{\gamma_1} + \frac{\alpha_o}{\alpha_1}\right) + \frac{\gamma}{\gamma_o}\left(\frac{\alpha_o}{\alpha_1} + \frac{\beta_o}{\beta_1}\right) = 0; \quad \text{(iv.)}$$

and the envelope of (iv.) is the conic S_o.

The line (iv.) will touch S_o at the point $\left(\frac{\alpha_o^2}{\alpha_1}, \frac{\beta_o^2}{\beta_1}, \frac{\gamma_o^2}{\gamma_1}\right)$.

The locus of points whose axes of homology with respect to Δ_1 pass through $\alpha_o\beta_o\gamma_o$, is the conic

$$\frac{\alpha^2}{\alpha_o^2} + \frac{\beta^2}{\beta_o^2} + \frac{\gamma^2}{\gamma_o^2} + 3\left(\frac{\beta\gamma}{\beta_o\gamma_o} + \frac{\gamma\alpha}{\gamma_o\alpha_o} + \frac{\alpha\beta}{\alpha_o\beta_o}\right) = 0; \qquad S_1$$

i.e., $L_o^2 + S_o = 0$,

showing that S_1 and S_o have double contact along $L_o = 0$.

If $\alpha_1\beta_1\gamma_1$ be one of the points of intersection of L_o and S_o, the line (iv.) becomes

$$\frac{\alpha}{\alpha_1} + \frac{\beta}{\beta_1} + \frac{\gamma}{\gamma_1} = 0; \qquad \text{(v.)}$$

i.e., the axes of homology of $\alpha_1\beta_1\gamma_1$ with respect to Δ_1 and Δ (the triangle of reference) are identical lines; hence (v.) passes through $\alpha_o\beta_o\gamma_o$, and therefore the axes of the two points in which L_o cuts S_o are the pair of tangents to S_o, S_o', and S_1 from $\alpha_o\beta_o\gamma_o$.

The lines forming the triangle Δ_1 are the tangents to S_o at the vertices of the triangle of reference.

§ 5. Let the triangle formed by the lines

$$2\frac{\alpha}{\alpha_0} + \frac{\beta}{\beta_0} + \frac{\gamma}{\gamma_0} = 0,$$

$$\frac{\alpha}{\alpha_0} + 2\frac{\beta}{\beta_0} + \frac{\gamma}{\gamma_0} = 0,$$

$$\frac{\alpha}{\alpha_0} + \frac{\beta}{\beta_0} + 2\frac{\gamma}{\gamma_0} = 0$$

be called the triangle Δ_2.

The axis of homology of the point $\alpha_0\beta_0\gamma_0$ with respect to Δ_2 is L_0.

The axis of any point $\alpha_1\beta_1\gamma_1$ on L_0 with respect to Δ_2 is

$$\frac{\alpha}{\alpha_0}\left(\frac{2\alpha_0}{\alpha_1} + \frac{\beta_0}{\beta_1} + \frac{\gamma_0}{\gamma_1}\right) + \frac{\beta}{\beta_0}\left(\frac{\alpha_0}{\alpha_1} + \frac{2\beta_0}{\beta_1} + \frac{\gamma_0}{\gamma_1}\right)$$
$$+ \frac{\gamma}{\gamma_0}\left(\frac{\alpha_0}{\alpha_1} + \frac{\beta_0}{\beta_1} + \frac{2\gamma_0}{\gamma_1}\right) = 0. \qquad \text{(vi.)}$$

The locus of points whose axes with respect to Δ_2 pass through $\alpha_0\beta_0\gamma_0$ is the conic

$$5\left(\frac{\alpha^2}{\alpha_0^2} + \frac{\beta^2}{\beta_0^2} + \frac{\gamma^2}{\gamma_0^2}\right) + 11\left(\frac{\beta\gamma}{\beta_0\gamma_0} + \frac{\gamma\alpha}{\gamma_0\alpha_0} + \frac{\alpha\beta}{\alpha_0\beta_0}\right) = 0; \qquad S_2$$

i.e., $5\,L_0^2 + S_0 = 0$.

The envelope of the axes of points on L_0 with respect to Δ_2 is the conic $S_1 = 0$.

The sides of the triangle Δ_2 are the tangents to S_1 at the vertices of the triangle Δ_1.

The line (vi.) is tangent to S_1 at the point

$$\alpha_0\left(-\frac{\alpha_0}{\alpha_1} + \frac{\beta_0}{\beta_1} + \frac{\gamma_0}{\gamma_1}\right),\ \beta_0\left(\frac{\alpha_0}{\alpha_1} - \frac{\beta_0}{\beta_1} + \frac{\gamma_0}{\gamma_1}\right),\ \gamma_0\left(\frac{\alpha^0}{\alpha_1} + \frac{\beta_0}{\beta_1} - \frac{\gamma_0}{\gamma_1}\right).$$

§ 6. Let the lines joining the vertices of the triangle of reference ABC to O $(\alpha_0\beta_0\gamma_0)$ meet the opposite sides of the triangle in D, E, F respectively.

The equations of the lines EF, FD, DE are respectively

$$\frac{\beta}{\beta_0} + \frac{\gamma}{\gamma_0} - \frac{\alpha}{\alpha_0} = 0,\ \frac{\gamma}{\gamma_0} + \frac{\alpha}{\alpha_0} - \frac{\beta}{\beta_0} = 0, \text{ and } \frac{\alpha}{\alpha_0} + \frac{\beta}{\beta_0} - \frac{\gamma}{\gamma_0} = 0.$$

Let these lines form the triangle Δ'.

The axis of homology of $\alpha_0\beta_0\gamma_0$ with respect to Δ' is L_0, and the axis of any point $\alpha_1\beta_1\gamma_1$ on L_0 with respect to Δ' is

$$\frac{\alpha}{\alpha_0}\left(\frac{\beta_0}{\beta_1}+\frac{\gamma_0}{\gamma_1}-\frac{\alpha_0}{\alpha_1}\right)+\frac{\beta}{\beta_0}\left(\frac{\gamma_0}{\gamma_1}+\frac{\alpha_0}{\alpha_1}-\frac{\beta_0}{\beta_1}\right)$$
$$+\frac{\gamma}{\gamma_0}\left(\frac{\alpha_0}{\alpha_1}+\frac{\beta_0}{\beta_1}-\frac{\gamma_0}{\gamma_1}\right)=0, \qquad \text{(vii.)}$$

which, if $\alpha_1\beta_1\gamma_1$ be one of the points of intersection of L_0 and S_0, reduces to (v.).

The locus of points whose axes with respect to Δ' pass through $\alpha_0\beta_0\gamma_0$ is S_0'.

The envelope of the axes with respect to Δ' of points on L_0 is

$$\sqrt{\frac{\beta}{\beta_0}+\frac{\gamma}{\gamma_0}-\frac{\alpha}{\alpha_0}}+\sqrt{\frac{\gamma}{\gamma_0}+\frac{\alpha}{\alpha_0}-\frac{\beta}{\beta_0}}+\sqrt{\frac{\alpha}{\alpha_0}+\frac{\beta}{\beta_0}-\frac{\gamma}{\gamma_0}}=0;$$

i.e., $5\,L_0^2-16\,S_0=0$. $\qquad S'$

The axis of $\alpha_1\beta_1\gamma_1$ on L_0 touches S' at the point

$$\alpha_0\left(\frac{2\alpha_0}{\alpha_1}+\frac{\beta_0}{\beta_1}+\frac{\gamma_0}{\gamma_1}\right),\ \beta_0\left(\frac{\alpha_0}{\alpha_1}+\frac{2\beta_0}{\beta_1}+\frac{\gamma_0}{\gamma_1}\right),\ \gamma_0\left(\frac{\alpha_0}{\alpha_1}+\frac{\beta_0}{\beta_1}+\frac{2\gamma_0}{\gamma_1}\right).$$

§ 7. Let the lines OA, OB, OC meet EF, FD, DE respectively in D′, E′, F′.

The equations of the lines E′F′, F′D′, D′E′ are respectively

$$3\frac{\alpha}{\alpha_0}-\frac{\beta}{\beta_0}-\frac{\gamma}{\gamma_0}=0,\ \ 3\frac{\beta}{\beta_0}-\frac{\gamma}{\gamma_0}-\frac{\alpha}{\alpha_0}=0,\ \ 3\frac{\gamma}{\gamma_0}-\frac{\alpha}{\alpha_0}-\frac{\beta}{\beta_0}=0.$$

Let these lines form the triangle Δ''.

The axis of homology of the point $\alpha_0\beta_0\gamma_0$ with respect to Δ'' is L_0.

The axis of homology of any point $\alpha_1\beta_1\gamma_1$ on L_0 with respect to Δ'' is

$$\frac{\alpha}{\alpha_0}\left(\frac{3\alpha_0}{\alpha_1}-\frac{\beta_0}{\beta_1}-\frac{\gamma_0}{\gamma_1}\right)+\frac{\beta}{\beta_0}\left(\frac{3\beta_0}{\beta_1}-\frac{\gamma_0}{\gamma_1}-\frac{\alpha_0}{\alpha_1}\right)$$
$$+\frac{\gamma}{\gamma_0}\left(\frac{3\gamma_0}{\gamma_1}-\frac{\alpha_0}{\alpha_1}-\frac{\beta_0}{\beta_1}\right)=0. \qquad \text{(viii.)}$$

The envelope of (viii.) is the conic

$$21\left(\frac{\alpha^2}{\alpha_0^2}+\frac{\beta^2}{\beta_0^2}+\frac{\gamma^2}{\gamma_0^2}\right)-22\left(\frac{\beta\gamma}{\beta_0\gamma_0}+\frac{\gamma\alpha}{\gamma_0\alpha_0}+\frac{\alpha\beta}{\alpha_0\beta_0}\right)=0;$$

i.e., $21\,L_0^2-64\,S_0=0.$ $\qquad S''$

The line (viii.) touches its envelope at the point

$$\alpha_0\left(\frac{2\alpha_0}{\alpha_1}+\frac{3\beta_0}{\beta_1}+\frac{3\gamma_0}{\gamma_1}\right),\ \beta_0\left(\frac{3\alpha_0}{\alpha_1}+\frac{2\beta_0}{\beta_1}+\frac{3\gamma_0}{\gamma_1}\right),$$

$$\gamma_0\left(\frac{3\alpha_0}{\alpha_1}+\frac{3\beta_0}{\beta_1}+\frac{2\gamma_0}{\gamma_1}\right).$$

The locus of points whose axes of homology with respect to Δ'' pass through $\alpha_0\beta_0\gamma_0$ is S$'$.

§ 8. Hence we have a series of triangles,

$$\Delta_2,\ \Delta_1,\ \Delta,\ \Delta',\ \Delta'',$$

which are in perspective with each other, and the series of conics

$$\begin{aligned}
S_2 &\equiv 5L_0^2 + S_0 = 0 \\
S_1 &\equiv L_0^2 + S_0 = 0 \\
S_0 &\equiv S_0 = 0 \\
S_0' &\equiv L_0^2 - 4S_0 = 0 \\
S' &\equiv 5L_0^2 - 16S_0 = 0 \\
S'' &\equiv 21L_0^2 - 64S_0 = 0
\end{aligned}
\quad
\begin{aligned}
&\}\ldots\ldots\ldots\ldots\Delta_2 \\
&\}\ldots\ldots\ldots\ldots\Delta_1 \\
&\}\ldots\ldots\ldots\ldots\Delta \\
&\}\ldots\ldots\ldots\ldots\Delta' \\
&\}\ldots\ldots\ldots\ldots\Delta''
\end{aligned}$$

so related to their respective triangles that any conic of the series is either a locus of points whose axes of homology with respect to the associated triangle pass through $\alpha_0\beta_0\gamma_0$ or the envelope of the axes of homology with respect to the corresponding triangle of the points of the line $L_0 = 0$.

Each conic in the series is connected with the ones adjacent to it in the series by the invariant relation

$$27\ \Delta\Delta' - 2\ \Theta\Theta' = 0.$$

Since all the conics of the series are of the form

$$p\left(\frac{\alpha^2}{\alpha_0^2}+\frac{\beta^2}{\beta_0^2}+\frac{\gamma^2}{\gamma_0^2}\right)+2q\left(\frac{\beta\gamma}{\beta_0\gamma_0}+\frac{\gamma\alpha}{\gamma_0\alpha_0}+\frac{\alpha\beta}{\alpha_0\beta_0}\right)=0,$$

it is easily proved that the locus of the centres of the conics is the line-pair

$$L_0 \equiv \frac{\alpha}{\alpha_0}+\frac{\beta}{\beta}+\frac{\gamma}{\gamma}=0$$

and $\frac{\alpha}{\alpha_0}(b\beta_0 - c\gamma_0)+\frac{\beta}{\beta_0}(c\gamma_0 - a\alpha_0)+\frac{\gamma}{\gamma_0}(a\alpha_0 - b\beta_0)\quad 0.$ (ix.)

Now, the co-ordinates of the centres of the conics being proportional to

$$\alpha_0\left[(p+q)\,a\alpha_0 - q\,(b\beta_0+c\gamma_0)\right],\ \beta_0\left[(p+q)\,b\beta_0 - q\,(c\gamma_0+a\alpha_0)\right],$$

$$\gamma_0\left[(p+q)\,c\gamma_0 - q\,(a\alpha_0+b\beta_0)\right],$$

it may be at once verified that all the centres lie on the line (ix.).

This line is the join of the points $(\alpha_0\beta_0\gamma_0)$ and $(a\alpha_0^2, b\beta_0^2, c\gamma_0^2)$.

To determine the point $(a\alpha_0^2, b\beta_0^2, c\gamma_0^2)$ consider the conic $U \equiv -\frac{\alpha^2}{\alpha_0^2} + \frac{\beta^2}{\beta_0^2} + \frac{\gamma^2}{\gamma_0^2}$, whose centre, H, is the point $(-a\alpha_0^2, b\beta_0^2, c\gamma_0^2)$.

Let $L_0 = 0$ meet BC, CA, and AB in D′, E′, F′ respectively; then U touches BE, BE′ at E and E′ respectively, and CF, CF′ at F and F′ respectively.

Let E″, F″ be the middle points of EE′, FF′ respectively; then H is the point of intersection of BE″ and CF″.

Through C draw a straight line CX, such that CA, CX, CB, CH form a harmonic range; then CX will intersect AH in the point required.

Hence the line of centres of the series of conics is determined.

§ 9. If any three points $(\alpha_1\beta_1\gamma_1)$, $(\alpha_2\beta_2\gamma_2)$, $(\alpha_3\beta_3\gamma_3)$ be taken on the line L_0, their axes of homology with respect to the triangle of reference form a triangle circumscribing the conic $S_0' = 0$, and the vertices of this triangle lie on the conic

$$\frac{\alpha_1\alpha_2\alpha_3}{\alpha_0^2\alpha} + \frac{\beta_1\beta_2\beta_3}{\beta_0^2\beta} + \frac{\gamma_1\gamma_2\gamma_3}{\gamma_0^2\gamma} = 0. \qquad \text{(A)}$$

Let, now, $\alpha_1\beta_1\gamma_1$ and the two other points be taken to be $(\lambda\alpha_0, \mu\beta_0, \nu\gamma_0)$, $(\mu\alpha_0, \nu\beta_0, \lambda\gamma_0)$, $(\nu\alpha_0, \lambda\beta_0, \mu\gamma_0)$ respectively, subject to the condition

$$\lambda + \mu + \nu = 0.$$

The conic (A) reduces then to the form

$$S_0 \equiv \frac{\beta\gamma}{\beta_0\gamma_0} + \frac{\gamma\alpha}{\gamma_0\alpha_0} + \frac{\alpha\beta}{\alpha_0\beta_0} = 0.$$

Hence, if values (other than zero) of λ, μ, ν be taken satisfying the condition $\lambda + \mu + \nu = 0$, the axes with respect to the triangle of reference of the points $(\lambda\alpha_0, \mu\beta_0, \nu\gamma_0)$, $(\mu\alpha_0, \nu\beta_0, \lambda\gamma_0)$, $(\nu\alpha_0, \lambda\beta_0, \mu\gamma_0)$ form a triangle inscribed in S_0 and circumscribing S_0'.

§ 10. Let three points O_1, O_2, O_3 be taken on $L_0 = 0$ whose co-ordinates are $(\lambda\alpha_0, \mu\beta_0, \nu\gamma_0)$, $(\mu\alpha_0, \nu\beta_0, \lambda\gamma_0)$, $(\nu\alpha_0, \lambda\beta_0, \mu\gamma_0)$, where $\lambda + \mu + \nu = 0$.

The axes of O_1 with respect to the triangles

$$\triangle_2,\ \triangle_1,\ \triangle,\ \triangle',\ \triangle''$$

are respectively

$$\frac{\alpha}{\alpha_0}(\mu^2+\nu^2) + \frac{\beta}{\beta_0}(\nu^2+\lambda^2) + \frac{\gamma}{\gamma_0}(\lambda^2+\mu^2) = 0,$$

$$\frac{\alpha}{\alpha_0}\lambda^2 + \frac{\beta}{\beta_0}\mu^2 + \frac{\gamma}{\gamma_0}\nu^2 = 0,$$

$$\frac{\alpha}{\alpha_0}\cdot\frac{1}{\lambda} + \frac{\beta}{\beta_0}\cdot\frac{1}{\mu} + \frac{\gamma}{\gamma_0}\cdot\frac{1}{\nu} = 0,$$

$$\frac{\alpha}{\alpha_0}(\lambda^2+\mu\nu) + \frac{\beta}{\beta_0}(\mu^2+\nu\lambda) + \frac{\gamma}{\gamma_0}(\mu^2+\lambda\mu) = 0,$$

$$\frac{\alpha}{\alpha_0}(\lambda^2+3\mu\nu) + \frac{\beta}{\beta_0}(\mu^2+3\nu\lambda) + \frac{\gamma}{\gamma_0}(\nu^2+3\lambda\mu) = 0.$$

These lines touch respectively the conics

$$S_1,\ S_0,\ S_0',\ S',\ S'',$$

and the vertices of the several triangles formed by these lines and the corresponding axes of the points O_2, O_3 lie respectively on the conics

$$S_2,\ S_1,\ S_0,\ S_0',\ S'.$$

The points of contact of the several axes of O_1 with the associated envelope-conic lie on the line

$$\frac{\alpha}{\alpha_0}(\mu^2-\nu^2) + \frac{\beta}{\beta_0}(\nu^2-\lambda^2) + \frac{\gamma}{\gamma_0}(\lambda^2-\mu^2) = 0. \qquad \text{(x.)}$$

Similarly, the points of contact of the axes of O_2 and O_3 are collinear.

The three lines on which the points of contact lie all pass through $\alpha_0\beta_0\gamma_0$.

The triangles formed by the axes of O_1, O_2, O_3 are in perspective, the centre of perspective being the point $\alpha_0\beta_0\gamma_0$, and corresponding vertices of the several triangles lie on the line (x.) and two similar ones.

The axes of O_1 with respect to the several triangles are concurrent, the co-ordinates of the point of concurrence being

$$\alpha_0\lambda(\mu-\nu),\ \beta_0\mu(\nu-\lambda),\ \gamma_0\nu(\lambda-\mu).$$

A similar concurrence holds for the axes of O_2 and O_3, and the three points of concurrence are collinear.

§ 11. If ω be one of the imaginary cube roots of unity, the co-ordinates of the points in which $L_0 = 0$ meets $S_0 = 0$ are

$$(\alpha_0,\ \omega\beta_0,\ \omega^2\gamma_0),\ (\alpha_0,\ \omega^2\beta_0,\ \omega\gamma_0).$$

Let the triangle formed by these points and $\alpha_0\beta_0\gamma_0$ be called ${}_0\triangle$. Two sides of the triangle are the tangents from $\alpha_0\beta_0\gamma_0$ to S_0', the third being the axis of $\alpha_0\beta_0\gamma_0$ with respect to $\triangle$.

The triangle ${}_0\triangle$ possesses the property that any side is the axis, with respect to $\triangle$, of the opposite vertex, while the axes, with respect to ${}_0\triangle$, of the vertices of $\triangle$ are the opposite sides of the latter triangle.

The axis of homology of any point $(\alpha_1\beta_1\gamma_1)$ with respect to ${}_0\triangle$ is

$$\frac{\alpha}{\alpha_0} P_1 + \frac{\beta}{\beta_0} Q_1 + \frac{\gamma}{\gamma_0} R_1 = 0, \qquad \text{(xi.)}$$

where $P = \frac{\alpha^2}{\alpha_0^2} - \frac{\beta\gamma}{\beta_0\gamma_0}$, $Q = \frac{\beta^2}{\beta_0^2} - \frac{\gamma\alpha}{\gamma_0\alpha_0}$, $R = \frac{\gamma^2}{\gamma_0^2} - \frac{\alpha\beta}{\alpha_0\beta_0}$.

The locus of points whose axes with respect to ${}_0\triangle$ pass through $\alpha_1\beta_1\gamma_1$ is the conic

$$\frac{\alpha_1}{\alpha_0} P + \frac{\beta_1}{\beta_0} Q + \frac{\gamma_1}{\gamma_0} R = 0.$$

Each of the conics P, Q, R, besides touching two sides of $\triangle$, circumscribes ${}_0\triangle$. The tangents drawn to P, Q, R at the points $(\alpha_0, \omega\beta_0, \omega^2\gamma_0)$, $(\alpha_0, \omega^2\beta_0, \omega\gamma_0)$ meet in the three points $(-\alpha_0, 2\beta_0, 2\gamma_0)$, $(2\alpha_0, -\beta_0, 2\gamma_0)$, $(2\alpha_0, 2\beta_0, -\gamma_0)$ respectively. These three points lie on $S_0 = 0$.

The envelope, with respect to ${}_0\triangle$, of the axes of points on (xi.) is the conic

$$(P_1^2 - 4Q_1R_1)\frac{\alpha^2}{\alpha_0^2} + (Q_1^2 - 4R_1P_1)\frac{\beta^2}{\beta_0^2} + (R_1^2 - 4P_1Q_1)\frac{\gamma^2}{\gamma_0^2}$$
$$- 2(2P_1^2 + Q_1R_1)\frac{\beta\gamma}{\beta_0\gamma_0} - 2(2Q_1^2 + R_1P_1)\frac{\gamma\alpha}{\gamma_0\alpha_0}$$
$$- 2(2R_1^2 + P_1Q_1)\frac{\alpha\beta}{\alpha_0\beta_0} = 0.$$

No. 2.—HEATING EFFECT OF THE RADIUM-EMANATION.

By E. Rutherford, F.R.S., Macdonald Professor of Physics, McGill University, Montreal.

Estimates have been made at various times of the energy radiated from the active substances in the form of α and β rays, and it was known that the amount of this energy was considerable. Rutherford and McClung* deduced that a thin layer of radium chloride, of activity 100,000 times uranium,

* Phil. Trans., A., p. 25, 1901.

emitted energy into the gas in the form of α rays at the rate of 3,000 gram calories per year. Taking the latest estimate, 1,500,000, as the activity of pure radium chloride compared with uranium, this corresponds to an emission of energy from pure radium chloride in the form of α rays of 45,000 gram calories per year.

P. Curie and Laborde* recently drew attention to the striking result that a radium compound continuously kept itself at a temperature of several degrees above that of the surrounding atmosphere. In addition to the energy emitted in the form of the ionizing radiations, there is thus a continuous emission of energy in the form of heat from the radium compound. Curie and Laborde determined by two distinct methods that 1 gram of radium emits heat continuously at the rate of 100 gram calories per hour, or 876,000 gram calories per year. These results have since been confirmed by other observers. Giesel found that a small thermometer placed in a tube containing 1 gram of radium bromide indicated a rise of temperature of 5° C. above that of the surrounding atmosphere.

As far as observations have at present gone, this rate of heat-emission of radium is constant. In the course of a few years 1 gram of radium would thus radiate an enormous amount of energy. It seems very improbable that such a large emission of heat is the result of an ordinary chemical change taking place in the radium. The union of hydrogen and oxygen to form a gram of water gives out only about 4,000 gram calories, and more heat is evolved in this reaction than in any other known to chemistry.

In order to explain the rapid and continuous heat-emission of radium two general theories have been proposed. On the one view, radium is supposed to absorb known or unknown types of radiation from the atmosphere, and acts as a mechanism to transform this borrowed energy into the form of heat and the peculiar radiations emitted by radium. On the other view, the energy is supposed to be derived from the energy latent in the radium atom. The radium atom is supposed to be undergoing spontaneous disintegration, accompanied by the emission of rays, and the energy emitted in the form of heat and of α, β, and γ rays is a result of this breaking-up of the atom.

The view that the radium acts as a transformer of borrowed energy has no experimental evidence in support of it. As far as experiments have gone the rate of heat-emission of radium is independent of external conditions. Curie and Laborde found that the radium gave out the same amount of heat when immersed in an ice calorimeter as under ordinary conditions. J. J. Thomson (*Nature*, p. 601, 1903) has pointed out that

* Comptes Rendus, 136, p. 673, 1903.

it is impossible to suppose that under such conditions the radium borrows the heat from the surrounding air.

P. Curie,* however, observed that the heating effect of radium varied with the age of radium compound. It was small when first prepared, but increased to a maximum value in the course of one month, and did not change appreciably in the following two months. The explanation of this result will be seen later.

On the disintegration theory advanced by Rutherford and Soddy (Phil. Mag., May, 1903), it is supposed that a definite small proportion of the radium atoms (about 1 in every 10^{10} will suffice) break up per second. The disintegration of each atom is accompanied by the expulsion of an α ray or particle with great velocity. I have recently shown that the α rays of radium consist of positively charged bodies, of mass about twice that of the hydrogen atom, projected at a speed of 20,000 miles per second. The expulsion of an α particle will leave the atom lighter than before, and will have changed its chemical and physical properties. The radium atom *minus* one α particle on this view constitutes the atom of the radium emanation. This emanation behaves like a chemically inert gas of high molecular weight, which obeys the laws of diffusion, and can be condensed by extreme cold. The atom of the emanation is again unstable, and in turn breaks up with the expulsion of another α particle. The α particles expelled from the emanation constitute the radiation from the emanation. After the expulsion of an α particle from the emanation, the residue behaves like a solid, and attaches itself to the surface of bodies, giving rise to the phenomena of "excited" or "induced" activity. This matter in turn breaks up, and, after a succession of well-marked changes, a final product is reached which is not radioactive. Each of the products, like the emanation and the matter which causes excited activity, break up at a definite rate, which is uninfluenced by any chemical or physical agency. The reactions that give rise to the series of well-marked products in radium are of a different character from those observed in chemistry, for no reaction is known which proceeds at the same rate at the temperature of liquid air as at a red heat.

On the disintegration theory, the heat emitted from radium arises partly from the rays emitted and partly from the systems from which the rays are expelled. Of the three types of rays emitted by radium the α, or easily absorbed rays, are by far the most important. More than 99 per cent. of the energy radiated in the form of ionizing rays is due to them. The β and γ rays, in comparison, are of far less significance.

* Société de Physique, Paris, 1903.

These α rays are very easily absorbed in matter, and in a pellet of radium a large proportion of the α particles which are expelled is absorbed by the mass of the radium itself. The radium should thus be heated above the temperature of the surrounding air by its self-bombardment. There is no reason, however, to suppose that all the energy emitted by radium is due to this self-bombardment. The expulsion of an α particle from a system must set it into violent vibration. The component parts of the system left behind will tend to arrange themselves so as to form a stable or temporarily stable system. During this rearrangement, which probably entails a condensation of the parts of the atom, energy will be emitted, which will be manifested in the form of heat. It remains for experiment to decide how much of the heat emitted is due to the α particles and how much to the resulting rearrangement of the parts of the atom.

If these views are correct, a proportion of the heat emitted by radium should be due to the active products which arise from the radium—viz., the emanation and the matter which causes excited activity—and the heat-emission should be directly connected with the radio-activity of radium.

This point has been recently investigated by Professor Barnes and myself (*Nature*, Oct. 29, 1903). The heating effect of 30 milligrams of radium bromide was first measured in a special form of differential air calorimeter. The radium bromide was then heated in a glass tube to a sufficient temperature to drive off the emanation occluded in it, and this emanation was condensed in a short glass tube immersed in liquid air. The tubes containing the radium and the emanation were then sealed off, and the heating effect due to each tested separately at definite intervals. It was observed that the heating effect of the de-emanated radium decreased for the first few hours to a minimum corresponding to about 30 per cent. of the original heat-emission. At the same time the heating effect of the emanation-tube increased for the first few hours to a maximum corresponding to about 70 per cent. of the rate of heat-emission of the radium. The radium was found to spontaneously regain its rate of heat-emission with time, and after a month's interval the rate of heat-emission was the same as at first. At the same time the heating effect of the emanation-tube, after reaching the maximum, steadily decayed with the time, falling to half-value in about four days. At any time the sum total of the heat-emission of the de-emanated radium and the emanation-tube was equal to that of the original radium. These results show that the heating effect of radium is directly connected with its radio-activity. It has long been known that radium when heated loses for the time 75 per cent. of its activity measured by the α rays. On leaving the radium the lost activity is spontaneously recovered in the course of a month's interval. This recovery of activity is due to the gradual production of the emanation by the radium. This emanation is occluded in the radium compound, and, together with the excited activity produced by it, adds its radiations to that of the radium proper. When, however, the emanation is removed from a radium compound by heat, the matter which causes excited activity is left behind. The activity due to this matter gradually decays, and in the course of a few hours practically disappears. At the same time the emanation in the closed vessel produces excited activity on the walls of the containing vessel. The gradual decay of the heating effect of the radium to a minimum after removal of the emanation, and the gradual rise of the heating effect of the emanation-tube, is connected with this decay and rise respectively of the excited activity produced by the emanation. The results indicate that a large proportion of the heate mitted from the emanation-tube is due to the matter which causes excited activity. It is a difficult experimental problem to isolate the heating effect produced by the emanation from that due to the secondary products which arise from it.

The conclusion, however, may be drawn that more than two thirds of the heat emission of radium is not directly due to the radium itself, but is due to the radio active emanation and the secondary products which result from it. I have indicated that probably three distinct changes occur in the matter which causes excited activity. The experiments have not yet been pushed far enough to decide how the rate of emission of energy is divided between the emanation and these three changes.

With the amount of radium so far available, the presence of the emanation of radium has not been detected, either by its volume or its weight. The amount of emanation from 30 milligrams of radium must have been extremely minute, but yet it produced a strong phosphorescence in the containing tube, and gave out a large quantity of heat. I have calculated from several lines of evidence (see *Nature*, p. 367, 1903) that 1 gram of radium in a state of radio-active equilibrium contains from 6×10^{-5} to 6×10^{-4} c.c. of emanation, measured as a gas at standard pressure and temperature. Since 1 gram of radium emits 100 gram calories per hour, the experiments show that the changes occurring in the emanation from it give rise to 70 gram calories per hour. 1 c.c. of the emanation would thus emit energy at a rate lying between $1{\cdot}2 \times 10^5$ and $1{\cdot}2 \times 10^6$ gram calories per hour. This rate of emission of energy would suffice to heat to a red heat, if not to melt down, the glass tube containing the emanation.

It is of interest to make a rough estimate of the amount of energy emitted per second from 1 lb. weight of the radium emanation. The emanation behaves as a gas of heavy molecular weight, probably lying between 100 and 200. Taking the molecular weight as 200, 1 lb. of the radium emanation corresponds to about 25,000 c.c. of gas.

The rate of emission of energy from 1 lb. of the emanation thus lies between 3×10^9 and 3×10^{10} gram calories per hour. This corresponds to an initial rate of emission of energy of about 5,000- to 50,000-horse power. Since the heating effect of the emanation falls to half-value in about four days, it can be readily deduced that the energy emitted from 1 lb. of the emanation while its activity lasts lies between 30,000- and 300,000-horse-power days.

Quite independently of any hypothesis, it can be calculated from the experiments that the amount of heat evolved by 1 lb. of the emanation is of a similar order of magnitude, for it is known that an unmeasurable and unweighable quantity of emanation emits energy at a readily measurable rate.

On the disintegration theory this enormous emission of energy is derived from the latent energy stored up in the complex radio-atom. This energy is released by the spontaneous disintegration of the atom in several successive stages.

It is very difficult to explain the experimental results on the view that the radium acts as transformer of energy borrowed from the atmosphere, for it would be necessary to postulate that most of the heat-emission of radium is not due to the radium at all, but is due to the radium-emanation, which is produced from itself. It is also necessary to suppose that the property of the emanation, and of the products to which it gives rise, of absorbing energy from external sources is not constant, but decays with the time.

It has been pointed out (Rutherford and Soddy: Phil. Mag., May, 1903) that the radio-elements have no special chemical characteristics except their high atomic weight which distinguish them from the other chemical elements. It is thus probable that the energy resident in the atoms of the elements is enormous compared with that released or absorbed in chemical reactions. This energy has not been observed on account of the difficulty of breaking up the atoms by the physical and chemical processes at our disposal.

No. 3.—NOTES ON A METHOD OF MEASURING DIELECTRIC CONSTANTS IN ELECTRIC FIELDS AT HIGH FREQUENCIES.

By O. U. Vonwiller, B.Sc.

[*Abstract.*]

The method is one elaborated from the work of Lecher, Morton, and others on the effect of capacity on stationary electric waves.

Electric oscillations with a frequency of twenty-five millions are set up along a pair of parallel wires, which are divided by metal bridges into a primary and a secondary circuit. The magnitude of the oscillations set up in each circuit is measured by a Rutherford detector placed in each. A condenser is placed across the wires of the secondary, and, being equivalent to an addition to the length of the circuit—the amount added depending on the capacity—any variation of capacity results in a change in the equivalent length of the secondary, and so to an alteration in the state of resonance between the two circuits, which is indicated by an alteration in the ratio of the deflections produced on a magnetometer by the two detectors.

The conditions under which this arrangement is most sensitive to a small change of capacity are investigated.

To measure dielectric constants a condenser of suitable dimensions, with the substance under examination as its dielectric, is placed across the wires of the secondary in the position where greatest sensitiveness obtains, and the deflections produced by the detectors observed. Then a condenser with air as its dielectric is used, and deflections observed as its capacity is given various known values. When the ratio of the deflections produced by the two detectors is the same for both condensers it is assumed that the capacities are the same, and so the capacity of the first condenser is determined, and, if its capacity when air is its dielectric is known, the unknown dielectric constant is readily calculated.

This method was employed by the author in investigating the variation in the dielectric constant of water with temperature, and is explained in full detail in a paper entitled " A Contribution to the Study of the Dielectric Constant of Water at Low Temperatures," published in the Journal and Proceedings of the Royal Society of New South Wales, vol. xxxvii., p. 224.

No. 4.—ON SOME CONTINUOUS OBSERVATIONS ON THE RATE OF DISSIPATION OF ELECTRIC CHARGES IN THE OPEN AIR.

By C. Coleridge Farr, D.Sc.

No. 5.—TABLES OF GEODETIC FACTORS FOR USE ON THE BRUNSVIGA CALCULATING-MACHINE.

By C. E. Adams, B.Sc. with Honours, N.Z. Univ., A.I.A. London.

These tables have been calculated from the latest values of the figure of the earth, given in Colonel Clarke's "Geodesy," thus—

Semi-major axis, $a = 20926202$ English feet.

Semi-minor axis, $b = 20854895$ "

Let e be the eccentricity of the meridian, where

$$e^2 = \frac{a^2 - b^2}{a^2}$$

Then $e^2 = 0{\cdot}006{,}803{,}481{,}018{,}843.$

The tables give the values of the factors N, M, and E for every degree of latitude from the equator to the pole, where

$$\mathrm{N} = \frac{\rho''}{\rho n} = \frac{\rho''(1 - e^2 \sin^2\phi)^{\frac{1}{2}}}{a}$$

$$\mathrm{M} = \frac{\rho''}{\rho m} = \frac{\rho''(1 - e^2 \sin^2\phi)^{\frac{3}{2}}}{a(1 - e^2)}$$

$$\mathrm{E} = \frac{\rho''}{2\,\rho m\,\rho n} = \frac{\rho''(1 - e^2 \sin^2\phi)^2}{2b^2}$$

In these expressions—

ρ'' = number of seconds in a radian = 206,264·806 ;

ρm = radius of curvature of meridian section of spheroid in latitude ϕ ;

ρn = radius of curvature of normal section perpendicular to the meridian in latitude ϕ ;

$\rho m = a(1 - e^2)(1 - e^2 \sin^2\phi)^{-\frac{3}{2}}$;

$\rho n = a(1 - e^2 \sin^2\phi)^{-\frac{1}{2}}$.

Now,

$$(1 - e^2\sin^2\phi)^{\frac{1}{2}} = 1 - \tfrac{1}{2}e^2\sin^2\phi - \tfrac{1}{8}e^4\sin^4\phi - \tfrac{1}{16}e^6\sin^6\phi - \tfrac{5}{128}e^8\sin^8\phi - \ldots \text{ \&c.}$$

$$= 1 - \tfrac{1}{4}e^2 - \tfrac{3}{64}e^4 - \tfrac{5}{256}e^6 - \tfrac{175}{16384}e^8 - \ldots \text{ \&c.}$$

$$+ (\tfrac{1}{4}e^2 + \tfrac{1}{16}e^4 + \tfrac{15}{512}e^6 + \tfrac{35}{2048}e^8 + \ldots \text{ \&c.})\cos 2\phi$$

$$- (\tfrac{1}{64}e^4 + \tfrac{3}{256}e^6 + \tfrac{35}{4096}e^8 + \ldots \text{ \&c.})\cos 4\phi$$

$$+ (\tfrac{1}{512}e^6 + \tfrac{5}{2048}e^8 + \ldots \text{ \&c.})\cos 6\phi$$

$$- (\tfrac{5}{16384}e^8 + \ldots \text{ \&c.})\cos 8\phi$$

$$+ \ldots \text{ \&c.}$$

$$= 0{\cdot}998{,}296{,}953{,}852$$

$$+ 0{\cdot}001{,}703{,}772{,}477 \cos 2\phi$$

$$- 0{\cdot}000{,}000{,}726{,}949 \cos 4\phi$$

$$+ 0{\cdot}000{,}000{,}000{,}620 \cos 6\phi$$

$$- \ldots$$

Also, $(1 - e^2 \sin^2\phi)^{\frac{3}{2}} = 1 - \frac{3}{2} e^2 \sin^2\phi + \frac{3}{8} e^4 \sin^4\phi + \frac{1}{16} e^6 \sin^6\phi + \frac{3}{128} e^8 \sin^8\phi + \ldots \&c.$

$$= 1 - \tfrac{3}{4} e^2 + \tfrac{9}{64} e^4 + \tfrac{5}{256} e^6 + \tfrac{105}{16384} e^8 + \ldots \&c.$$
$$+ (\tfrac{3}{4} e^2 - \tfrac{3}{16} e^4 - \tfrac{15}{512} e^6 - \tfrac{21}{2048} e^8 - \ldots \&c.) \cos 2\phi$$
$$+ (\tfrac{3}{64} e^4 + \tfrac{3}{256} e^6 + \tfrac{21}{4096} e^8 + \ldots \&c.) \cos 4\phi$$
$$- (\tfrac{1}{512} e^6 + \tfrac{3}{2048} e^8 + \ldots \&c.) \cos 6\phi$$
$$+ (\tfrac{3}{16384} e^8 + \ldots \&c.) \cos 8\phi$$
$$\ldots \&c.$$
$$= 0{\cdot}994,903,901,560$$
$$+ 0{\cdot}005,093,922,637 \cos 2\phi$$
$$+ 0{\cdot}000,002,173,421 \cos 4\phi$$
$$- 0{\cdot}000,000,000,618 \cos 6\phi$$
$$+ \ldots$$

And $(1 - e^2 \sin^2\phi)^2 = 1 - e^2 + \frac{3}{8} e^4$

$$+ (e^2 - \tfrac{1}{2} e^4) \cos 2\phi$$
$$+ \tfrac{1}{8} e^4 \cos 4\phi$$
$$= 0{\cdot}993,213,876,739$$
$$+ 0{\cdot}006,780,337,342 \cos 2\phi$$
$$+ 0{\cdot}000,005,785,919 \cos 4\phi$$

Hence, for distances in chains (1 chain = 66 ft. = 100 links)

$$\text{N} = 0{\cdot}649,439,051,078$$
$$+ 0{\cdot}001,108,384,015 \cos 2\phi$$
$$- 0{\cdot}000,000,472,914 \cos 4\phi$$
$$+ 0{\cdot}000,000,000,404 \cos 6\phi$$
$$\ldots$$
$$\text{M} = 0{\cdot}651,665,308,716$$
$$+ 0{\cdot}003,326,535,973 \cos 3\phi$$
$$+ 0{\cdot}000,001,423,598 \cos 4\phi$$
$$- 0{\cdot}000,000,000,403 \cos 6\phi$$
$$+ \ldots$$
$$\text{E} = 0{\cdot}000,001,025,911,20$$
$$+ 0{\cdot}000,000,007,003,55 \cos 2\phi$$
$$+ 0{\cdot}000,000,000,005,98 \cos 4\phi$$

For convenience the series may be written

$$\text{N} = k_1 + a_1 \cos 3\phi + b_1 \cos 4\phi + c_1 \cos 6\phi + \ldots$$
$$\text{M} = k_2 + a_2 \cos 2\phi + b_2 \cos 4\phi + c_2 \cos 6\phi + \ldots$$
$$\text{E} = k_3 + a_3 \cos 2\phi + b_3 \cos 4\phi$$

From these series the tables have been calculated thus: Let the tabular interval be $\Delta\phi$, then $\Delta \text{N} = a_1 \Delta \cos 2\phi + b_1 \Delta \cos 4\phi + c_1 \Delta \cos 6\phi + \ldots$ and similar expressions for Δ M and Δ E are obtained. At convenient intervals values of N, M, and E are calculated direct from the series, and thus check the calculations.

Example of calculation of tables :—

Tabular interval $= \Delta\,\phi = 1^\circ$.

(1.) ϕ	(2.) $\cos 2\,\phi$	(3.) Δ	(4.) $\cos 4\,\phi$	(5.) Δ	(6.) $(3) \times a_1$	(7.) $(5) \times b_1$	(8.) Δ N $(6) + (7)$	(9.) N.
	+	−	+	−	−	+	−	+
0°	1·0000000		1·0000					0·650,546,966
		0·0006092		0·0024	675	1	674	
1°	0·9993908		0·9976					46,292
		·0018267		0 0073	2025	3	2022	
2°	0·9975641		0·9903					44,270
		·0030422		0·0121	3372	6	3366	
3°	0·9945219		0 9781					40,904

The headings of the columns explain their mode of formation.

It should be noted that columns (1) to (5) serve equally for the calculation of M and E.

In practical work tables for a tabular interval of 10′ are desirable, and are readily calculated, as shown above.

If measurements are made in feet, then the distances can be reduced to chains and the tables used; or the tables can be altered by dividing the N and M factors by 66 and the E factors by 66^2.

THE CALCULATION OF GEODETIC POSITIONS.*

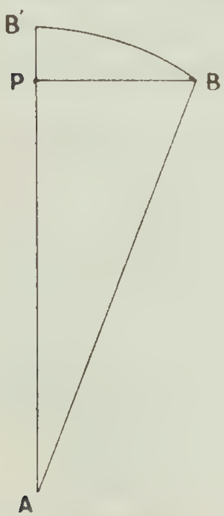


Fig. 1.

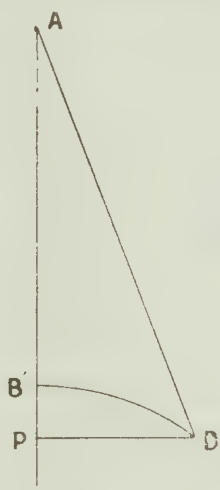


Fig. 2.

In the figures let A be a station in south latitude ϕ; let B be another station distant s chains from A; and let PA be the meridian through A.

* For the formulæ used see Clarke's "Geodesy," where elegant demonstrations are to be found.

From B draw an arc PB perpendicular to AP.

From B describe the latitude circle BB^1, meeting the meridian through A in B^1.

Let α_1 = angle between AB, and the meridian through $A = BAB^1$.

Then we require the differences of latitude, longitude, and azimuth between A and B.

First solve the right-angle spherical triangle APB, using Legendre's theorem.

We have $AP = s \cos(\alpha_1 - \frac{2}{3}\epsilon)$,

$PB = s \sin(\alpha_1 - \frac{1}{3}\epsilon)$,

where ϵ is the spherical excess of the triangle APB.

Now, $\epsilon = s \sin \alpha_1 \,.\, s \cos \alpha_1 \,.\, E$, where E corresponds to the mean of the latitudes of A, P, and B; but E can usually be taken, in practice, for ϕ_1, the latitude of P.

Let ϕ_1 = latitude of P, and ϕ^1 = latitude of B = latitude of B^1.

Obtain an approximate value of ϕ_1 from $\phi_1 - \phi = s \cos \alpha\, M$ (M need only be taken to the nearest degree). With this value of ϕ_1 take out the value of E from the table, and calculate ϵ; thence obtain AP and PB.

Latitude:

Figure 2. $\phi^1 - \phi = (\phi_1 - \phi) - (\phi_1 - \phi^1)$.

Figure 1. $\phi - \phi^1 = (\phi - \phi_1) + (\phi_1 - \phi^1)$.

Now, $\phi_1 - \phi = AP \,.\, M$, M for $\frac{1}{2}(\phi + \phi_1)$.

and $\phi_1 = \phi + (\phi_1 - \phi)$

Also, $\phi_1 - \phi^1 = \eta = PB^2 \,.\, E \,.\, \tan \phi_1$, E for ϕ_1.

and $\phi^1 = \phi_1 - \eta$.

Longitude: ω = difference of longitude.

$$\omega = \frac{PB \,.\, N}{\cos(\phi^1 + \frac{1}{3}\eta)}. \qquad \text{N for } \phi_1.$$

Azimuth: v = difference of azimuth.

$$v = \omega \sin(\phi^1 + \tfrac{2}{3}\eta) - \epsilon \qquad \text{Figure 2.}$$

$$v = \omega \sin(\phi^1 + \tfrac{2}{3}\eta) + \epsilon \qquad \text{Figure 1.}$$

Check calculation:

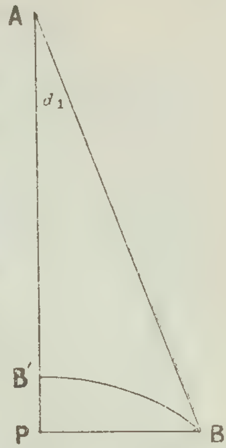
$$\tan \tfrac{1}{2} v = \frac{\sin \frac{1}{2}(\phi^1 + \phi)}{\cos \frac{1}{2}(\phi^1 - \phi)} \,.\, \tan \frac{\omega}{2}.$$

EXAMPLE OF USE OF TABLES.

Given $\phi = 51^\circ\ 57'\ 0''$ south latitude of A,

s = 6613·355 chains = distance AB,

$\alpha = 159^\circ\ 20'\ 42''\cdot760$ = azimuth of B at A,



required the difference of latitude, longitude, and azimuth between A and B.

From B draw BP perpendicular to the meridian through A, meeting it in P.

Then in the right-angled spherical triangle APB we have

$$AP = s\cos(PAB - \tfrac{2}{3}\epsilon) = s\cos(\alpha_1 - \tfrac{2}{3}\epsilon),$$
$$PB = s\sin(PAB - \tfrac{1}{3}\epsilon) = s\sin(\alpha_1 - \tfrac{1}{3}\epsilon),$$

where ϵ is the spherical excess of the triangle PAB.

Approximately, $\epsilon = s^2 \sin \alpha_1 \cos \alpha_1$ E, where E corresponds to ϕ_1.

Let ϕ_1 = lat. of P

ϕ^1 = lat. of B

$\phi_1 - \phi = s \cos \alpha_1$ M approx. M for 52° = 0·6508569.

$\therefore \phi_1 = 53° \; 4' \; 8''$ approx. E for ϕ_1 = 0·000,001,0240.

$\therefore \epsilon = 14''{\cdot}782$

$\alpha_1 = 20° \; 39' \; 17''{\cdot}240$

$\alpha_1 - \frac{1}{3}\epsilon = 20° \; 39' \; 12''{\cdot}313$, sin 0·3527143

$\alpha_1 - \frac{2}{3}\epsilon = 20° \; 39' \; 7''{\cdot}386$, cos 0·9357395

$\therefore$ AP = 6188·378 chains,

and PB = 2332·625 chains.

Latitude :

$\phi^1 - \phi = (\phi_1 - \phi) - (\phi_1 - \phi^1)$

$\phi_1 - \phi$ = AP . M . M for $\frac{1}{2}(\phi_1 + \phi)$ = 0·6507994.

= 4027″·394

= 1° 7′ 7″·394

ϕ = 51° 57′ 0″

$\therefore \phi_1$ = 53° 4′ 7″·394

$\phi_1 - \phi^1 = \eta = PB^2 . E . \tan \phi_1$ E for ϕ_1 = 0·000,001,0240.

= 7″·412 tan ϕ_1 = 1·33036.

$\therefore \phi^1$ = 53° 3′ 59″·982

$\phi^1 + \frac{1}{3}\eta$ = 53° 4′ 2″·453, cos = 0·6008758

$\phi^1 + \frac{2}{3}\eta$ = 53° 4′ 4″·924, sin = 0·7993495

Longitude :

$$\omega = \frac{PB . N}{\cos(\phi^1 + \frac{1}{3}\eta)}$$ N for ϕ_1 = 0·6491313.

= 2519″·955

= 41′ 59″·955.

Azimuth :

$v = \omega \sin(\phi^1 + \frac{2}{3}\eta) - \epsilon$

$\omega \sin(\phi^1 + \frac{2}{3}\eta)$ = 2014″·325

ϵ = 14″·782

v = 1999″·543

$$= \quad 33' \; 19''{\cdot}543$$
$$\alpha = 159^\circ \; 20' \; 42''{\cdot}760$$
$$\therefore \alpha^1 = 338^\circ \; 47' \; 23''{\cdot}217.$$

Check of above results :

$$\tan \tfrac{1}{2} v = \frac{\sin \frac{1}{2} (\phi^1 + \phi)}{\cos \frac{1}{2} (\phi^1 - \phi)} . \tan \frac{\omega}{2}$$

$$\phi^1 = 53^\circ \;\; 3' \; 59''{\cdot}982$$
$$\phi = 51^\circ \; 57' \;\; 0''{\cdot}000$$
$$\tfrac{1}{2} (\phi^1 + \phi) = 52^\circ \; 30' \; 29''{\cdot}991, \sin = 0{\cdot}7934418$$
$$\tfrac{1}{2} (\phi^1 - \phi) = \;\; 0^\circ \; 33' \; 29''{\cdot}991, \cos = 0{\cdot}9999525$$
$$\frac{\omega}{2} = \;\; 0^\circ \; 20' \; 59''{\cdot}978, \tan = 0{\cdot}006108623$$

$$\therefore \tan \tfrac{1}{2} v = 0{\cdot}004847067$$
$$\therefore \tfrac{1}{2} v = 999''{\cdot}7715$$
$$v = 1999''{\cdot}543,$$ which agrees exactly with the former value, and consequently checks the work.

TABLES of GEODETIC FACTORS for computing Differences of Latitude, Longitude, and Azimuth, based on Clarke's 1880 Spheroid.

Unit = the chain = 66 English feet = 100 links.

ϕ	N.	Δ	M.	Δ	E.
0°	0·6505470		0·6550033		0·000,001,0329
		7		21	
1	5463		0·6550012		1,0329
		20		61	
2	5443		0·6549951		1,0329
		34		101	
3	5409		9850		1,0329
		47		143	
4	5362		9707		1,0329
		60		182	
5	0·6505302		0·6549525		0·000,001,0328
		74		223	
6	5228		9302		1,0328
		87		262	
7	5141		9040		1,0327
		100		302	
8	5041		8738		1,0326
		113		341	
9	4928		8397		1,0326
		126		380	
10	0·6504802		0·6518017		0·000,001,0325
		138		418	
11	4664		7599		1,0324
		151		456	
12	4513		7143		1,0323
		163		493	
13	4350		6650		1,0322
		176		529	
14	4174		6121		1,0321
		187		566	

TABLES of GEODETIC FACTORS—*continued.*

φ	N.	Δ	M.	Δ	E.
		–		–	
15°	0·6503987	199	0·6545555	600	0·000,001,0320
16	3788	210	4955	635	1,0319
17	3578	222	4320	669	1,0317
18	3356	232	3651	702	1,0316
19	3124	244	2949	734	1,0314
20	0·6502880	253	0·6542215	765	0·000,001,0313
21	2627	264	1450	795	1,0311
22	2363	273	0·6540655	825	1,0309
23	2090	282	0·6539830	853	1,0308
24	1808	292	8977	880	1,0306
25	0·6501516	300	0·6538097	906	0·000,001,0304
26	1216	309	7191	931	1,0302
27	0907	317	6260	955	1,0300
28	0590	324	5305	977	1,0298
29	0·6500266	331	4328	999	1,0296
30	0·6499935	338	0·6533329	1020	0·000,001,0294
31	9597	345	2309	1038	1,0292
32	9252	350	1271	1057	1,0290
33	8902	356	0·6530214	1072	1,0288
34	8546	361	0·6529142	1088	1,0285
35	0·6498185	366	0·6528054	1102	0·000,001,0283
36	7819	369	6952	1114	1,0281
37	7450	374	5838	1126	1,0278
38	7076	377	4712	1135	1,0276
39	6699	379	3577	1143	1,0274

TABLES of GEODETIC FACTORS—*continued.*

φ	N.	Δ	M.	Δ	E.
		–		–	
40°	0·6496320		0·6522434		0·000,001,0271
		382		1151	
41	5938		1283		1,0269
		384		1156	
42	5554		0·6520127		1,0266
		386		1161	
43	5168		0·6518966		1,0264
		386		1163	
44	4782		7803		1,0261
		387		1164	
45	0·6494395		0·6516639		0·000,001,0259
		387		1165	
46	4008		5474		1,0257
		386		1162	
47	3622		4312		1,0254
		385		1160	
48	3237		3152		1,0252
		385		1156	
49	2852		1996		1,0249
		382		1150	
50	0·6492470		0·6510846		0·000,001,0247
		380		1143	
51	2090		0·6509703		1,0245
		377		1134	
52	1713		8569		1,0242
		374		1125	
53	1339		7444		1,0240
		370		1113	
54	0969		6331		1,0237
		366		1100	
55	0·6490603		0·6505231		0·000,001,0235
		361		1187	
56	0·6490242		4144		1,0233
		356		1071	
57	0·6489886		3073		1,0231
		351		1055	
58	9535		2018		1,0228
		345		1037	
59	9190		0·6500981		1,0226
		339		1018	
60	0·6488851		0·6499963		0·000,001,0224
		332		997	
61	8519		8966		1,0222
		325		976	
62	8194		7990		1,0220
		317		953	
63	7877		7037		1,0218
		309		929	
64	7568		6108		1,0216
		301		904	

TABLES of GEODETIC FACTORS—*continued*.

φ	N.	Δ	M.	Δ	E.
		–		–	
65°	0·6487267		0·6495204		0·000,001,0214
		292		878	
66	6975		4326		1,0212
		284		851	
67	6691		3475		1,0210
		274		822	
68	6417		2653		1,0209
		264		794	
69	6153		1859		1,0207
		254		763	
70	0·6485899		0 6491096		0·000,001,0205
		244		732	
71	5655		0·6490364		1,0204
		233		700	
72	5422		0·6489664		1,0202
		222		667	
73	5200		8997		1,0201
		211		633	
74	4989		8364		1,0200
		200		599	
75	0·6484789		0·6487765		0·000,001,0198
		188		564	
76	4601		7201		1,0197
		175		528	
77	4426		6673		1,0196
		164		491	
78	4262		6182		1,0195
		152		454	
79	4110		5728		1,0194
		138		417	
80	0·6483972		0·6485311		0·000,001,0193
		127		379	
81	3845		4932		1,0193
		113		340	
82	3732		4592		1,0192
		100		301	
83	3632		4291		1,0191
		87		261	
84	3545		4030		1,0191
		74		222	
85	0·6483471		0·6483808		0·000,001,0190
		61		182	
86	3410		3626		1,0190
		47		142	
87	3363		3484		1,0190
		34		101	
88	3329		3383		1,0189
		20		61	
89	3309		3322		1,0189
		7		20	
90	0·6483302		0·6483302		0·000,001,0189

No. 6.—THE WANGANUI ASTRONOMICAL OBSERVATORY.

By J. T. Ward.

No. 7.—ON THE CONSTRUCTION OF PLANISPHERES.

By C. W. Adams, Chief Surveyor and Commissioner of Crown Lands for Marlborough, New Zealand.

[*Abstract.*]

In this paper the author described five planispheres which he designed and constructed to show the altitude, azimuth, and hour angle (as the case may be) of any Nautical Almanac star for a given latitude in any of the following positions: (1) On the prime vertical; (2) on the sixth hour circle; (3) on the horizon; (4) on the almucantar (or small circle parallel to the horizon passing through the elevated pole); and (5) at its greatest elongation. He also exhibited a sixth planisphere, which shows, without any calculation, the altitude and azimuth of the close circumpolar star Sigma Octantis at any time and in any latitude.

Published in full in the "New Zealand Surveyor."]

No. 8.—THE FIGURE OF THE EARTH, AND THE TIDES.

By W. T. Neill.

No. 9.—NOTES ON THE TEACHING OF ELEMENTARY MATHEMATICS, WITH SPECIAL REFERENCE TO GEOMETRY.

By George Hogben, M.A., Inspector-General of Schools, New Zealand.

As you are aware, reform in the teaching of mathematics has been a subject of discussion in Great Britain for many years, and the interest taken in the question has been manifested by the formation more than thirty years ago of the Association for the Improvement of Geometrical Teaching and similar societies, and by the issue of an improved syllabus (1875) and text-book (1884) published by the Association. Its efforts, which were, indeed, chiefly directed to the substitution of a more logical scheme of deductive geometry for that of Euclid, were not very successful.

Greater attention has more recently been directed to the movement by the discussion which took place in 1901 at the Glasgow meeting of the British Association, and was introduced by a paper read by the distinguished engineer Professor Perry, F.R.S., at a joint meeting of two sections—viz., the Section of Mathematics and Physics and the Section of Education.

The recommendations made by the committee then set up have been circulated far and wide, and are being adopted by many teachers and by various examining bodies in various parts of the Empire; the first steps in the direction of reform—very slight ones, it is true—have already been taken in this far-off colony of New Zealand, and I dare say, although I do not know, by other Australasian Colonies also. It seems to me that it was, therefore, a very happy idea on the part of the organizers of these meetings of the Association to arrange for a similar joint meeting for the discussion of the same question.

As one who has been pleading for this reform for many years—somewhat, I fear, after the manner of a pelican in the wilderness—who, as far as the exigencies of examinations would permit, has endeavoured to carry out the new methods in secondary-school teaching, I had much pleasure in consenting to the request of the secretary of Section A that I should open the discussion by reading a paper upon the subject, although I could have wished that the task had been placed in the hands of a better man than myself.

As a preliminary step one might go over the ground covered by Professor Perry's paper and by the speakers that followed him; but that would take too much time, and I shall assume that most of you have read the accounts of the discussion at the British Association, or are, at all events, familiar with the lines on which it proceeded. I shall endeavour at the same time to make myself intelligible to those who have not seen the report.

Professor Perry makes usefulness the ground or reason for teaching mathematics, and to show that he does not take a narrow view of what he means he names eight obvious forms of usefulness in the study of mathematics, which it is not necessary that I should recapitulate here. Setting aside utility in passing examinations, which he says is the only form that has not been neglected, and is, indeed, in itself scarcely a legitimate form of usefulness, we may roughly classify Professor Perry's forms of usefulness under two heads—namely, (1) educational utility—*i.e.*, in brain-development, and in the intellectual power and culture that this branch of science is able to give; (2) practical utility—*i.e.*, in supplying mental tools to engineers and others by giving them dexterity in the manipulation of calculations required by their work, and a knowledge of the principles on which their applied science rests.

This statement might seem to introduce a conflict in aims and perhaps, therefore, in methods of teaching according to the view of utility that is taken. A narrow view of utility might, indeed, appear to make such a conflict inevitable; but, after listening to the eloquent address of Professor David on Wednesday, we shall be all ready to admit that the securing of intellectual power is in the long-run one of the most practical aims that we can keep before us in the teaching of mathematics. Still, in the higher stages a conflict may exist, or, rather, a parting of the ways when the pure mathematician and the engineer begin to pursue different lines of study. Let us ask ourselves the question, "Does this conflict between what is educationally useful and what is immediately practically useful exist in the teaching of elementary mathematics?" Or would you treat alike in the early stages the future mathematician, the future engineer, and the man who takes mathematics merely as a part of an ordinary liberal education?

My reply to that is a distinct affirmative. This answer is already given in the teaching of elementary arithmetic, although that teaching would be vastly improved by considerably extending the use of the concrete in forming the basis for the fundamental ideas, and by making more extensive use of those ideas in their immediate application to easy practical examples. Euclidean geometry is the science (or the philosophy) of the concepts of certain standards to which actual physical facts may be referred, and upon which as definitions (or *quasi*-definitions, for you cannot define a primary concept) and as axioms (assumed as universally true) the whole science by a process of deductive reasoning is founded. It is not a physical science, but a science of abstractions from certain physical facts. Its value, both for educational purposes and for the practical purposes of life—among other things, for the engineer (whom I take as a type of the practical man who must use mathematics as a tool for his work)—will depend upon the soundness of the concepts upon which it is founded, and upon the degree in which its conclusions can be applied to practical use. I therefore assume—

(*a*.) That the teaching of deductive geometry should be preceded by a careful examination of the physical facts upon which its concepts rest—that is, by a course of what is called experimental geometry;

(*b*.) That all teaching of geometry should include some deductive geometry, as the generalisation which is scarcely possible without it widens the intellectual outlook, and gives an immensely increased breadth of power in dealing even with merely practical questions;

(*c*.) That the propositions evolved by the deductive method should be tested in order to ascertain how far they are applicable to the facts of nature; and

(*d*.) That these propositions should then be actually used for the solution of all kinds of practical questions.

It does not follow that the whole of each stage should be completed before the next stage is begun; for instance, it is not necessary that the pupil should finish a complete course of experimental geometry before beginning deductive reasoning; but in each subdivision of the subject experimental work should precede deductive demonstration, and so on.

The double difficulty that has to be faced by the boy (or girl) beginning Euclid—viz., dealing with unfamiliar subject-matter and being introduced to a new method of reasoning—and the lack of interest consequent upon this double difficulty, are largely answerable for failure and delay in reaching the stage at which he is allowed to use his knowledge. It is simply absurd that boys or girls that have been studying geometry for two or three years should leave school without knowing anything about similar triangles, or the area of a circle and its sectors, or the volumes of solids other than rectangular solids, or without having used even the partial knowledge they have gained.

Some of the ordinary fallacies that have marked the orthodox system should disappear as soon as possible; among these is the sharp artificial line that has been drawn between geometry on the one hand and arithmetic and algebra on the other. Arithmetic must enter largely into experimental geometry, for it is a science of magnitudes, and therefore of measurements; and algebra, being merely generalised arithmetic, should be used in the generalised propositions of geometry wherever its use is appropriate or of practical advantage.

The use of squared paper is one very obvious form of the happy conjunction of arithmetic or algebra with geometry; but I am of opinion that Professor Perry, in his engineering zeal, advocates its use, in some instances at least, at too early a stage. I will endeavour to illustrate this point presently with reference to the area of the circle.

Another fallacy which should disappear at once from all examination programmes is the unwarranted assumption that the soundness of a theorem depends upon whether a particular geometrical construction can or cannot be performed by the student; in other words, the assumption that hypothetical constructions must be excluded. For instance, several of the properties of an isosceles triangle can be deduced immediately from its symmetry with regard to the bisector of the vertical angle, and the proof depends for its soundness upon the fact that there must be *a* bisector (which follows from the primary concept of an angle), and not upon the student's power to draw the bisector with geometrical accuracy.

To some extent the order of Euclid's propositions has been determined by this consideration, which has helped to make that order strained and unnatural. A striking example is the postponement of the propositions with regard to the angles formed at a point by the intersection of two straight lines (Euc. i., 13, 14, 15) until the construction of a perpendicular can be made and proved.

It will be generally agreed that Euclid's treatment of parallels, of areas, and, above all, of proportion is unsatisfactory. Alternative proofs are now very generally used in the case of parallels and to some extent for propositions dealing with areas. But there has been much timidity in regard to reform in the treatment of proportion; in standard books one still sees Euclid's definition referred to as the "geometrical definition," on the assumption, I presume, that no other definition can be found that would apply to incommensurables. Now, I would banish the attempt at a complete treatment of incommensurable quantities altogether from elementary textbooks; but, even if we were not prepared to do that, the idea of measures or submultiples is no more foreign to geometry than that of multiples, on which Euclid's definition depends. Cuthbertson's Euclidean geometry contains a definition based on the idea of measures or submultiples which is geometrically as sound as Euclid's, and infinitely more natural. I need only quote it to enforce the point: "The first of four magnitudes is said to have the same ratio to the second which the third has to the fourth when, if the first be divided into any number whatever of equal parts. and the third be divided into the same number of equal parts, the second contains the same integral number of the former parts as the fourth does of the latter."

If the ground were cleared by relegating Euclid's definition of proportion to a mathematical museum, and the treatment of proportion limited in the early stages to commensurable quantities, the propositions relating to the proportion existing between the sides of equiangular triangles and to that existing between their areas might be taken at a much earlier stage; and soon afterwards the definitions of the sine, cosine, and tangent of an angle might be introduced and applied. I refrain from pointing out at length how the propositions of Euclid's Third and Fourth Books might gain in simplicity, especially by a different treatment of the tangent to the circle.

The use of squared paper might easily be made to lead to some of the elementary parts of algebraic geometry, and I would lay down as a principle the statement that the ordinary school teaching of mathematics should include the equations of the straight line and of the circle referred to rectangular co-ordinates, and the tracing of other curves expressed by equations involving easy algebraic functions; and also the simple use of polar co-ordinates.

Every elementary course of geometry should include the measurement of volumes, and a few of the most elementary notions of the properties of solids.

If we admit some amount of deductive reasoning into our course of geometry, the question arises at once as to whether we are to discard Euclid altogether, or only to modify it so far, for instance, as to admit other proofs and hypothetical constructions. If the first alternative is adopted, are we to substitute another rigid order of deductive reasoning for Euclid's, or are we to allow complete freedom? It would appear to follow logically from what has been said that Euclid should be abandoned altogether; but, if so, are we prepared for complete freedom? We should be faced at once, it is said, by the difficulty of examining candidates who have adopted various methods of arrangement of the propositions; for although it is true that every student must choose some definite logical order for the proper study of the subject, yet there is left room for much variety of arrangement. The habits and prejudices in favour of a fixed order are the natural consequence of the study of Euclid, but I do not myself see any real danger in allowing complete freedom in regard to logical order to teachers and students; any proof of a proposition might, as the Cambridge programme states, be accepted which appears to the examiners to form part of a systematic treatment of the subject.

Some have spoken of a preliminary course of geometrical drawing as affording all that is required as an introduction to the abstractions of Euclidean geometry; but, in fact, geometrical drawing may mean much or little. It is only one of several instruments for observing and examining the physical ideas that underlie geometry. Paper-folding, cardboard-cutting and the making of cardboard models, wires, weighing to ascertain volumes, squared paper, and wooden blocks, and other devices may all be means to the end in view.

I will give one or two examples of what appears to me to be the natural method of treating a question of geometry, and will then proceed to suggest a scheme of geometrical teaching to embrace three years at school.

Let us suppose the question to be, to find the area of a circle. The pupils will already have investigated experimentally and otherwise the most obvious properties of the circle, including the ratio of the circumference to the diameter. They will also know how to find the area of a parallelogram and of a triangle.

(*a*.) Their first step will be to find in what direction the solution lies. For that purpose they will inscribe a square in the circle. Its area they will calculate from previous knowledge to be twice that of the square on the radius. The area of the circle is obviously considerably greater than that.

Next, they will describe a regular hexagon in the circle, which they will have done before as an elementary exercise in angles, each side subtending an angle of 60° at the centre, and also again as a preliminary to finding the ratio of the circumference to the radius, showing thereby that the circumference is greater than six times the radius or greater than three times the diameter. The area of the hexagon they can show to be about $\cdot 866 \times 3$ times, or 2·6 times the area of the square on the radius.

Therefore the area of the circle is greater than 2·6 times that of the square on the radius. The error is caused by leaving out the outside segments. To get the area of the circle we must take the sectors instead of the triangles.

Inscribe a dodecagon in the circle. Its area is nearer that of the circle, and is equal to 12 times the area of one of the small triangles, which may be found by measurement and calculation.

But we really want the area of the sectors. Divide the circle into 24 sectors. Cut them out and mount them between two parallel straight lines, the distance of the radius apart.

The sectors form nearly a parallelogram, whose opposite sides $= \frac{1}{2}$ circumference, and whose height = radius.

$\therefore$ area $= \frac{1}{2}$ circumference $\times$ radius (nearly, at all events).
$= \pi$ *(found previously)* $\times$ (radius)^2.

(*b*.) Demonstration: If we take 48 sectors the rule is still more nearly true; and so on.

(*c*.) Tests—

(1.) By cutting out a circle and the square on the radius and weighing: the average for a large class should give a very close result for the ratio of the areas.

(2.) By counting small squares on squared paper.

[I here note that Professor Perry would use squared paper in the first investigation: I would urge that the logical character of the process is impaired by using squared paper at that stage—although in some questions no other method may be available. The first stage should, if possible, be heuristic in method; the use of squared paper comes in appropriately in the "testing" process.]

(*d.*) Next we apply the result to the solution of practical questions in mensuration, and so on.

(*e.*) Then we extend the principle to find the areas of sectors, of rings, of segments, and the volume of a right cylinder, and so of an oblique cylinder, which by piling pennies or cardboard circles or thin wooden circles one over another can be shown to be equivalent in volume to a right cylinder on the same base and of the same height.

(*f.*) Each of these riders or deduced rules in then applied as before.

The steps are more or less similar for other propositions: the truth of Euclid i., 4, is examined into by trial measurements, and then by actual superposition, the formal proof following at once; then we have the application to mensuration, &c.

And, again, Euclid vi., 19, is discovered by trial—*i.e.*, by cutting out paper triangles whose sides are 2, 3, 4.........times those of a given triangle, dividing them thus into 4, 9, 16......... triangles, each equal to the given triangle. The deductive proof follows at once. The proposition is also tested by measuring the sides and calculating the area of the triangles, by counting the number of squares on squared paper, by cutting out and weighing, &c. Then it is applied to practical examples.

I shall now give a very rough sketch of a programme of geometry occupying about three years of school work:—

Space.—Preliminary ideas of space as the room taken up by bodies, or that might be taken up by bodies, illustrated by reference to a cube, a cylinder, a sphere, a glass of water, &c.

Surfaces—as the boundaries of any finite portion of space, of the cube, cylinder, &c. The different forms of surfaces, flat and curved.

Lines—as the boundaries of a surface, or of two portions of a surface.

Points—as the intersections of lines; as marking position, as on a map or plan.

Lines—as measuring the distance between points—*e.g.*, length of a road or of a fence on a plan.

Tests of straightness. How to measure straight lines, unit of length.

Lines—as showing direction.

Angle (or corner)—as showing difference in direction; when angles are equal—test by superposition; bisect angle by folding and cutting out; hence angle as *amount of turning.* Division of straight angle into two right angles, by folding and by drawing perpendicular with set-square. Exercises in drawing perpendiculars to straight lines with set-square. Division of angles at a point into 4 right angles, into 8 equal angles by folding, and by drawing; into 6 equal angles by folding, with set-squares, and with compasses; hence one-third of right angle, one-sixth of right angle, measure these with protractor; division of right angle into 90 degrees. Construct protractor. Examples of angles on the clock, compass, &c. Drawing of angles of given size. Angles formed by two straight lines at point of intersection. Copy rectilineal figures, measuring sides with dividers and rule, and angles with protractor. Draw simple plans to scale.

Parallel straight lines.—Draw perpendicular to fixed straight line, revolve it (using, say, a wire) about a point (not the point of intersection); note variation of angle as point of intersection recedes; note reappearance of point of intersection on opposite side of foot of perpendicular. One position, when lines do not meet—*i.e.*, *directions are the same*, or lines are *parallel*.

Playfair's axiom.—Angles made by a transversal with parallels. Test by drawing and measurement. Drawing of parallel lines with set-squares and with compasses, also with protractor; &c.

Proofs of fundamental propositions on parallels. Sum of interior angles of a triangle—by cutting off corners and fitting together at a point; by measurement with protractor and addition; by folding the three corners inward to foot of perpendicular from largest angle upon opposite sides. Sum of exterior angles of any convex rectilineal figure, by measurement, by drawing lines at a point parallel to sides.

[*Circle.*—Centre and radius.]

Equilateral triangle.—Size of each angle by measurement; argued from sum of 3 interior angles. Cut out equilateral triangle from cardboard; turn it round, and fit it into opening left in cardboard; follow same by reasoning; reverse it; &c.

Isosceles triangle.—Cut out, invert, and replace so as to prove equality of base-angles, accompanying each step by reasoning.

Congruency of two triangles having two sides and included angles equal, (i.) similarly situated, (ii.) one inverted. In each case (*a*) measure bases and base-angles, (*b*) test and prove by superposition, (*c*) apply to examples in class-room and playground. Prove equality of base-angles of isosceles triangle by folding—*i.e.*, by symmetry—and as case of congruency of two triangles formed by bisector of vertical angle.

With compasses and rule draw five sides of regular hexagon inscribed in circle, complete the five equilateral triangles: what is size of remaining angle at centre? Draw remaining side of hexagon, show the last triangle has 3 equal angles. Measure side.

Other cases of *congruent triangles.* Practical examples. Symmetrical figures generally. Rhombus; construction for bisection of angle and of straight line, drawing perpendiculars from internal or external points—all derived from symmetry of rhombus.

Chief properties of *parallelogram.*

Area of square, rectangle, parallelogram, triangle, trapezium —by drawing and cutting out paper, &c. Test by weighing and by squared paper. Practical examples thereon from pupils' own measurements.

Euclid vi., 1—by drawing and calculation (commensurables only), and by squared paper; test by weighing.

Similarity of equiangular triangles—by drawing and measurement. *Ratio of their areas*—by cutting out; test by squared paper and by weighing; by calculation.

Drawing to scale of areas actually measured.

Drawing plans on squared paper.

Elementary surveying: drawing of plans with base-line and observed angles. Measurement of other lines and distances from the plan. Measurement of height of school from the shadow; altitude of sun. Definition of tangent of an angle.

Angle of elevation of top of tree or school-wall from point at measured distance from its foot; calculation of its height, using tangent of angle; test by drawing to scale.

Sine and cosine of an angle. Easy examples. Heights and distances.

Measurement of *ratio of circumference of circle to diameter,* using cylinder, penny, &c. Diameter of a sphere. Section of sphere.

Area of circle (method already explained).

Expression of area by algebraical formulæ; calculation of area thereby, or of other elements, area, &c., being given. Geometrical meaning of $a(b+c+d) = ab + ac + ad$; $(a+b)^2 = a^2 + b^2 + 2ab$; $(a-b)^2 = a^2 + b^2 - 2ab$; $a^2 - b^2 = (a+b)(a-b)$, &c., figures being drawn in each case.

Wrap paper round cylinder. Unroll and find area.

Proposition of Pythagoras.—Draw right-angled triangle, measure sides and hypotenuse; calculate squares, and hence infer proposition. Test also by squared paper. Prove by cutting out. Must the pieces fit? Which sides, angles, and figures are equal? Hence prove the proposition. Numerous examples, indoors and outside; *e.g.*, form a right angle on the ground with the chain.

Euclid ii., 12 and 13.—By using i., 47, and arithmetic, with practical examples with angles 150° or 30°, 135° or 45°, 120° or 60°, and other angles drawn with protractor. Formal proof.

Elementary properties of circles, their chords and tangents.—Ratio of arcs, angles, and sectors. Area of sector. Wrap paper round cone. Unroll and find area of surface. Geometrical drawing: Figures inscribed in and described about circle.

Development of prisms and pyramids. Making of nets and carton or cardboard models therefrom.

Measurement of cubes and other rectangular solids; building up with cubes, blocks, and slabs. [Carton or cardboard and wire models may be used with advantage for nearly all the solid figures bounded by planes.] Calculate volumes; test by weighing wooden or metal blocks; by weighing sand or small shot or water in hollow models, or by water displaced by immersion of models ("capacity tests").

Volume of prism.

Volume of pyramid.—Cardboard models of 3 pyramids fitting together to form triangular prism. Test by weighing, and by capacity tests.

Volume of cylinder.

Volume of cone, deduced from that of pyramid; test, &c.

Volume of sphere, deduced from volume of cone and cylinder; test, &c.

Formulæ of volumes; practical examples in use of formulæ; hence deduce the *surface of sphere* from volume of sphere considered as made up of pyramids whose common vertex is the centre.

Rectangular co-ordinates in a plane; finding points with given co-ordinates. [Use of squared paper for diagrams of temperature, barometric pressure, population, trade-returns, heights and ages, &c.] *Graphic solution of simultaneous linear equations. Equation to a straight line. Tracing easy curves.* Easy interpolations. Slope of curve (*i.e.*, $\frac{dy}{dx}$). Distance between points with given co-ordinates. *Equation of circle.* Finding areas between ordinates by counting squares, &c. Graphic solutions of simultaneous quadratic equations. Determination of a point in a plane by its *polar co-ordinates;* also $x = r \cos \theta$, $y = r \sin \theta$.

Lines and planes normal to a given plane; angles made by lines and planes with a given plane. *Projection of point, line, and rectilineal figure on a plane.* Sum of face-angles of a polyhedral angle. Euler's formula ($A + F = E + 2$). Plans and elevations of solids in simple positions. Areas of projections. Ellipse as an oblique section of cylinder. Area of ellipse;

describe ellipse with thread and pins, and test area by squared paper; also by weighing. Compare figure with the figure traced from the equation $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$.

Projection of a point in three planes at right angles. Determination of a point by reference to three rectangular axes, and to its polar co-ordinates (illustrated by wires, cardboard models, &c.).—Explanation of longitude and latitude as angles and as arcs; other practical examples.

I have not set out above all the geometrical drawing which might be done, or the various kinds of practical examples to which the propositions may be applied. The course gains immensely if it is accompanied by a course of physical measurements wherein such ideas as specific gravity or relative density, centre of inertia (or centre of gravity), are dealt with. Graphic methods may also be employed to solve easy problems of velocities and accelerations, averages, maxima and minima, and so on. Further, I have not indicated in every case the stage at which I would introduce the formal deductive proof of a proposition. Generally, the teacher will be his own best guide in this matter. As to what propositions should be included in the scheme of deductive proof, I do not think we could adopt any better programme than that set forth by the University of Cambridge for the Previous Examination, with an extension to the elementary parts of solid geometry.

Speaking generally, we may say that deductive proofs of propositions may be introduced in the first time of going over if they are closely related to the practical proof used, but only with caution. In actual teaching I was accustomed to introduce them somewhat in the following manner: "We have seen that in the isosceles triangle we have taken the base-angles are equal. Is the triangle we have cut on an exact isosceles triangle? Would the proposition still be true if the triangle were an exact isosceles triangle such as we can imagine, although we cannot make it? Let us go over it again to see if it would be true." And so on.

Revision will be necessary from time to time, and a complete logical scheme of deductive proof may be conveniently introduced when any section of the work is being revised.

The scheme I have sketched out so far is, in its main features, one that I have used for some years. It takes, with the necessary revision, which includes the subject-matter of Euclid, Books I. to IV. and parts of Books VI. and XI., about two hours a week for three school-years—that is, for the average boy or girl attending a secondary school.

In regard to algebra and trigonometry, mere manipulation should be subordinated to practical ends, both on educational and practical grounds. Elaborate factors and transformations should not appear in the elementary stages. Decimal fractions (but not recurring decimals) should be used for all measurements. Ratios should be stated as vulgar fractions. Riders should be practical in character—that is, capable of being at once applied to practical examples.

I shall conclude by suggesting the following as the general principles upon which it is possible to base an immediate reform of elementary geometrical teaching :—

I. A physical basis for geometrical teaching, as a preliminary to deductive geometry — *i.e.*, a course of practical geometry.

II. The acceptance of any well-defined logical order of theorems and problems respectively, but independently—that is, the acceptance of any proof that is part of a general scheme, and permission to use hypothetical constructions in the proofs of the theorems, and to use any theorems in the solutions of problems.

III. The free use of arithmetic and algebra in their connection with elementary geometry.

IV. The application, at every stage, of the propositions of geometry to practical numerical examples, and to practical geometry generally.

No. 10.—THE PATH OF EARTHQUAKE WAVES.

By George Hogben, M.A.

[*Abstract.*]

The writer has examined the records of several earthquakes as given by Milne seismographs at different stations situated all over the world, with the object of determining the question whether the waves are propagated along chords or arcs of the earth. In this paper he gives the results of a fairly complete examination of the records of two earthquakes—viz., the Cheviot (New Zealand) earthquake of November, 1901, and the great Guatemala earthquake of the 19th April, 1902. The evidence of the former is more or less inconclusive; but in the case of the latter the evidence is, in the writer's opinion, almost wholly in favour of the theory that the first waves (commonly called "preliminary tremors") did not travel along chords, as some have maintained, but along arcs at no very great depth, the most probable speed being $17 \cdot 52 \pm 0 \cdot 51$ kilometres per second. The need for great caution is, however, emphasized by the writer, who considers it very desirable to make very careful comparison of the photograms of the same earthquakes at different stations in order to be sure that the same phases of any given disturbance are being compared. He believes that as yet we do not understand the character of the records well enough to be able to draw with any certainty definite conclusions from our interpretation of them.

No. 11.—NOTES ON THE EARTHQUAKES AT GLENELG, SOUTH AUSTRALIA, ON THE 19th SEPTEMBER, 1902.

By H. Tarlton Phillips.

[*Abstract.*]

The severe shock was at 8.5, and was felt in all the southern part of South Australia, including Adelaide. The writer has collected a large number of facts, based largely upon his own observation, as to the effects of the earthquake in the disturbance of movable objects, the fall of chimneys, cracking of walls, &c., and, reasoning therefrom as to the direction and character of the vibrations, comes to the conclusion that the origin was probably situated beneath the bed of the St. Vincent Gulf at no great depth below the surface.

No. 12.—A COMPARISON OF THE MAGNETIC DECLINATION AT SYDNEY AND MELBOURNE.

By Professor J. A. Pollock, M.A.

No. 13.—A COMPARISON OF THE PERIODS OF THE ELECTRICAL VIBRATION CONNECTED WITH SIMPLE CIRCUITS.

By Professor J. A. Pollock, M.A.

The substance of this paper may be found in a paper by the author Proc. Roy. Soc. of N.S.W., vol. xxxvii.

No. 14.—THE UNIVERSAL DATUM OF MEASURE.

By Thomas Ranken.

No. 15.—ON THE CONSTRUCTION OF SCALES.

By C. W. Adams, Chief Surveyor and Commissioner of Crown Lands for Marlborough, New Zealand.

[*Abstract.*]

The author exhibited eleven scales of thin cardboard, 10 in. long and 1½ in. wide, designed and constructed by himself to show at a glance, without any calculation, the solution of eleven simple astronomical problems. For a given latitude, and for any suitable Nautical Almanac star visible in that latitude, the scales show (1) the altitude and (2) the hour angle on the prime vertical; (3) the altitude and (4) the azimuth on the sixth hour circle; (5) the hour angle and (6) the amplitude on the horizon; (7) the hour angle and (8) the azimuth on the almucantar passing through the elevated pole; (9) the altitude, (10) the hour angle, and (11) the azimuth of a circumpolar star at its greatest elongation.

[*Published in full in the "New Zealand Surveyor."*]

No. 16.—THE MEASUREMENT OF LARGE MOLECULAR MASSES.

By William Sutherland.

The determination of the large molecular masses of such substances as the physiologist is occupied with, presents almost insuperable difficulties when attempted by the usual methods of the chemist. The vapour-density is unobtainable, and the molecular lowering of the freezing-point of a solvent produced by massive molecules is so small as to be merged in the experimental error of the freezing-point of the solvent in its purest obtainable state. The method to be proposed and discussed in this paper is founded on the measurement of the coefficient of diffusion of the substance through a solvent. The only difficulty about measuring the velocity of diffusion of a substance of large molecular mass is that the experiment for measuring it has to be prolonged for a time inversely proportional to the velocity in question. Graham, the pioneer in the investigation of diffusion, made measurements of the velocity of diffusion of albumen in water. If, then, we can establish a dynamical relation between the velocity of diffusion of a substance and the size of its molecule, it will be possible to measure the molecular mass of substances like albumen and its products of more or less complete disintegration.

It is true that a very simple relation has been discussed in connection with velocities of diffusion—namely, that the square of the velocity of diffusion of a substance through a given medium when multiplied by the molecular mass of the substance is a constant—that is, the kinetic energy of diffusion is constant for all molecules under like conditions. H. Euler (Wied. Ann., 1897, vol. lxiii.) proposed this law from an empirical study of known velocities of diffusion for non-electrolytes, Nernst having already supplied his beautifully simple theory for the diffusion of electrolytes. Obviously, the relation discussed by Euler is an attempt to treat diffusion through a liquid as a parallel phenomenon to the transpiration of gases through porous partitions, for which Graham had discovered his law that mv^2 is a constant. Indeed, in 1893 S. U. Pickering pointed out that by regarding osmostic pressure as the equivalent of gas-pressure one might be led to conclude that $m\mathrm{D}^2$ would be constant for different substances of molecular mass m and velocity of diffusion D. He tested this relation by experiments on a number of substances (Phil. Mag., 1893, vol. xxxv.), and pronounced against its truth. But quite recently (Comptes Rendus, Paris, 1902, vol. cxxxv.) J. Thovert, who has developed a delicate and expeditious optical method of measuring velocities of diffusion and has applied it to a number of substances diffusing through water, has found that for nineteen substances, ranging from methyl-alcohol, with a molecular mass 32, to raffinose, with one of 500, the product mD^2 shows a remarkable approach to constancy, ranging from 55×10^{-10} to 68×10^{-10}. But no dynamical proof that such a relation is to be expected has yet been furnished. The relation has been used by Nernst to calculate the molecular mass of albumen from Graham's data (see Arrhenius's "Text-book of Electro-chemistry"). But it is very desirable for such a purpose to have a dynamical rather than an empirical formula. Accordingly, I propose to apply to Nernst's theory of diffusion certain considerations advanced in "Ionization, Ionic Velocities, and Atomic Sizes" (Phil. Mag., Feb., 1902), in order to show what is the nature of the connection between velocity of diffusion and molecular size.

In Nernst's theory of the diffusion of an electrolyte the solution is assumed to be so dilute that the solute is entirely dissociated into ions along the whole path of the diffusion. The more rapid ion diffuses faster than the other, and so a separation of electric charges takes place, and causes an electro-motive force in the direction of diffusion. This electro-motive force increases until it causes the opposite ions to diffuse with equal velocities. Then there is a stationary state. The atomic charges of electricity are so powerful that this electro-motive force is produced by a difference of concentration in the two ions, which may be neglected so far as any other effects are concerned. Thus, if c is the concentration at a distance x along the diffusion-stream where the osmotic pressure is p, the ions of each sort in a cubic centimetre are subject to a driving force dp/dx on account of osmotic pressure. If E is the electro-motive force, then the cations in unit volume are subject to a driving force proportional to cE, while the anions experience an equal retarding force, denoted by bcE. If, then, U and V are the velocities which unit force can maintain in the two sorts of ion against the friction of the solvent, we have the following equations for the amount A of each ion crossing unit surface in unit time

$$A = U\left(\frac{dp}{dx} + bcE\right) = V\left(\frac{dp}{dx} - bcE\right) \quad \ldots \quad (1)$$

the two amounts being equal because the state is steady. Eliminating bcE, we get

$$A = \frac{2UV}{U + V}\frac{dp}{dx} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

But according to the theory of osmotic pressure $p = c$RT, and so by definition of the coefficient of diffusion D of the solute we have

$$D = \frac{2UV}{U + V}RT \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

This formula has been remarkably well verified, both as to the relative and absolute coefficients of diffusion for electrolytes. The velocities U and V are derived direct from the ionic velocities of the two ions. But in my paper on "Ionization, &c.," it has been shown that the dielectric capacity of the atoms of the ions is fundamental in determining the electric forces acting on the ions. Yet dielectric capacity of the atoms is entirely ignored in Nernst's successful theory. It seems to me that from the electrical point of view Nernst is not justified in assuming uniform electro-motive force E, but that his assumption works out all right dynamically because the one kind of ion is thrusting the other back, while the other is thrusting the one forward by means of electric force. By writing the forces proportional to + E and − E Nernst introduces Newton's third law, which is all he really requires; and, as he eliminates the action and the reaction from his final result, the incompleteness in his electrical specification of the forces at play does not affect it. The point is of importance, because it is necessary to explain how dielectric capacity is of fundamental importance in ionic velocities and of none in diffusion velocities.

We can now proceed to determine the connection between diffusion velocities and molecular radius exactly as in "Ionization, &c.," for ionic velocities and ionic radius. Let a molecule of solute of radius a move with velocity V through the solution of viscosity η, then the resistance experienced by the molecule is given by Stoke's formula—

$$F = 6\pi V\eta a \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (4)$$

If there are N molecules of solute in a cubic centimetre their total resistance will be N times this, and in the steady state of diffusion will be equal to the driving force of osmotic pressure $dp/dx = \mathrm{RT}\, dc/dx$, thus

$$\mathrm{RT}\frac{dc}{dx} = 6\pi V\eta\, a\, N \qquad \ldots \qquad \ldots \qquad \ldots \qquad (5)$$

By definition of coefficient of diffusion we have

$$D = \frac{\mathrm{RT}}{6\pi\eta a} \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (6)$$

Thus we find that, for solutions dilute enough to give osmotic pressure, according to the laws of gaseous pressure we have the coefficient of diffusion of a substance through a given medium inversely proportional to the molecular radius, and also inversely proportional to the viscosity of the medium.

In regard to this connection between coefficient of diffusion and viscosity there is a difficulty to be removed similar to one which appears in connection with ionic velocities. It is this: that substances diffuse almost as quickly through jellies prepared with water as through water itself. Now, the molar viscosity of jellies is enormously greater than that of water. The inference, therefore, is that in a jelly the water is enclosed in meshes which interfere but little with the motion of single molecules. To the molecule the jelly is practically nothing but water, which is unconfined so far as its effect on the molecule is concerned. The first test of the formula (6) is, then, to see how the coefficients of diffusion of a given substance through different liquids are related to the viscosities of the liquids. According to (6) $D\eta$ should be constant. H. Euler has given the following data for the diffusion of Br and I through water and benzine at 12° and through CS_2 at 16° C. The viscosities of these liquids are given from Thorpe and Rodger (Phil. Trans., 1894) :—

Bromine.

	H_2O	C_6H_6	CS_2
η	·01234	·00732	·00378
D	·8	1·75	3·11
$D\eta$	·0099	·0128	·0118

Iodine.

	H_2O	C_6H_6	CS_2
D	..	1·41	2·55
$D\eta$	..	·0103	·0096

These data show that on the whole the coefficient of diffusion varies inversely as the viscosity. For a small range of temperature Thovert (Ann. de Ch. et de Ph. [7], 26, 1902) finds that for 1° rise of temperature the coefficient of diffusion of salts in water increases by ·0265 of the value at 0°. Now, for the viscosity of water Thorpe and Rodger give the formula

$$\eta = \frac{5{\cdot}9849}{(43{\cdot}252 + t)^{1{\cdot}5423}},$$

whence by (6) the coefficient of diffusion would change by ·0227 of its value at 0° C. for a rise of 1° near 15° C. Thus the connection between diffusion and viscosity given by (6) is verified within the limits of experimental error in these measurements. We proceed, therefore, to our main business—namely, the relation between coefficient of diffusion and molecular radius.

The following table contains the coefficients of diffusion for various gases through water determined by Hüfner (Wied. Ann., 1897, vol. lx.; and Zeit. F. Ph. Ch., 27). I have reduced these all to a temperature of 16° C., and expressed them with the second as unit of time instead of the day. The values of B, the volume of the gramme-molecule of the gases, are taken mostly from "Further Studies on Molecular Force" (Phil. Mag. [6], 39). In the last row are given the values of $10^6DB^{\frac{1}{3}}$, which by (6) ought to be constant. H. Euler's values for the diffusion coefficients of Cl_2 and Br_2 are added.

	CO_2	NH_3	O_2	N_2	N_2O	Cl_2	H_2	Cl_2	Br_2
10^7D ..	166	132	167	178	156	127	474	154	101
B ..	30	21	19·3	22·7	29	38	8·6	38	52
$10^6DB^{\frac{1}{3}}$ ..	51	36	44	50	48	43	97	52	38

Hydrogen is conspicuous as an exception to the constancy of $DB^{\frac{1}{3}}$. If CO_2 in water is taken to exist chiefly as H_2CO_3, and NH_3 as NH_4OH, the values of B would be increased to 44 and 35, and those of $10^6DB^{\frac{1}{3}}$ to 59 and 43. As regards H_2, it should be remembered that the ion H has a much larger velocity than should go with its size.

For ordinary electrolytes in water we will take the diffusion data of Thovert (Comptes Rendus, 135) :—

Alcohols.

	Methyl.	Ethyl.	Allyl.	Propyl.	Butyl.	Amyl.
10^7D ..	137	111	99	98	88	88
B ..	26	42·5	52	59	75·5	92
$10^6DB^{\frac{1}{3}}$ ..	41	39	37	38	37	40

Other Substances.

	Urea.	Urethane.	Glycerol.	Phenol.	Hydroquin.	Resorcin.
10^7D ..	98	87	79	80	73	75
B ..	51	75	72	80	85	85
$10^6DB^{\frac{1}{3}}$ ..	36	37	33	34	32	33

	Pyrogall.	Glucose.	Mannite.	Antipyrin.	Maltose.	Raffinose.
10^7D ..	66	57	55	57	41	35·5
B ..	90	134	141	166	254	374
$10^6DB^{\frac{1}{3}}$ ..	30	29	29	31	26	26

It will be noticed that the values of the product $10^6DB^{\frac{1}{3}}$ diminish progressively with increasing size of molecule. The coefficient of diffusion appears to vary inversely as a rather higher power of B than the cube root. In fact, for some reason yet to be investigated the diffusion data as a whole could be better represented if the diffusion coefficient were taken to vary inversely as the square root of the molecular volume, rather than as the theoretical cube root. Since for these compounds as a whole the square root of the molecular volume varies approximately as the square root of the molecular mass, we see how the square of the diffusion velocity multiplied by the molecular mass may come to be nearly constant within the above range of molecular masses, without there being any genuine dynamical foundation in the idea that the kinetic energy of diffusion of all substances ought to be the same. If by means of further inquiry the theoretical relation between D and B can be brought into closer harmony with the experimental, the measurement of large molecular masses will be made possible with the aid of diffusion experiments.

No. 17.—THE DIELECTRIC CAPACITY OF ATOMS.

By William Sutherland.

The electron theory imparts more interest than ever to the investigation of the properties of atoms. At the present stage of this theory the electrical properties of atoms demand investigation from every possible point of attack. The dielectric capacity of the atom being the most fundamental of such properties, it seemed to me desirable to investigate it by means of certain principles developed in a paper on "Ionization, Ionic Velocities, and Atomic Sizes" (Phil. Mag. [6], iii., Feb., 1902). In that paper it was shown that at infinite dilution the ionic velocity ${}_1\lambda_0$ of an element 1 whose atom has a radius a_1 and a dielectric capacity K_1 dissolved in a solvent whose viscosity is η and dielectric capacity K_0 is given by the equation

$${}_1\lambda_0 = ve^2K_0/6\pi\eta a_1K_1 \quad \ldots \quad \ldots \quad \ldots \quad (16)$$

where v is the valency of the ion and e is the electric charge of a monovalent ion. In seeking to verify this relation by means of published experimental data, in the absence of measured values of K_1, the dielectric capacity of the stuff of an atom, I used Maxwell's relation $K_1 = N_1^2$, where N_1 is the refractive index of the stuff of the atom. For ten metallic ions —namely, those of the Li family, those of the Be family from Mg to Ba, and for Zn, and for the six negative fatty-acid radicals from formic to caproic—the equation (16) was found to be verified in a broad way. But in the case of the halogens from F to I the relation seemed to break down completely, as also in the case of the ions H and OH. By means of further data I have found that Cd ranges itself with the metals mentioned, while Ag and Pb rank as further exceptions. In the case of the halogens it was suggested that, as their atoms are heptad as well as monad, we must imagine each halogen-atom to have associated with it four negative electrons and three positive ones. Three of the negative electrons unite with the three positive ones when the halogen-atom acts as a monad, and so form inside the halogen-atom three electric doublets. With a notation which I have proposed this idea would be expressed by writing the following as the formula for the Cl ion ϸ Cl (ϸ)$_3$. In this way we can briefly record the fact that Cl is a monad with heptad capabilities. Now, if the three electric doublets ϸ inside the halogen-ion are not nimble enough to take part in the propagation of light through the halogen-ion, we shall not be justified in using Maxwell's relation for finding the dielectric capacity from the refractive index. Just as water and a number of similar substances have two limiting dielectric capacities—namely, 80 and 2 in the case of water—with every intermediate value for electric alternations of suitable frequencies, so it seems to me that the halogen-atoms have a dielectric capacity K_1, which is different from N_1^2, for the conditions under which their ionic velocities are measured. Accordingly I propose to use equation (16) for finding the dielectric capacities of the halogen-atoms and of atoms in general. By means of the data given on page 175 of the Phil. Mag. paper, and the assumption that $K_1 = N_1^2$ on the average for the regular ions, the equation becomes one for K_1 in the following form—

$$K_1 = 280v/{}_1\lambda_0 B^{\frac{1}{3}} \quad \ldots \quad \ldots \quad \ldots \quad (17)$$

where B is the volume of a gramme-atom of the ion. The following table contains the values of the ionic velocities given by Kohlrausch except for Cd and Pb, the values of B taken from "Further Studies on Molecular Force" (Phil. Mag. [5], xxxix.), and also the values of K_1 calculated by (17), using for v the value 1 for the monad-atoms and 2 for the dyads. In the last row of the table are given the values of $10K_1B^{\frac{1}{2}}/v$, to be discussed immediately.

	Li	Na	K	Rb	Cs	Mg	Ca	Sr	Ba
${}_1\lambda_0$ ..	35·5	44·4	65·3	67·3	67·8	48	53	54	57·3
B ..	2	7·4	18·6	34·4	56	5·6	8·6	10·6	16·6
K_1 ..	6·27	3·24	1·62	1·28	1·08	6·58	5·16	4·72	3·83
$10K_1B^{\frac{1}{2}}/v$	89	88	70	75	81	78	76	77	78

	Zn	Cd	Ag	Pb	F	Cl	Br	I
${}_1\lambda_0$	47·5	52·5	55·7	57	46·1	65·9	67·5	66·7
B	10·6	12·5	6·8	9·8	9	19	26	36
K_1	5·36	4·60	2·66	4·59	2·92	1·59	1·40	1·27
$10K_1B^{\frac{1}{2}}/v$ ..	87	82	70	72	88	70	71	76

In the case of the halogens it is interesting to compare the values of the dielectric capacity thus derived with the values of N_1^2, thus—

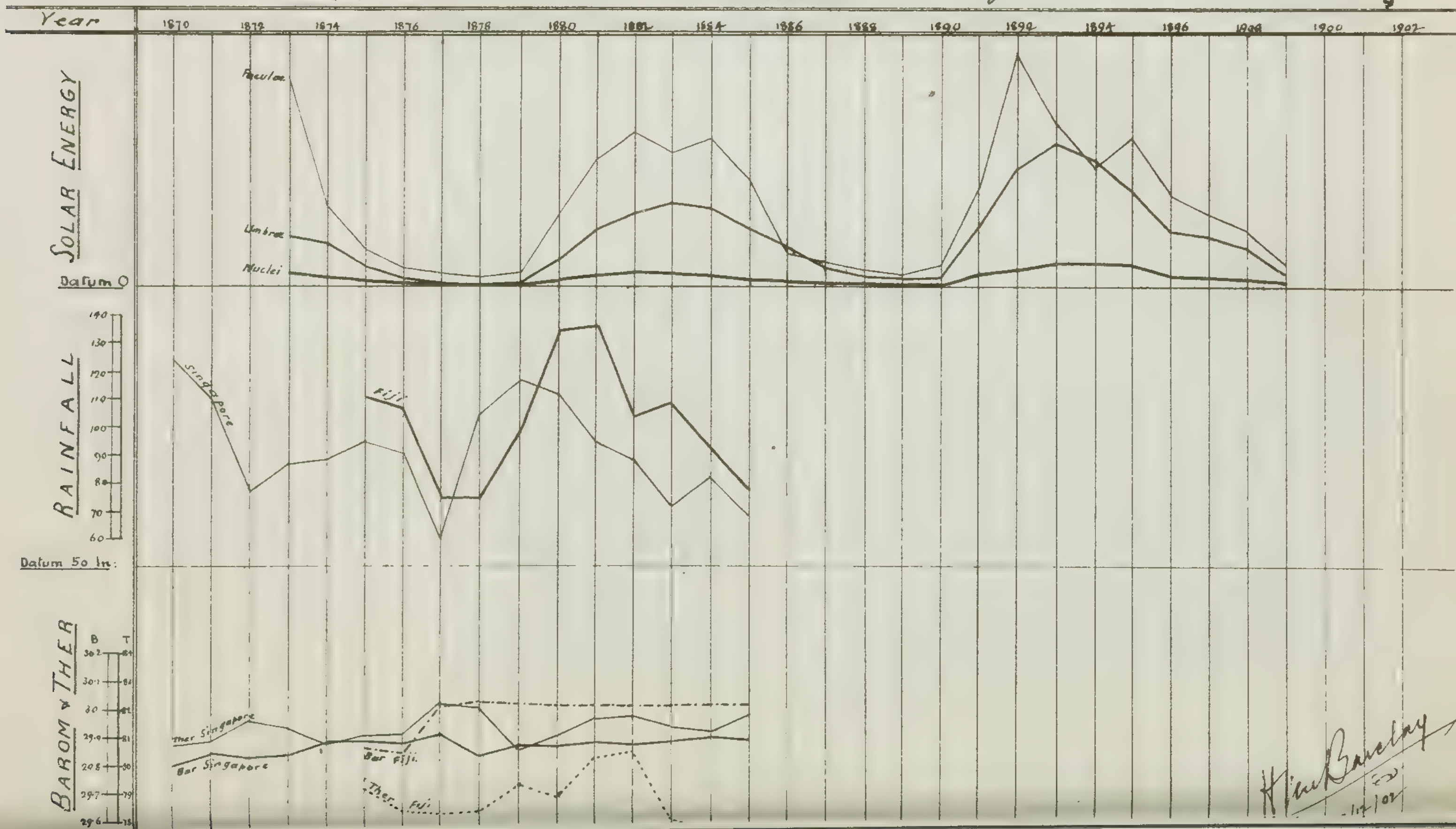
	F	Cl	Br	I
N_1^2	1·34	2·43	2·72	3·10
K_1	2·92	1·59	1·40	1·27

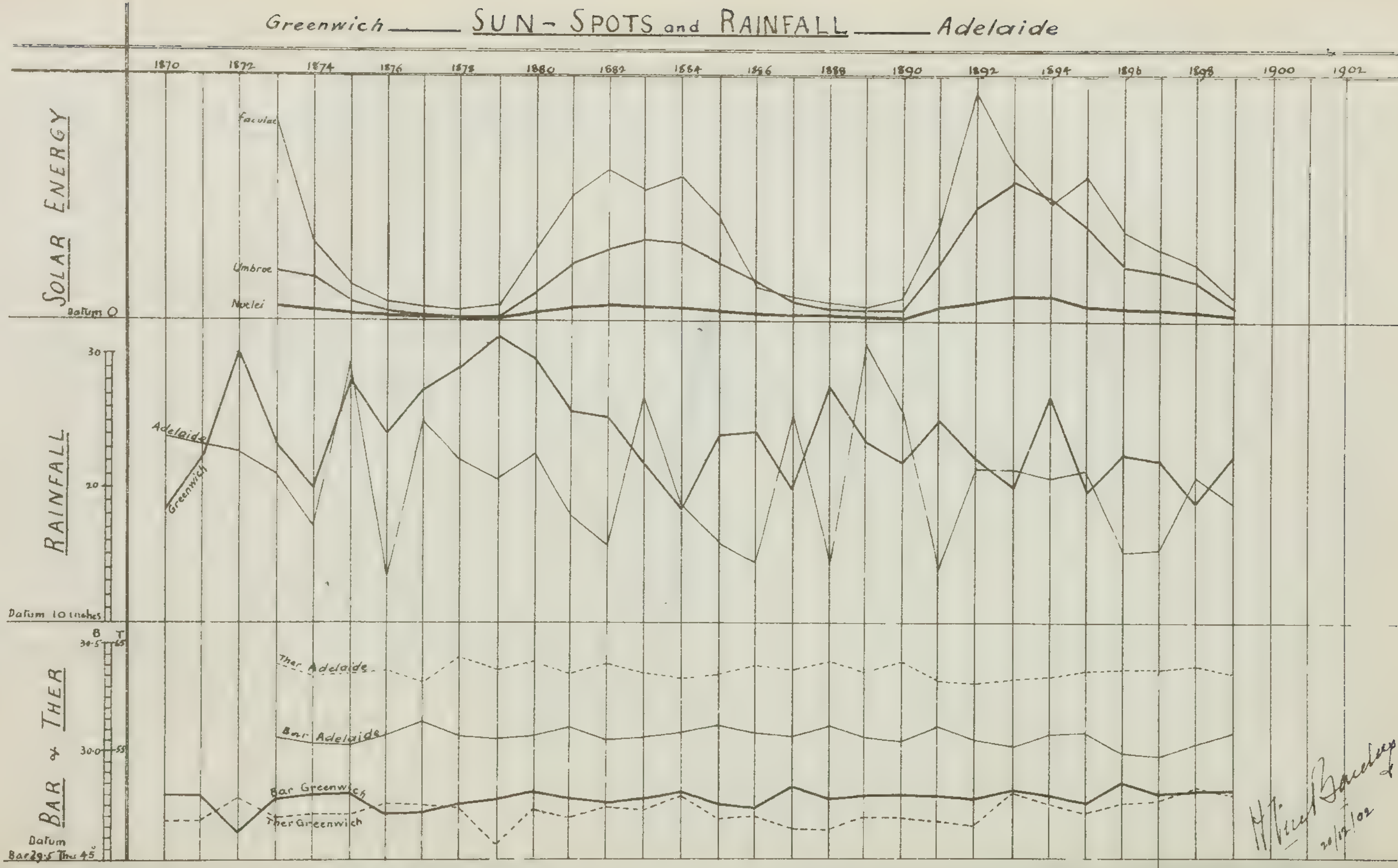
A study of these values shows that in the halogen-atoms K^1, instead of being equal to N_1^2, varies inversely as N_1^2. Returning to the main table, we find that $K_1B^{\frac{1}{2}}/v$ is constant without a single marked exception, although the halogens have just been shown to be so exceptional in regard to Maxwell's law.

We have therefore this result: that the dielectric capacity of an atom is directly proportional to the valency and inversely proportional to the square root of the volume of the atom. It is interesting to find that valency, which Faraday proved to be of fundamental importance in his electrolytic law, is of similar importance in connection with dielectric capacity, that predominating electric property of matter which Faraday discovered. As to the physical signification of our law for K_1, it seems that it may be sought by the following short train of speculation. I have shown that cohesion can be traced to the mutual attractions of the electric doublets in molecules acting like minute magnets. Thus cohesion is an electrical phenomenon. By following out a similar train of reasoning it can be shown that rigidity in solids is a mechanical result of the electric doublets in the molecules. At absolute zero the rigidity is equal to the electric energy of these doublets per unit volume. But to express this electric energy we must regard it as proportional to the square of an electric quantity associated with the molecule. Thus rigidity is proportional to the square of an electric quantity. Now, our law for the dielectric capacity of an atom means that the square of K_1/v for an atom, when multiplied by the volume of the atom, is the same for all. It seems, then, as though a certain stock of electric energy associated with the electrons in an atom were the same for all atoms. The law for K_1, then, seems to be of a similar nature to that of Dulong and Petit and the fundamental law of molecular physics, which makes the kinetic energy of translation of all molecules at a given temperature the same.

But to return from speculation to the immediate bearings of the formula $K_1B^{\frac{1}{2}}v =$ constant, we find that in (16) it makes the ionic velocity of an atom directly proportional to the sixth root of the volume of the atom—that is to say, to the square root of its radius. This brings out neatly the old paradox about ionic velocities. Hitherto it has been assumed that the ionic velocities have all been measured with the same driving force for all ions. The result that a large ion like that of K travels faster than a small one like that of Li under the same driving force in a resisting medium is indeed puzzling until, in taking account of the dielectric capacity of the atom, we see that the driving forces assumed equal are in reality not so at all.

Singapore — SUN-SPOTS and RAINFALL — Fiji




Greenwich — SUN-SPOTS and RAINFALL — Adelaide
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No. 18.—SUN-SPOTS AND RAINFALL.

By Captain H. V. Barclay, F.R.G.S., Adelaide.

The recent announcement of the discovery of a relationship between sun-spot periods and those of drought and rainfall in India by Sir Norman Lockyer induced me to examine the available records with a view of ascertaining whether such a connection could be traced in other parts of the world.

For this purpose I took the annual total areas of faculæ, umbræ, and nuclei measured at Greenwich from photographs obtained in India, Mauritius, and Greenwich as the index of solar activity, and made a large-scale diagram with the vertical ordinates proportional to these areas, using the same scale throughout. The resulting curves accord well together, giving a graphic representation of the wave-like periods of solar activity.

Taking the mean annual rainfall and barometer and thermometer at Greenwich and Adelaide, I plotted them on the diagram, but the result does not disclose the slightest indication of there being any connection whatever between the two sets of curves so far as these places are concerned. Subsequently I added some fragmentary data obtained from Singapore and Fiji, which seem to show the possibility of there being a slight correspondence in these tropical regions, which, however, requires verification from a much greater number of observations.

The diagrams forwarded to the Association have been reduced by proportional compass from the large plot, and, I trust, may prove interesting. Special attention is requested to the very remarkable depression in the faculæ curve at the years 1883 and 1895. Should these prove periodic they seem worthy of careful investigation, being exceedingly well defined. The magnetic curves are so erratic that it has been found impossible to show them on the small diagrams. Generally they correspond fairly with the curves representing solar activity, but not invariably so, being evidently affected by other causes.

No. 19.—THE SIFTING OF THE SUNBEAM IN ITS PASSAGE THROUGH THE ATMOSPHERE TO THE EARTH.

By A. H. Chapman, Kurow.

[*Abstract.*]

I find the sunbeam is sifted for water by its passage through the aqueous-vapour-laden air to the earth. The aqueous vapour, acting as the sifting agent, arrests those rays which most specially affect water in any of its states of aggregation.

Experiment.—Take a sheet of pure ice: rough ice would cause dispersion of the ray. Take also a bi-convex lens, a common burning-glass—mine is 4 in. diameter. Concentrate the sunbeam on the ice; it does not melt, but the heat passes through so fiercely as to set fire to a piece of damp wood against which the ice is leaning. This may be often repeated and the ice still show no signs of melting. The heat from the burning wood melts the ice; so also does the touch of the human hand, though at a much lower temperature than the concentrated sunbeam, because these are unsifted heats.

Tyndall, in his work "Heat as a Mode of Motion," proposes to partly melt ice by a concentrated sunbeam in order to show to his pupils the beautiful ice-flowers on a screen (Article 127), but not having the sunbeam he used the heat of the electric arc instead. Had he tried the sunbeam he would have found that it would not melt ice, and the natural sifting of the sunbeam to protect water for man's use would have been recognised.

Section B.

CHEMISTRY AND MINERALOGY.

PRESIDENTIAL ADDRESS.

By J. Brownlie Henderson, F.I.C., F.C.S., Government Analyst at Brisbane.

(Delivered Thursday, 7th January, 1904.)

CHEMISTRY AND FOOD.

I have, in the first place, to thank the Council of the Association for the honour it has conferred in appointing me President of the section. I appreciate the honour fully, and, while not hoping to discharge the duties of the position in so distinguished a manner as some of my predecessors, well known for their explorations into the great unknown in chemistry, I trust my efforts may not be without result in calling attention to a branch of my subject with which, although not having had time to give it the thorough study it deserved, I have been brought into rather close contact. While it was usual to give a *résumé* of recent general advances in the science of chemistry, or of special advance in some particular branch of it, in the presidential addresses, I am, unfortunately, not in a good position, in Brisbane, to do this. Matters are in rather a primitive state there with regard to the higher education, the grammar-school education being as yet the highest obtainable locally; and as a result of this there are no good scientific libraries.

I intend on this occasion to call attention to the influence the science of chemistry has had in keeping up the purity of the food-supply, and in doing so I would treat broadly of the results obtained by analysis, and of what could be learned from these results towards helping to the obtaining of a better supply of pure food for the community at large.

So long as any body of men in the history of the earth had subsisted entirely by what was called "pastoral pursuits" they had probably had a pure food-supply—that was, a food-supply which had not been wilfully adulterated. But as civilisation of a very advanced kind, including even a knowledge of physics, mathematics, astronomy, and other sciences, seemed to have existed long ages before even ancient Egypt heard of it, and as such civilisation certainly meant handling of food-products by middlemen, it was almost certain that adulteration of food existed at that time. I do not infer that all middlemen were dishonest, but all records, from ancient Egypt down, go to show that it was the men who handled the food between the time it was grown in the country and its final consumption that had been most guilty of this kind of fraud. The reason was not far to seek. They had the greatest opportunities for sophisticating foodstuffs, and, as they had greater temptation, a larger proportion of them yielded to the temptation. The farmer had to sell his wheat or other grain whole, and even if he were inclined to be dishonest in this respect, he had not the opportunity. But the millers and bakers who afterwards handled the grain could, if dishonest, with comparative ease and, until recently, with little risk of detection, sell the prepared grain so as to bring into their pockets a fraudulent revenue. It was certain that as far back as there were any records of bodies of men settling down in one place, so that it became necessary to store and handle food several times between the producer on the soil and the user in the town, there were records of food being very much adulterated. Human nature seemed to have been exactly the same thousands of years ago as it was to-day, and in all ages there had been many men who, when they could by fraud obtain a little extra money, were prepared to take almost any risk in doing so.

It was only when the Middle Ages were looked at that there was much record of the sophistication of foods, and from what could be learned adulteration of food seemed to have flourished exceedingly well in those days when might was right. A few extracts would show to what extent this adulteration had occurred in the past. Greek history recorded the flavouring of new and poor wines to resemble mature and good wines. Pliny recorded that the Roman bakers added white earth to their bread; that the wine merchants adulterated and coloured their wines; and that the dealers in drugs adulterated the drugs. In the early history of England there seemed to have been much trouble with the bakers, brewers, spicers, &c., for records of pillory, fines, whippings, and expulsion from the towns as punishment for adulteration were not uncommon. It was rather strange to note that, while four hundred years ago in England putting sugar in beer was an offence for which a brewer was liable to be carried round the town in the public refuse-cart, put in the pillory, fined, or whipped, very much of the beer now made in England and the colonies was brewed more from sugar than from malt.

The lack of chemical and microscopical knowledge in the Middle Ages prevented systematic checking of food-adulteration; but, then, this lack of knowledge also limited very much the scope of adulteration. With the rise of the science of chemistry a powerful weapon was put in the hands of the law to combat the adulteration of food, but it also, unfortunately, opened up new fields for the practice of adulteration. The recent history of the food-supply, and of many other commercial articles, such as oils, &c., was often a history of the fight between the analyst of the fraudulent manufacturer and the analyst representing the law. The fraudulent manufacturer's analyst knew what tests the public analyst would probably use, and took care that when the sample was examined the looked-for reactions were forthcoming although the article was not genuine. I saw a notice some time ago that in Germany the manufacturers were turning out a margarine which answered all the official tests for butter. It was generally after such frauds had been practised for a considerable period that some analyst with more time at his disposal than usual made a more thorough examination and discovered the fraud. It was, of course, quite impossible for a public analyst to make a complete examination of every sample he received, and so the fraud remained undiscovered long enough to pay.

Fortunately many of the most harmful methods of food-adulteration have become practically obsolete. There is nothing to record nowadays like Hassal's examination of 101 samples of confectionery, where the principal colouring-matters found were as follows:—Yellows: Chromate of lead, 59 samples; gamboge, 11. Reds: Cochineal and other organic colours, 61; red-lead, 12; sulphide of mercury, 6. Browns: Red ferruginous earth, 8. Purples: Prussian blue, 2. Blues: Prussian blue, 22; artificial ultramarine, 15; indigo, 1. Greens: Chromate of lead and Prussian blue, 10; carbonate of copper, 1; and arsenite of copper, 9. Many of the samples had more than one colour on them, varying up to as many as seven colours on one sample. Four of the samples also contained carbonate of lead, while 13 contained plaster-of-paris, the quantity varying from 4 to 44 per cent. Bottled fruits and vegetables are no longer systematically coloured with copper-compounds, convictions for the use of this poisonous colouring being now comparatively rare. The general use of alum in flour to enable the baker to turn out a seemingly good loaf from a bad flour has also become rare, while the use of white earths to make bulk or weight for flour is quite unknown. These and similar methods of adulteration in which harmful substances were used have been practically abolished, thanks to the application of a knowledge of the science of chemistry.

The advance as a whole in the quality of the food-supply to-day is very marked indeed, the Foods and Drugs Act, poor as it is in some respects, having done much good work. Taking the principal division of our food-supply separately, it was first found that the supply of prepared cereals, such as flours, meals, &c., was better and purer now than ever it was, and moderate vigilance on the part of the authorities should keep it so. The bread made from the cereals was also much improved, though there was still room for improvement in quality if not in purity. The next important branch, the supply of fresh meat—at least, in such a climate as in New Zealand—should leave nothing to be desired in the matter of purity; but it is otherwise in the hotter climate of Australia generally. It is not at all an uncommon practice—at least, in Queensland in summer-time—to have the presumably fresh meat dipped in sulphite-of-lime solution or other preservative, particularly where cold-storage is not available to the butcher. It is, however, satisfactory to think that these, the two main divisions of the food-supply, are on the whole supplied to the general public in a pure state.

The milk and milk-products supplies are certainly no worse than they were, though the proportion of watered samples is still high. It is rather a pity that when cases of selling watered milk are proved before Magistrates as a rule they are looked on as rather harmless lapses from the paths of rectitude. The danger of starving children through watered milk requires to be more strongly brought home to most people. The doctor, believing the milk to be good, orders the addition of one part of water to two parts milk for the child; but the milkman has already done this, and so the child suffers. Even from an economic standpoint the watering of milk should be severely punished. It must be remembered that the milk of a good cow could have nearly one-third of water added without bringing it below the generally accepted standard, and that in milk from a herd of cows, if the analyst states that there was added water present, there was almost invariably much more there than the amount to which he certified. Suppose the cows are not first-class, and the milk is brought to a little below the standard by the addition of one-third water, and suppose the analyst certifies to 10 per cent. added water, the milkman actually has 25 per cent. added water in his milk. And if he sells 100 gallons per day at 4d. per quart, the general retail price in Brisbane, he gets £6 13s. 4d.; but as he has 25 gallons of water in it he disposes of the water at the same rate, £1 13s. 4d. of the amount therefore being for the 25 gallons of water—rather a good price for water, and generally dirty creek water too. Then the Magistrate fines the milkman £1, and the milkman goes away smiling and repeats the offence, for it pays. £1 13s. 4d. per day clear profit for water was £11 13s. 4d. per week stolen from the public. Had the milkman stolen £11 13s. 4d. from a shopkeeper's till he would have been imprisoned, and had a clerk embezzled it from a merchant's office he would probably have received a term of penal servitude. And yet the maximum penalty for stealing from the public through their food-supply is only £20, although the offence is aggravated by the fact that the public health suffers as well as the purse. Surely Tony Weller's famous dictum anent the law was correct.

A new departure of recent years has arisen—the use of preservatives in milk, butter, and cream. I have examined samples of reputed fresh milk containing formalin or boric acid, and one sample of concentrated milk showed 3 per cent. of boric acid—an abnormally high and totally unnecessary amount.

With reference to tea, coffee, and cocoa there is little new to be said. I recently discovered in Queensland the revival of an old form of food-adulteration. This was the use of "lie" tea, a mixture of tea-dust and magnetic oxide of iron, bound together with starch. It seemed to only occur in China tea from one district; but as this tea, being cheap, was largely used for blending, pellets of "lie" tea were often found in blended teas of fair quality and price. These pellets could generally be picked out with a magnet. Coffee and cocoa were still much subject to admixture, the so-called disclosure label often being a farce. The labels were often so printed that it was only after very careful examination that the "disclosure" was disclosed.

The liquids we drink constitute the other important branch of the food-supply. A larger proportion of these is adulterated than of any of the other important divisions. I do not mean adulterated with deleterious ingredients, but that they are more often other than they pretended to be. With the exception of Victoria, where the use of sugar was prohibited, wines made in the colonies are often brewed from a mixture of sugar-solution and grape-juice. Of course, certain well-known growers use only grape-juice; but many small growers not only use sugar, but strongly defend their action in doing so. The natural result is that there is to be found on the market so-called wines made almost entirely from sugar, flavoured with artificial essences, and coloured with aniline dye. There would be little objection to the use of sugar in this connection did the makers label the product by some other name than wine, for the general public certainly expected to get pure fermented grape-juice when they asked for wine. Whisky, rum, and gin are generally sold pure, though I have examined samples of whisky containing oil of vitriol, and others containing tobacco-extract; but in every case the samples were from sources where little else was to be expected—from bush pubs, &c. Brandy is rarely the distillate of pure wine; it is generally a sugar-spirit. French statistics show that ten times more so-called brandy is exported from France than there is genuine brandy distilled there. Probably the bulk of the so-called brandy on the market is just as good a stimulant as genuine brandy, but then it ought not to masquerade before the public in such misleading guise. Beer in these States is rarely brewed from malt only; almost invariably a certain proportion of sugar is used, and, according to the brewers, the public prefer sugar beer. One brewer informed me that he had on the market for some time a pure malt beer, but it did not suit the public taste. They were too much used to sugar beer, he said, so now he always used sugar and malt together. It was questionable if the general public knew it was a sugar beer they drank, and it certainly ought in some way to be distinguished from malt beer. Unfortunately, the custom of adding a preservative had arisen, and in Queensland, at any rate, nearly all the brewers used a small quantity of salicylic acid, from ½ gr. to about 2 gr. per pint, the average in the samples he had analysed being about 1 gr. Lastly, there were the non-alcoholic drinks, and those were less in accordance with their ordinary titles than any other class of food. The use of artificial flavouring essences had put the manufacture of this class of food within the reach of every one who had sufficient capital to buy a few bottles of essence and some aniline dye, sugar, and preservatives. The result was that many people had gone into the trade who knew absolutely nothing about the nature or physiological effects of the substances they used. I will give a few examples of temperance drinks which have come under my notice in Brisbane; and, judging from public reports, Brisbane was no worse off in this respect than most other places in Australia governed under variations of the 1875 Foods and Drugs Act. Ginger wine: This sample was made from capsicum, sugar, and flavouring essence; contained no ginger, and was preserved with 112 gr. of salicylic acid per gallon. Strawberry syrup: This sample was entirely fictitious, having been made from sugar, artificial flavouring essence, aniline dye, and tartaric acid, and contained 4 gr. of salicylic acid per gallon. About twenty times more dye had been added than was necessary for colouring the liquid. Raspberry syrup: This sample was made from artificial essence, sugar, and water, and was coloured with rose aniline, and contained 16 gr. of salicylic acid per gallon. It contained no raspberry-juice. Ships' lime-juice: This sample was a flavoured solution of tartaric acid containing 1 gr. of salicylic acid per pint. The flavouring was probably oil of limes, but there was no juice of the limes present. Its use on board ship as an anti-scorbutic would therefore be valueless. Perhaps it is needless to say that these were a few of the worst samples examined. I fail to see how they could be more fraudulent. Certain classes of the temperance drinks examined—such as, *e.g.*, hop beer and horehound beer—were much less fictitious than others, but on the whole the samples were not what they purported to be, by far the greater proportion containing some preservative. If our authorities could be made to realise that most of this fictitious essence, aniline dye, and preservative rubbish was imbibed by children, surely they would take some steps to at least force the sellers of such concoctions to let the public know by adequate labels what it was that the children are drinking. All the more is this necessary as it is the children of the poorer classes, least able to protect themselves, who drink it, and these children are least of all able to take it with impunity. The greater proportion of the entirely fictitious samples I have examined were obtained in those small cheap "soft-drink" shops that were only patronised by the poorer classes. The temperance societies might well take up the matter of seeing that wholesome temperance drinks were provided for sale, more especially in those places like Brisbane, where the town water-supply was often totally unfit for drinking.

The question of the use of preservatives has been very much discussed of late years. Some Royal Commissions have gone so far as to state that preservatives are "necessary" in certain foods; but, unfortunately for the general public, they omit to give the exact meaning they wish to convey by the use of this term "necessary." Take, for example, the New South Wales Commission, which reported lately that, while preservatives should not be permitted in certain articles of food, they were necessary in concentrated milk. Probably the New South Wales Commission meant that if the trade in concentrated milk was to be carried on exactly as it had been in the past, and if the concentrated milk was required to keep good for several days, then a preservative was necessary. But is it imperative that such trades should be allowed to carry on without interference of any sort, and is it necessary for concentrated milk to keep several days? Why not replace boric acid by clean working and pasteurisation? The vested-interest cry of increased cost of production and ruining the trade would, of course, be very loud. It always has been in such cases; but the results of Government interference have often been more beneficial to the manufacturer than they have been even to the general public. It is doubtless a dangerous thing for any Parliament to interfere with honest, thriving industries—such interference more often results in hurt than in benefit—but interference with industries which thrive at the expense of the health of the community, and on false representations as to the quality of the manufactured goods, can only result in benefit to the country as a whole, even if the industry has to be entirely suppressed, which would not be the case with foodstuffs. I quite fail to see that it is necessary to have boric acid in concentrated milk; and, as to requiring it to keep for several days, why not buy one day's supply for each day? And why not apply the same arguments to the fish-supply as to the concentrated-milk supply? Fish is a very desirable article of food, but, unfortunately, it does not keep well. Why should not the vested interests of the fish trade insist that it is "necessary" to use preservatives for fish? The conclusion one is apt to be driven to by the reports of the commissions on this subject is that preservatives are harmful and ought to be prohibited; but, as the commissions have more respect for the vested interests of certain trades than they have for the health of the general public, they allow a small proportion of preservatives. If the commissions are satisfied that boric acid is harmless, why place restrictions on its use? And if convinced that it causes harm, why permit it at all? Boric acid was necessary in butter, said one commission. Undoubtedly it was to most makers of butter. But butter had been made even in the Queensland climate without boric acid, sent to London, and had brought top prices. Of most of the experiments made to throw light on the question of the harmlessness or otherwise of preservatives it could only be said that they proved nothing. I am strongly of opinion that, while our sedentary habits and our methods of cooking are responsible for the bulk of the increase in digestive troubles so pronounced at the present day, there is a fair proportion of it caused by the preservatives in food, and the trouble must undoubtedly in many cases be much accentuated through this use of preservatives. Unfortunately, there were many medical men who condoned the use of certain preservatives, but the great bulk of the leading men unhesitatingly condemned them. During last summer in Brisbane I had exhibits sent for analysis in nine cases of food poisoning. Seven of these were through eating corned beef, one sausage, and one pig's cheek. In connection with the corned-beef samples, nearly every one partaking of them was ill, while four children died; and one child died through partaking of the pig's cheek. The point I wish to call particular attention to is that in every case the food contained preservatives. In spite of the argument so often used that it was better to eat preserved food than putrid food, it is obviously much more dangerous to eat "preserved" food than fresh food. I am not prepared at present to say why the preservative should make this class of food more dangerous, but there are the facts—the true explanation, I am sure, will not be long in coming to light. The battle for a pure food-supply will not be won except after a long struggle, in which many hard things will be said by those holding vested interests in the sale and use of preservatives; and it is really to the medical men we have to look for the bulk of the fighting, and not to the analyst. Methods of analysis are sufficiently accurate at the present day for most food purposes—certainly for detecting and investigating the preservatives used in food—but what inference is to be drawn from the results obtained remains an open question till medical evidence finally decides whether or not preservatives are to be permitted. And in deciding the question I trust it will be remembered that it is not a question of a small quantity of preservatives in one article of food; it is used in many. If a man happened to be using highly preserved foods the following was an estimate of what he might have to take into his system in a day: One pint of milk made by 2-to-1 dilution of concentrated milk containing 3 per cent. boric acid would give 87 gr. boric acid; 1 oz. butter containing 1 per cent. boric acid would give 4 gr. boric acid. This, probably, would be the only food consumed containing much boric acid, the total being 91 gr. per day. Fresh meat was often dipped in sulphite-of-lime solution, or occasionally in salicylic-acid solution. With an 8 oz. allowance per day, and the meat retaining, say, about 0·1 per cent. salicylic acid, he would imbibe 4 gr. of salicylic acid. Two pints of beer per day, at 2 gr. salicylic acid per pint, would be other 4 gr. salicylic acid. This gave a total of 91 gr. boric acid and 8 gr. salicylic acid per day. I do not quote this as a probable but as a possible case, judged from the analysis of actual samples. As all the butter, cream, concentrated milk, bacon, and corned beef, and nearly all the fresh milk, beer, and temperance drinks, and some of the sausages, jams, fresh fish, fresh meat, &c., contains at least some preservatives, it is evident that most folk, at least in Brisbane—and, judging from published reports, in Sydney and Melbourne also—have to partake daily some dose of preservative. The preservative question might not be so keenly felt in New Zealand as in Queensland. I have seen no records of New Zealand investigations in this direction, but in Queensland, where the mean temperature was a good deal higher, people were plentifully drugged with preservatives even in the presumably fresh food. Apart from the use of preservatives, there is, so far as I have seen, not much that is actually harmful in our food-supply, though a good deal that is fraudulent.

There is one other matter in connection with our food-supply which affects Australia more, perhaps, than New Zealand. I refer to the presence of zinc in the drinking-water. In many of the large towns in Australia the bulk of the drinking-water used is rain-water collected in galvanised-iron tanks from galvanised-iron roofs. This tank water contains on the average about 1 gr. of zinc per gallon, varying from 0·25 to 2·5, the zinc being present as bi-carbonate. In nearly every other part of the world zinc has been found to have poisonous effects if continually imbibed with drinking-water.

Under the law the two officers who have most to do with the Foods Act are the inspector and the analyst. So far as the equipment of the analyst was concerned, we do not require much improvement to enable him to detect modern methods of adulteration. Modern analytical methods are quite capable of testing the purity of the great bulk of our food-supply, and if it were only adulterated in a manner which our present methods failed to detect, then we would indeed have a pure food-supply. The inspector of foods, however, is not in such a good position ; but in his case it is not lack of knowledge that interferes with a more perfect discharge of his duties—it is lack of power. The law, then, is at fault, and I would suggest the following changes as being reasonable, practical, and not unduly interfering with trade, and in the interests not only of the general public, but of the honest manufacturer, who must find it harder every year to compete with the sophisticated foods now on the market. I give the suggestions shortly—the details would require to be worked out by a legal expert : (*a*.) All food-factories to be licensed. This was already the law as regarded the manufacture of alcoholic liquors, and particularly as regarded explosives. Surely good food was more essential to our welfare than good explosives. (*b*.) All food-factories to be open to inspection at any time to any authorised inspector. Again similar to liquors and explosives trades, and not found oppressive by them. (*c*.) No deleterious substances to be allowed in the factory. This was already embodied in our Liquor Acts, which prohibited any brewer or seller of beer, &c., from having on his premises deleterious substances, unless for medicinal use, proof of which must rest with the licensee. The term "deleterious substances" would have to cover not only poisonous substances, and, I hope, preservatives, but also all substances which might be used in the adulteration of any food manufactured on the premises. This would prevent such things as the open carting of pumpkins into a jam-factory, an occurrence observed in Brisbane by an inspector there, and one that was certainly not confined to Brisbane, but is common elsewhere. The onus of proof of the legitimate use of any such article not obviously intended for legitimate use in the manufacture of foods on the premises should, of course, rest on the licensee. This licensing and inspection of food-factories, while it would not prevent adulteration of food, would make it more difficult, and could be also made to insure clean premises and clean handling of the foodstuffs, while the prohibition of deleterious substances would tend greatly to prevent their use. It would only be fair to put the makers of ordinary food under the same restrictions in this respect as the makers of beer. (*d.*) All foods must be correctly labelled. If the law were more stringent on this point much of the present adulteration would cease. I would go so far as to suggest that in the case of all mixed food the nature and amount of each ingredient be given. Who would buy concentrated milk if it were labelled as containing 3 per cent. boric acid, or raspberry syrup if it were labelled as "Artificial Raspberry Syrup," containing artificial essence of raspberry, aniline dye, saccharine, and salicylic acid? and what chance would a pepper labelled as 20 per cent. pepper, 20 per cent. ground olive-stones, and 60 per cent. rice-starch have against pepper labelled "Pure Pepper"? It was not only a matter of pounds, shillings, or pence; it was a matter of life or death to some, and of sound health or sickness to many. Recently in Brisbane there was recommended for sale by a storekeeper as suitable for children, and better than Nestlé's or any other well-known brand of condensed milk, a condensed separated milk devoid of fat. This was referred to me, and as a consequence the result of an analysis, with name of brand, was published, and no further sale was obtained for that brand. But in the meantime how many children had been starved to death who were being fed on that milk, for the drought had enormously reduced the sale of fresh milk in Brisbane, and the sales of condensed milk were correspondingly great at that time? (*e.*) Inspectors to take samples of food to the Government Analyst, results of analyses to be published in Government *Gazette* and local newspaper. This, I think, would do more than anything else to check adulteration of food. At present, except in the principal centres of population in Australia, there is practically no examination of food, and this provision would enable cheap supervision of foods to be made even in the most remote settlements. The responsibility thrown on the analyst was great, but no greater than that thrown on any Judge of the law-courts. This system had already worked splendidly in South Australia in the Manure Act. (*f.*) All second or subsequent convictions for adulteration of food to have both imprisonment and fine as essential parts of the penalty. Why it should be considered less criminal for a dishonest milk-dealer to steal £5 from a householder by supplying him with watered milk, which is also a menace to the health of his family, than for the same man to take five sovereigns from the householder's purse without otherwise injuring him was hard to tell. Penalties for food-adulteration ought to be more severe than for petty stealing, and the individual who is guilty of the former variety of dishonesty ought to be socially more of an outcast than the one who is guilty of the latter.

The poor were at one time called "God's poor," I suppose because no one else was much concerned about their lives or comforts. These days are fortunately now past, and in the van of those who looked after the interests of the poor were the disciples of sanitary science, and it reflects great credit on the medical profession that nearly all the principal workers in this direction have been medical men. It is refreshing in these days of unions to protect at all costs the pockets of various trades and professions to find one body of men devoting their energies to raising the percentage of healthy individuals in our midst, although thereby deliberately reducing the total income of their profession.

There is a pressing need for an awakening of the authorities and a systematic and continuous examination of the food-supply, and if anything that is said here in any way helps towards that consummation the Australasian Association for the Advancement of Science will have added one more item to the already long list of benefits it has conferred on the people of Australia and New Zealand.

No. 1.—SOME ABNORMAL BORE-WATERS.

By J. Brownlie Henderson, F.I.C., F.C.S.

The following is a record of some analyses of abnormal waters from artesian and sub-artesian bores. The average bore-water of Queensland contains from about 10 gr. to 30 gr. of sodium-carbonate per gallon, and about 5 gr. to 8 gr. of sodium-chloride per gallon, with very little silica, iron, lime, or magnesia.

WOLFGANG STATION (SUB-ARTESIAN).

(December 29, 1895.)

Total solids... ...	(Grains per gallon)	949·1
Silica and insoluble ...	"	·9
Iron-oxide and alumina	"	181·3
Calcium-carbonate ...	"	88·3
Magnesium-carbonate	"	58·7
Sodium-chloride ...	"	528·0
Sodium-carbonate ...	"	91·9
Free ammonia ...	(Parts per million)	Trace.
Albuminoid ammonia	"	·40

HELIDON (ARTESIAN).

(D. Smith, December 12, 1895.)

Total solids... ...	(Grains per gallon)	1,027·6
Iron-oxide and alumina	"	10·0
Calcium-carbonate ...	"	88·0
Magnesium-carbonate	"	205·0
Sodium-carbonate ...	"	146·6
Sodium-chloride ...	"	578·0
Free ammonia ...	(Parts per million)	Trace.
Albuminoid ammonia	"	·6

MARIA CREEK BORE (ARTESIAN).

(August 19, 1898.)

Total solids... ...	(Grains per gallon)	864·5
Silica and insoluble ...	"	2·55
Iron and alumina ...	"	1·45
Calcium-carbonate ...	"	15·20
Magnesium-carbonate	"	45·45
Sodium-carbonate ...	"	576·00
Sodium-chloride ...	"	223·85
Sulphates	"	Trace.

NEW ROMA BORE (ARTESIAN).

(December 18, 1900.)

Total solids... ...	(Grains per gallon)	45·91
Silica and insoluble ...	"	2·02
Iron and alumina ...	"	·28
Calcium-carbonate ...	"	·68
Magnesium-carbonate	"	·93
Sodium-carbonate ...	"	31·18
Sodium chloride ...	"	9·73
Sodium-sulphate ...	"	1·09

The Maria Creek bore gives off a large amount of gas containing 98·2 per cent. of carbon-dioxide (CO_2), the remainder being mostly nitrogen.

The Roma bore is remarkable as giving off large quantities of a splendid illuminating-gas having the following composition:

	Per Cent.
Carbon-dioxide	1·5
Carbon-monoxide	5·8
Benzine series	5·0
Olefine series	1·5
Paraffin series (including ethane, 9·8 per cent.)	82·8
Nitrogen (residual gas)	3·4
Oxygen	Nil.
Hydrogen	Nil.
Candle-power	24

At first a little mineral oil came up with the water, but now it is free from any smell of oil.

No. 2.—STORAGE OF WATER-SUPPLIES IN A SEMI-TROPICAL CLIMATE.

By J. Brownlie Henderson, F.I.C., F.C.S.

The solution of the problem of providing a good water-supply in a semi-tropical climate is beset with many difficulties. Where good river supplies are not available nearly all hydraulic engineers in our British colonies, where the mean temperature is high, have in the past attempted to deal with the question in the same manner as they would have done in Britain, by simply building large storage-reservoirs. In a very short time the water stored in these large reservoirs, especially if there is little flow through them, teems with animal and vegetable life, and becomes totally unfit for drinking. We have a good example of this in that part of the Brisbane water-supply which is derived from two large storage-reservoirs, Enoggera and Gold Creek. The catchment-area is partly granite and partly schistose rock, so the water is soft; and, as in each case this area is entirely reserved from habitation and cultivation, there is no danger of contaminanation from "sewage" diseases.

The following are a few data about each reservoir:—

ENOGGERA RESERVOIR.

Catchment-area	8,295 acres.
Estimated capacity ...	1,000,000,000 gallons.
Available storage	600,000,000 gallons.
Height above sea-level ...	Top water 239 ft. above H.W.S.T.
Miles from city along pipe-line	7 miles 20 chains.

GOLD CREEK RESERVOIR.

Catchment-area	2,476 acres.
Estimated storage-capacity ..	405,938,547 gallons.
Available storage-capacity ...	400,000,000 gallons.
Height above sea-level ...	Top water 315 ft. above H.W.S.T.
Miles from city along pipe-line	12 miles 10 chains.

They are situated about two miles from each other, and the mean annual rainfall is about 50 in.

The water is in each case about 40 ft. deep in the centre (maximum depth—Enoggera, 55 ft.; Gold Creek, 64 ft.), but, as is always the case where dams have been erected in low hilly country, there are large flats that are only a few feet under water. In summer the surface temperature rises to 86° Fahr., while the bottom temperature remains about 59° Fahr., so that there is no vertical circulation of the water. For a month or two in winter the surface temperature must fall below the bottom temperature on cold nights, and there is then vertical circulation.

The result of storing water in such large stagnant pools could easily have been foretold, and is strikingly shown by the following analyses. I give only the figures showing the organic contamination. The free ammonia, albuminoid ammonia, and oxygen consumed in moist combustion were determined as described by Wanklyn, while the oxygen consumed in fifteen minutes and in four hours was determined at 80° Fahr.

ENOGGERA RESERVOIR WATER.

—	Parts per Million.			
	1898.	1901.	1902.	1903.
Free ammonia ...	·006	·10	·04	·005
Albuminoid ammonia ...	·28	·21	·47	·40
Oxygen consumed (Wanklyn)	11·0	15·4	18·1	13·0
Oxygen consumed in fifteen minutes	...	..	...	2·0
Oxygen consumed in four hours	...	...	...	4·0

GOLD CREEK WATER.

—	Parts per Million.			
	1896.	1901.	1902.	1903.
Free ammonia ...	·18	Nil	·02	·005
Albuminoid ammonia ...	·43	1·48	·60	1·49
Oxygen consumed (Wanklyn)	11·8	52·7	13·8	21·6
Oxygen consumed in fifteen minutes	...	..	2·03	2·61
Oxygen consumed in four hours	...	...	4·12	5·68

In every case the water teemed with algæ, while the sediment from a collecting-jar seemed to show representatives of nearly every known species of animalculæ found in water. Not being a biologist, I was unable to do more than classify a few of the commoner and best-known species; but should any biologist care for a fresh field to work on he would find it in such large reservoirs as these.

The water in the reservoirs, while the animal and vegetable life is fresh and lively, as a rule neither looks, smells, nor tastes bad, but after it has been shut up in the water-mains away from the light for some time it often becomes dark-brown in colour, gives a thick sediment, and sometimes has an offensive smell of decaying fish. And this must always be the case with such waters; and, even if the reservoirs were filled with distilled water, in the course of a few months they would teem again with life. Running off the water in a wet season and allowing the reservoir to fill with fresh water again reduces the amount of organic matter for a time, but a few months' stagnation in a dry season brings back the old state of things once more. Nor is there much to be gained by going below the surface, away from the excess of the lower forms of animal and vegetable life, as is shown by the following analyses:—

Date.	Depth.	Free Ammonia.	Albuminoid Ammonia.	Oxygen consumed (Wanklyn).	Oxygen consumed, Fifteen Minutes.	Oxygen consumed, Four Hours.
			GOLD CREEK RESERVOIR.			
1/12/03	2 ft.	Trace	·92	15·7	2·26	4·55
"	20 "	·24	·34	12·1	1·67	5·65
27/10/03	2 "	·005	1·49	21·6	2 61	5·68
"	10 "	·05	·54	12·5	1·76	3·63
"	20 "	·14	·32	11·3	1·54	3·42
"	30 "	·37	·29	11·0	1·52	3·34
29/9/03	2 "	·02	·60	13·8	2·03	4·12
"	10 "	·02	·43	12·2	1·9	3·56
"	20 "	·03	·29	11·0	1·25	2·60
"	30 "	·12	·275	9·0	1·30	2·54
1/9/03	2 "	·025	·40	13·1	1·66	3·18
"	10 "	·015	·38	13·0	1·62	3·05
"	20 "	·025	·27	11·3	1·29	2·52
"	30 "	·01	·20	9·5	1·19	2·31
6/8/03	2 "	·02	·37	11·8	1·44	2·88
"	10 "	·02	·31	12·1	1·52	2·96
"	20 "	·04	·30	11·0	1·38	2·61
"	30 "	·025	·265	10·8	1·32	2·65
12/2/01	2 "	Nil	1·48	52·7	..	..
"	10 "	·61	·74	22·8	..	..
"	20 "	·88	·70	17·0	..	..
"	30 "	1·02	·64	17·0	..	..
			ENOGGERA RESERVOIR.			
19/9/02	Surface	·01	·37	13·6	..	..
"	Bottom	·26	·30	12·4	..	..
26/7/02	1 ft.	·02	·34	13·8	·98	2·39
"	15 "	·01	·27	13·5	·96	2·41
"	30 "	·01	·24	13·5	·96	2·40
"	41 "	·04	·24	13·5	1·21	2·32

On Stradbroke Island, near Brisbane, there is a small lagoon called the Blue Lagoon, only a few feet above the level of the sea. The catchment-area is about 3,320 acres, and the estimated storage-capacity about 200,000,000 gallons, and the daily surface outflow, towards the end of the longest drought we ever had in Queensland, was about 3,145,536 gallons. The extraordinary thing about the lagoon is that it is from 12 ft. to 14 ft. deep close to the sides all round, and the water in it is perfectly clear and pure. That it should run in pure is only natural, as the whole catchment-area is sandhills covered with very light timber. The rain on falling at once penetrates the sand, and has no opportunity of taking up organic impurities. The entire absence of shallows serves to prevent the growth of any water-weeds or algæ, and I suppose their absence, or perhaps also the depth, prevents the growth of the lower forms of animal and vegetable life. The following is an analysis of water from this lagoon :—

BLUE LAGOON, STRADBROKE ISLAND.

(May 7, 1902.)

Total solids ...	(Grains per gallon)	5·3
Chlorine	"	2·4
Hardness	(Degrees)	1·0
Free ammonia ...	(Parts per million)	Nil.
Albuminoid ammonia	"	·02
Oxygen consumed (Wanklyn) ...	"	1·7

Evidently if water could be stored in reservoirs which were not less than 13 ft. deep at any part it would keep pure for a long time. But this is impracticable, as the level of the reservoirs is never constant, and in times of drought falls many feet below the level of the overflow.

Where storage in a hot climate has to be adopted it is evident that provision must be made to purify the water—always a costly and unsatisfactory proceeding. Simple sand filtration of these waters has proved utterly useless. The filters quickly choke, and even the water that does get through, though clear, is full of dissolved organic matter.

Experiments were undertaken in Brisbane some time ago, and it was found that a very fair water could be obtained by the use of 4 gr. of lime and 0·5 gr. aluminium-sulphate per gallon, followed by settlement and machine filtration. The following, though not the best result obtained, is a fair sample of the improvement brought about by this treatment :—

ENOGGERA WATER.

		Untreated.	Treated.
Total solids ...	(Grains per gallon)	8·51	8·77
Loss on ignition (not CO_2)	"	2·50	1·02
Silica and insoluble	"	·60	·58
Iron-oxide and alumina	"	·16	·10
Lime	"	·66	2·4
Water of hydration (calculated) ...	"	Nil	·48
Magnesia (MgO)	"	·61	·12
Soda (Na_2O) ...	"	1·10	1·10
Chlorine (Cl) ...	"	1·7	1·7
Carbonates (CO_2)	"	1·18	·93
Sulphates (SO_3)...	"	Nil	·34
Nitrates, nitrites, and phosphates ...	"	Nil	Nil.
Hardness ...	(Clark's degrees)	3·0	4·5
Free ammonia ...	(Parts per million)	·02	·60
Albuminoid ammonia	"	·32	·09
Oxygen consumed in moist combustion ...	"	12·0	6·0
Oxygen consumed in fifteen minutes ...	"	·91	·39
Oxygen consumed in four hours ...	"	2·23	1·32

The increase in the free ammonia was due to ammonia in the alum used.

While the treated water does not show up well when compared with water stored in a cold climate, it kept clear and sweet for months after being shut up away from the light, and would make a good town supply.

Some experiments of a most interesting character have recently been undertaken by Mr. Morry, of the Public Works Department, Brisbane. He suggested the use of an intermittent filter-bed, such as is used for sewage-purification, as a preliminary to sand filtration.

The beds tried are about 8 ft. high by about 6 ft. square, built of gravel and sand, the water being fed in the usual intermittent manner by a revolving sprinkler. At first the results were not at all encouraging, but lately, after the beds have been running for a year, they seem to be doing far better work, and have not since they started choked or been cleaned out or touched in any way. I give the last analysis made to show that a marked improvement has been achieved :—

BACTERIOLOGICAL FILTER.

(November 20, 1903.)

Marks.	Free Ammonia.	Albuminoid Ammonia.	Oxygen consumed (Wanklyn).	Oxygen consumed, 15 Minutes.	Oxygen consumed, 4 Hours.
Enoggera Reservoir	·005	·40	13·0	2·0	4·0
No. 1 bed (filtrate)	Nil	·20	8·9	1·3	2·4
No. 2 bed „	Nil	·13	6·8	·9	1·9

It still remains to be seen whether this process will turn out practicable. If it does it will be much cheaper and less liable to break down than any method of precipitation.

No. 3. NOTE ON THE SAPONIFICATION OF FATTY OILS IN PRESENCE OF MINERAL OIL.

By J. Brownlie Henderson, F.I.C., F.C.S.

The methods generally given in text-books for determining the amount of saponifiable oil in a mixture containing mineral oil do not state in a sufficiently definite manner the time necessary for completing the saponification. The time indicated I have found almost invariably much too short. The statements made are generally to heat to boiling for from half an hour to an hour or more, or until saponification is complete, with frequent agitation.

I had occasion lately to test a mixture containing 85 per cent. mineral oil (specific gravity 0·882 at 60° Fahr., and free from saponifiable matter) and 15 per cent. rape-oil (commercially pure). The apparatus was fitted up as usual: 7·5 grammes of the mixed oil was put into a 150 c.c. wide-mouthed flask, and 25 c.c. of $\frac{N}{2}$ alcoholic potash added. The flask was fitted with a cork and a condensing-tube about 3 ft.

long and placed on a water bath, so that the contents just simmered, as described by Lewkowitsch. The contents of the flask were thoroughly agitated every five minutes. Experiments were made with various times of heating, with the results shown in the following table :—

Time of Heating.	Per Cent. of Rape-oil found.
15 minutes	2·8
30 "	6·8
45 "	8·3
60 "	9·6
75 "	11·3
90 "	13·0
105 "	14·3
120 "	15·1

No additional saponification was obtained on further heating. By more rapid boiling and using a good reflux condenser the time can be considerably shortened. The experiments show that, for this method of working, when it is desired to saponify a small proportion of fatty oil in presence of a large proportion of mineral oil at least two hours' heating is necessary. If time is an object, then another method should be adopted, such as heating under pressure or boiling briskly with stronger alkali under a reflux condenser.

Some time ago I had submitted to me for analysis a sample supposed to be pure mineral oil—in fact, certified to be free from other oils by an analyst of repute. It was found to contain nearly 4 per cent. of fatty oils. The probable explanation of the difference of opinion—one which should certainly not have existed—was that the heating in one case had only been continued for the orthodox half-hour. If only 2·5 grammes of such an oil were taken, as recommended in the text-books, certainly after half an hour's simmering there would not have been sufficient fatty oil saponified to give a definite reaction.

No. 4.—THE DISTILLATION OF FATTY ACIDS, ETC.

By P. W. Robertson.

No. 5.—THE PRODUCTION AND IDENTIFICATION OF THE VEGETABLE (BACTERIAL) GUMS.

By R. Greig Smith, D.Sc., Macleay Bacteriologist to the Linnean Society of New South Wales.

At the time of the last meeting of this Association nothing was known concerning the origin of the vegetable gums. Since that time the author has shown that they are the products of certain bacteria which inhabit the tissues of the gum-bearing trees. The bacteria were isolated and made to produce their gum in the laboratory. Arabin (gum arabic), the soluble gum of the wattle, &c.; metarabin, the insoluble gum of the wattle and certain fruit-trees; and pararabin, the insoluble constituent of *Sterculia* gum, are produced by three distinct bacteria. The gums formed in the laboratory were identical with those that occur naturally. Since these gums are produced by bacteria, it is extremely probable that all other vegetable gums are bacterial products, and that the world's supply of gum might be increased by a judicious infection of susceptible trees.

Two years ago, at the Hobart meeting of this Association, I read a paper in which the utilisation of micro-organisms in the various industries was briefly noted. During the interval that has elapsed I have been instrumental in showing how a very important industry depends upon the activity of bacteria. I refer to the vegetable gums, which are used for so many purposes in the arts. Two years ago the vegetable gums were generally supposed to be products of certain trees in a pathological condition, which is another way of saying that the gum is produced in some unknown manner when the trees are unhealthy. Although it had been claimed that certain moulds play a part in causing the plant to form gum, and that bacteria generally are found in certain slime-fluxes of trees, yet it had not been shown that bacteria produce the gum directly. The state of our knowledge in 1901 has been thus indicated by Marshall Ward ("Disease in Plants." London, 1901): "Beyond the fact that gummosis (gum-flux) is a pathological phenomenon we know very little of the disease."

I have been able to demonstrate that the gum-flux (sometimes called "gummosis") of trees is the direct product of bacteria by causing certain bacteria, which had been isolated from trees affected with gum-flux, to manufacture the gum in the laboratory. Thus the origin of certain of the vegetable gums was placed beyond all doubt. In view of this fact, I need scarcely point out how the knowledge of the origin of the gum will enable us to increase the world's supply as well as to improve the quality of the substance. This can be done by a judicious infection of certain trees with particular bacteria, possibly after these have been under cultivation in the laboratory, or possibly while contained in the fresh sappy gum taken from selected gum-bearing trees.

The various stages in my researches upon the vegetable-gum bacteria have been elsewhere* recorded, and in this paper I purpose giving a short account of the chemical side of the investigations.

Gum acacia, when exported from Australia, is known as Australian or wattle gum, and obviously it is with this variety that I have to deal. But what applies to this kind will also apply generally to all other gums of the arabin group, although it has yet to be proved that the bacterium of the soluble wattle-gums is identical with the bacterium or bacteria of the Arabian, Egyptian, and similar gums of tropical arid regions. I believe that they will prove to be the same, and that the differences in appearance and properties of the natural gums are due both to the temperatures of the localities in which the gums are found and to the nutrition of the bacteria—that is, to the nature of the sap of the host plants.

A bacterium, which I have named *Bacterium acaciæ*, was isolated from *Acacia binervata*, from which a gum exuded. The natural gum, which was wholly soluble in water, occurred as brownish and pale-yellow tough lumps and "tears" upon branches, and did not have the clear transparent appearance and brittle fracture of the ordinary commercial gum acacia. But as the tree grew in Sydney one could not expect to find there a gum with the characters of a tropical gum. Otherwise it was an arabin gum, and gave the same general chemical reactions as gum acacia.

Many gum bacteria when removed from their natural habitat do not form gum readily, and the organism obtained from the *Acacia binervata* was of this order. In ordinary media the bacteria grew easily enough, but produced very little gum. Acting, however, upon an observation that the tissues of the plant adjoining a wound through which gum was oozing were acid and contained tannin, I prepared a medium containing agar, saccharose, tannin, and potato-extract. This medium, less the tannin, had been found to produce a luxuriant crop of cells. The effect of the tannin was marvellous. Instead of a watery growth of bacterial cells there was produced a thick slime, which could be easily removed from the agar-surface. About 3 c.c. of slime were obtained from 20 c.c. of medium. The ready removal of the slime or gum is an important point, for it must be remem-

* See the proceedings of the Linnean Society of New South Wales, 1902-4.

bered that agar-agar is allied to the vegetable gums, inasmuch as it is a pararabin, and if the bacterial product cannot be readily removed it might become contaminated with fragments of agar. But I have grown many different gums upon agar, and also in fluids, and in no case have I found any difference between the solid and fluid cultures, so that no constituent capable of being detected is removed with the slimes from the agar.

With the aid of the tannin a quantity of slime was then obtained. This slime is not gum, but a mixture of gum with bacterial albuminoids and suspended cells. A method had, therefore, to be devised for separating the gum from the bulk of the other constituents. After some experimental work it was found that the digestion of the slime in the autoclave at a pressure of three atmospheres for a quarter of an hour was sufficient to convert the slime into a solution of a gum and a coagulum of bacterial albuminoids and dead cells. In some cases a longer digestion was necessary, in others a drop or two of dilute sulphuric acid was beneficial. This method of digestion not only separates certain bacterial slimes into gums and other bodies, but also converts many of the insoluble vegetable and bacterial gums into soluble modifications, which, however, revert to their former condition upon desiccation. Recently I have found that this method is used commercially for the solution of the metarabin or cerasin gums of the cherry and other fruit-trees.

The solution of the bacterial gum when evaporated to the condition of a thick mucilage gave the reactions for gum acacia. The most convenient and successful method for testing gum mucilages is that recommended by Maben, and consists in placing a drop upon a sheet of glass and stirring into it a drop of the reagent. Coagulation or precipitation was obtained with basic lead-acetate and ferric chloride, but not with neutral lead-acetate, the salts of silver and mercury, and the hydrates of the alkaline earths. The natural gum gave all the reactions, positive as well as negative, of the bacterial gum.

The furfural or pentosan reaction was obtained both with the natural and the bacterial gum acids upon distilling them with dilute hydrochloric acid (sp. g., 1·06). The distillate gave the red colour with a solution of phloroglucin in hydrochloric acid (1·06). Furthermore, upon heating both gums with dilute nitric acid (sp. g., 1·12) crystalline plates of mucic acid were obtained, and oxalic acid was detected in the filtrates.

The bacterial gum had thus all the reactions and the same decomposition products as the natural gum that was obtained from the tree in the bark of which the bacteria had been found.

The two gums have been shown to possess many chemical properties in common. The identity of the products of hydrolysis now remained to be proved. Arabin hydrolyses to a mixture of arabinose and galactose, and it was expected that the two gums would yield the same sugars upon hydrolysis.

The natural gum was first attacked with 2 per cent. sulphuric acid upon the water bath, a method recommended by O'Sullivan for effecting a separation of the constituents. The galactan, however, was also partly hydrolysed, and it was found to be much more satisfactory to completely hydrolyse the gum by boiling for five hours with 5 per cent. acid, and to effect the separation of the sugars afterwards as osazones. During the hydrolysis the strength of the acid was maintained by attaching an aerial condenser to the conical flask containing the solution. After the hydrolysis the acid was neutralised with barium-carbonate, and the neutral fluid, after filtration, was evaporated down to small volume and clarified with aluminium-hydrate. A portion was tested with alcohol for unaltered gum, and if any was found it was eliminated from the whole solution by alcohol. Generally all the gum was hydrolysed, and the fluid reduced Fehling's solution strongly.

The sugars were then converted into osazones by warming the solution on the water bath and adding 1 c.c. of a mixture of phenylhydrazine 4 c.c., glacial acetic acid 4 c.c., water 2 c.c. With the sugars from the natural gum, but more especially with those from the bacterial gums, there is a production of a black tarry substance, much of which can be removed by filtering the hot turbid solution at the end of half an hour. To the filtrate 2 c.c. of phenylhydrazine solution is added and the heating continued for another hour, when the solution is, if necessary, filtered to remove more tarry matter and then cooled. The osazones, which separate upon cooling, are filtered off, and the mother liquor is treated with another 2 c.c. of phenylhydrazine; the process is repeated until all the sugars have been precipitated. The crude osazones are dried on porous porcelain. As a rule the quantity of crude osazone obtained is too small and the amount of impurity in the form of a tarry substance, residual phenylhydrazine, &c., relatively too large to enable the osazones to be purified by crystallization from alcoholic, pyridine, acetone, or other solutions. Practically all this impurity can be eliminated by slowly percolating the crude dry osazone with ether. Although this process is simple it does not appear to have been suggested, for when one reads through the literature connected with the determination of the hydrolysed products of bacterial gums or slimes one sees either that the osazones have melting-points that indicate no known sugar or that the quantity was too small to purify. Probably if ether had been employed in the former cases an osazone with a known melting-point would have been found. In the latter cases the quantity of osazone would, in all probability, have been ample, for with the impurity out of the way a very small quantity of osazone is enough to enable the nature of the sugars to be determined. With very small quantities watch-glasses are used instead of beakers, and evaporation is employed instead of precipitation and filtration.

In separating the osazones of arabinose and galactose advantage is taken of the relative insolubility of galactosazone and the solubility of arabinosazone in hot water, together with the relative insolubility of galactosazone in dilute alcohol. The osazones are either treated with hot water, then with solutions of hot alcohol of increasing strengths, or they are completely dissolved in hot strong alcohol, which is slowly evaporated, hot water being added to maintain the original volume. Both methods are fractional, and galactosazone (m.p., 193°) is obtained at one end, and arabinosazone (m.p., 158°) at the other. The intermediate fractions consist of mixtures of the two. The end products are known to be pure by microscopical observation and by their inability to be resolved into fractions with differing melting-points. In the microscopical examination oil-globules and amorphous particles are sought for; the presence of these show that the purification of the osazone has not been complete. The intermediate fractions are either treated as before, or they are grouped together before treatment according to their respective melting-points.

The natural gum of *Acacia binervata* and the bacterial gum hydrolysed to the same sugars — viz., arabinose and galactose—in about the same proportions. Furthermore, as the gum-acids of both gums were easily soluble in water, there was no doubt that the natural gum had been the product of the bacterium which I had isolated from the tissues of the tree.

Many of our wattle-gums are insoluble in water, swelling up to form a jelly; others, again, are partly soluble and partly insoluble. The insoluble gum is known as "metarabin" or "cerasin," and is a modification of the soluble arabin. From a tree which furnished a mixture of arabin and metarabin I obtained *Bact. acaciæ*, the arabin-former, and another *Bact. metarabinum*, which produced a slime. From this there was obtained a soluble gum that upon desiccation became insoluble, swelling up to form a jelly just like metarabin. It was an arabinan-galactan gum, and undoubtedly was metarabin. Thus the bacterial origin of metarabin was proved.

That the activity of *Bact. acaciæ* and *Bact. metarabinum* is not confined to the particular trees examined, or even to the trees of that particular natural order, was shown by their presence in the vine, and of one of them—*Bact. acaciæ*—in the cedar, the peach, the plum, the almond, *Sterculia* and *Diospyros*, all of which exhibited gum-flux.

The mucilage that exudes from several species of *Sterculia* consists of a mixture of arabin and pararabin. An investigation showed that the former was produced by *Bact. acaciæ* and the latter by *Bact. pararabinum*, Greig Smith. This organism produces its slime on or in almost any medium, and from the slime the gum can be readily obtained upon digestion in the autoclave. Like pararabin, the bacterial gum tended to revert to the insoluble condition, and this form was soluble in dilute acids and insoluble in dilute alkali. It was not hydrolysed upon being boiled with dilute (5 per cent.) sulphuric acid, while concentrated acid converted it to a mixture of arabinose and galactose. Thus the gum had all the typical properties of pararabin, which it undoubtedly was. The pararabin of *Sterculia* therefore owes its origin to the activity of *Bact. pararabinum.*

In the tissues of the peach, almond, and cedar there was found an organism—*Bact. persicæ*, Greig Smith—which produced a slime upon solid and in fluid media containing a sugar. From the fluid cultures only a soluble gum was obtained, which easily reverted to the insoluble condition. Although it was hydrolysed by dilute acid to a mixture of arabinose and galactose, its reactions showed that it differed from the members of the arabin group. The gum was soluble in faintly acid alcohol, and by taking advantage of this property a small quantity of the same gum was separated from the insoluble portion of the natural gum of the almond.

These examples show that the chief vegetable gums have a bacterial origin, and it is probably but a matter of investigation to show that all vegetable gums are likewise the products of bacteria. The proof of those which I have quoted depended upon the chemical identity of the natural and the laboratory product, but before this could be done improvements had to be effected in the methods of growing the slime, of obtaining the gum, and of determining the products of hydrolysis; all of which I have described in this paper.

No. 6.—THE RESIN-ACIDS OF THE *CONIFERÆ*.

Part I.—The Chemistry of Colophony.

By Thomas H. Easterfield and George Bagley.

The forest flora of New Zealand is peculiarly rich in coniferous trees, no fewer than four genera and twenty species having been recorded. Many of these trees are highly resinous, but the chemistry of their resins has hitherto remained uninvestigated, with the exception of kauri-resin (from *Dammara australis*), which has been superficially studied by various chemists.

It is a well-known fact that the resins have received less attention on the part of the scientific chemist than almost any class of vegetable products. Indeed, our knowledge of the chemical constitution of the constituents of the plant-resins is to-day in as unsatisfactory a state as was that of the sugars before the investigations of Kiliani and of Emil Fischer. The labours of these authors have demonstrated that the sugars are built upon a common type, and a similar rule appears to be generally true in the case of the terpenes, the fixed oils, the tannins, and the alkaloids.

Analogy would seem to indicate that the vegetable resins should have some common basis of constitution, or that, at any rate, the resin-acids derived from plants belonging to a common genus, or even to a common order, should be built upon a common type. With this idea as a working hypothesis, and as an introduction to the study of the New Zealand *Coniferæ*, the authors have carried out a series of experiments upon the constitution of abietic acid, the principal constituent of common colophony.

Though the resin-acids derived from the *Coniferæ* differ greatly amongst themselves, they appear to possess the following common properties:—

(1.) They show in a marked degree the phenomenon of superfusion, setting if quickly cooled to a glass or resin with no definite melting-point.

(2.) They behave as unsaturated compounds of carbo-cyclic character, yielding both addition products and nitro derivatives.

(3.) They do not form ethereal salts when treated with alcohol and hydrochloric acid, and hence probably contain a diortho-substituted carboxyl group.

(4.) When treated with hydriodic acid they readily yield hydrocarbons, which have generally, though erroneously, been regarded as diterpenes.

In the expectation that examination of the products of reduction and the products of destructive distillation of abietic acid would yield the key to the constitution of the acid, the authors have paid much attention to these reactions. Contrary to expectation, it was found that the action of destructive distillation and the action of hydriodic acid bring about the same reaction.

$$C_{19}H_{28}O_2 \text{ (abietic acid)} = C_{18}H_{28} \text{ (abietene)} + CO_2.$$

The composition of abietene is within the limits of experimental error almost the same as that of a diterpene, which no doubt accounts for the fact that the hydrocarbon has been mistaken for a diterpene.

Calculated for $C_{20}H_{32}$.	Calculated for $C_{18}H_{28}$.	Found. I.	II.
C = 88·2	88·5	88·3	88·6
H = 11·8	11·5	11·7	11·2

Molecular-weight determinations favour the formula $C_{18}H_{28}$.

Calculated for $C_{20}H_{32}$.	Calculated for $C_{18}H_{28}$.	Found.
M = 272	244	244 and 249

The most conclusive evidence, however, as to the origin of the hydrocarbon is obtained by examining the action of hydriodic acid upon abietic acid. Abietene and oxides of carbon are practically the only products of the reaction; it is remarkable that amongst the gases carbon-monoxide greatly preponderates.

When abietene results by distillation of abietic acid under diminished pressure in iron vessels no other volatile products are produced.

Abietene has the specific gravity ·973 and refractive index 1·538; the boiling-point is 250° at 82 mm., 340–345° at 760 mm.; it is optically active. It rapidly absorbs nearly 10 per cent. of its weight of oxygen from the air; with slaked lime it forms a "grease," in which respect it resembles commercial resin-oil, of which it is no doubt an important constituent.

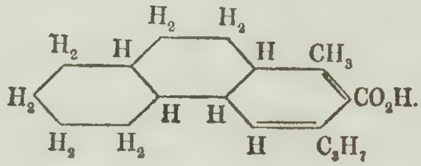
The fact that abietic acid is capable of simple resolution into abietene and carbonic anhydride shows that the gas is to be regarded as abietene carboxylic acid. If, then, the constitution of abietene can be arrived at, the constitution of abietic acid itself will be known. As a matter of fact, abietene is deca-hydro-retene; abietic acid is therefore deca-hydro-retene-carboxylic acid.

That abietene is deca-hydro-retene is rendered highly probable by the observation that carefully purified abietene, if dehydrogenised by means of sulphur, yields retene, and by the discovery that abietene, upon reduction, yields a di-hydro-abietene of the same composition and almost the same boiling-point as the dodeca-hydro-retene obtained by Liebermann and Spiegel as the ultimate product of the reduction of retene.

Calculated for $C_{18}H_{30}$.	Found.
C = 87·8	87·7
H = 12·2	12·3

Objection may be raised to the suggested constitutional formula for abietic acid on account of the fact that the accepted constitution for retene does not allow of the possibility of diortho-substituted mono derivatives. This objection, however, is at once met by drawing attention to the fact that the relative position of the alkyl groups in retene has been hitherto assumed, and never experimentally investigated. That the alkyls in abietic acid are really in the meta and not in the para position is rendered highly probable by the observation, due to Kelbe, that meta-cymene is an important constituent of resin-spirit.

All the known facts about abietic acid are explained by the constitutional formula—



In particular the formula satisfactorily accounts for the following facts:—

(1.) Abietic acid is intimately related to retene and to fichtelite, both of which hydro-carbons occur in the fossil pine forests of Bavaria.

(2.) Meta-cymene occurs amongst the products of destructive distillation.

(3.) Trimellitic acid is a constant product of oxidation.

(4.) Nitro derivatives have been obtained.

(5.) The optical activity of the acid is not destroyed when the carboxyl group is eliminated.

(6.) The velocity of esterification is extremely low.

During the course of the experiments which have led the authors to the above constitutional formula the following further points were noticed :—

The distillation of colophony under reduced pressure does not yield iso-sylvic anhydride, as stated by Bischoff and Nostvogel; the product of distillation has the composition of abietic acid, and is not changed by six refractionations.

In the presence of metallic iron colophony cannot be distilled, even at 15 mm., without much decomposition into abietene and carbonic anhydride.

The distillation of colophony with superheated steam can be carried out in iron stills (Hunt and Pochin's 1858 patent), and the distillate from the first coil, if slowly cooled, sets to a crystalline mass of abietic acid.

The distillation of abietene with sulphur gives rise either to retene or to a hydrocarbon melting at 86°, according to the conditions under which the reaction is carried out. The hydrocarbon melting at 86° has the same composition as retene, and has been prepared by distilling Merck's "retene puriss" with sulphur.

No. 7.—THE ACIDS OF SOME NEW ZEALAND TIMBER TREES.

By Professor EASTERFIELD.

No. 8.—ON THE RETROGRESSION OF SOLUBLE PHOSPHATES IN MIXED MANURES.

By George Gray, F.C.S., Lecturer on Chemistry, Canterbury Agricultural College, Lincoln, N.Z.

The term "retrogression" applied to superphosphate of lime implies certain chemical changes by which the soluble monocalcic phosphate is converted into an insoluble form.

The chief advantage possessed by superphosphate over other forms of phosphatic manure lies in the fact that the phosphoric anhydride, being in a soluble form of combination, is better distributed through the soil, and brought more within the range of plant-roots. In well-made superphosphate the retrogression is but small, but in cases where insufficient sulphuric acid has been employed, and the raw tricalcic phosphate is but partially decomposed, the degree of retrogression may be considerable. In the presence of undecomposed tricalcic phosphate monocalcic phosphate is reduced to the condition of dicalcic phosphate. In cases where the original phosphate contains much calcic carbonate, and where a portion of this remains undecomposed, or where superphosphate is mixed with other manures containing calcic carbonate, the retrogression may proceed further, and tricalcic phosphate may be formed. When iron is present in the raw phosphate, either as silicate or as pyrites, no action occurs; but when in the form of ferric or ferrous oxide these form the corresponding sulphates, which react on the monocalcic phosphate, and the retrogression is of a more serious nature. Alumina when present also causes retrogression, but the reactions are similar to those with calcium-compounds. The retrograded phosphates are insoluble in water, but soluble in solutions of ammonic citrate, and hence the term "citrate soluble phosphates," frequently applied.

Considerable difference of opinion exists as to the agricultural value of these citrate soluble phosphates, some agricultural chemists regarding them as being of equal value to the monocalcic phosphate, while others consider them only of value equal to tricalcic phosphate. Considering that the diffusive power of the phosphoric acid present has been destroyed, my own practice has been to value them only as tricalcic phosphate. Manufacturers generally argue that, as the tricalcic phosphate has been rendered once soluble at their expense, they should receive credit for it, while agriculturists maintain that it is only fair that they should pay a higher price for the phosphoric acid actually existing in the soluble form, and that the retrograde phosphate should be assessed at a lower value.

In the blending of manures, such as is largely done by our freezing companies, mistakes are often made, and the value of the superphosphate used considerably reduced by retrogression. Farmers, again, by mixing superphosphate with other substances in order to improve the mechanical texture, and to cause the manure to pass more easily through the drill, often completely destroy the soluble phosphate for which they have paid an increased price, the comparative market value of the soluble to the insoluble phosphate being about 100–63.

The object of the present investigation was to ascertain the nature of the retrogression, and the rate at which it proceeds in mixtures of superphosphate and other manures such as have come under notice as having been used in actual practice. In the experiments a good, well-made superphosphate was employed, containing "soluble" phosphate equal to 17·74 per cent. of phosphoric anhydride. This was mixed with equal parts of other manures and the amounts of water soluble, citrate soluble, and insoluble phosphate determined from time to time. Briefly, the method of analysis consisted in extracting the mixtures with pure water and afterwards with a neutral solution of ammonium-citrate, determining the total phosphoric anhydride, that soluble in water, and that insoluble in ammonium-citrate, the citrate soluble being taken by difference. The method of determining citrate soluble phosphoric anhydride is not by any means a satisfactory one, but still it is the best in use. Ammonic-citrate solution, even when neutral, attacks the various forms of phosphates in different degrees. Thus the manures used in the present case were found to yield to neutral ammonic-citrate solution proportions of tricalcic phosphate equivalent to phosphoric anhydride as follows: Bonedust, 9 per cent. of total phosphoric anhydride; Chesterfield guano, 17·5 per cent.; Coral Queen guano, 18·5 per cent.; basic slag, 16·4 per cent.

The following table (A) shows the condition of the phosphoric anhydride on first mixing the manures and at intervals afterwards. The results are all expressed as phosphoric anhydride.

TABLE A.—Showing Retrogression of Soluble Phosphoric Anhydride in Mixed Manures.

—	Original Mixture.	3 Hours.	24 Hours.	6 Days.	12 Days.	18 Days.
1. A mixture of equal parts of superphosphate and bonedust:—						
Phosphoric anhydride—						
Soluble in water	8·87	8·87	8·87	8·87	8·62	8·62
Citrate soluble	1·57	3·45	3·95	3·70	3·95	3·95
Insoluble	9·63	7·75	7·25	7·50	7·50	7·50
Total	20·07	20·07	20·07	20·07	20·07	20·07

TABLE A—*continued.*

—	Original Mixture.	3 Hours.	24 Hours.	6 Days.	12 Days.	18 Days.
2. Equal parts of superphosphate and Coral Queen guano:—						
Phosphoric anhydride—						
Soluble in water	8·87	8·87	8·57	8·37	8·37	8·25
Citrate soluble	3·43	10·89	7·94	9·64	8·64	8·26
Insoluble	12·96	5·50	8·75	7·25	8·25	8·75
Total	25·26	25·26	25·26	25·26	25·26	25·26
3. Equal parts of superphosphate and Chesterfield guano:—						
Phosphoric anhydride—						
Soluble in water	8·87	7·87	7·37	4·87	4·00	3·37
Citrate soluble	2·24	1·95	1·45	3·70	3·32	4·70
Insoluble	8·21	9·50	10·50	10·75	12·00	11·25
Total	19·32	19·32	19·32	19·32	19·32	19·32
4. Equal parts of superphosphate and basic slag:—						
Phosphoric anhydride—						
Soluble in water	9·43	4·00	2·12	1·37	1·25	1·12
Citrate soluble	2·49	15·67	16·05	14·80	15·92	14·80
Insoluble	10·25	2·50	4·00	6·00	5·00	6·25
Total	22·17	22·17	22·17	22·17	22·17	22·17
5. Equal parts of superphosphate and kainit:—						
Phosphoric anhydride—						
Soluble in water	8·87	8·87	8·87	8·50	8·25	8·25
Citrate soluble	0·72	1·75	1·75	0·62	1·62	2·37
Insoluble	1·03	0·00	0·00	1·50	0·75	0·00
Total	10·62	10·62	10 62	10·62	10·62	10·62
6. Equal parts of superphosphate and slaked lime:—						
Phosphoric anhydride—						
Soluble in water	8·87	0·50	0·00	0·00	0·00	0·00
Citrate soluble	0·72	7·37	10·62	6·87	7·87	6·62
Insoluble	1·03	2·75	0·00	3·74	2·75	4·00
Total	10·62	10·62	10·62	10·62	10·62	10·62
7. Equal parts of superphosphate and ground limestone:—						
Phosphoric anhydride—						
Soluble in water	8·87	7·87	1·75	1·12	0·75	1·25
Citrate soluble	0·72	2·03	8·15	8·78	9·15	8·65
Insoluble	1·06	0·75	0·75	0·75	0·75	0·75
Total	10·65	10·65	10·65	10·65	10·65	10·65

Table B shows the percentage of the total phosphoric anhydride present that has retrograded during different periods.

TABLE B.—Showing Percentage of Total Soluble Phosphoric Anhydride reduced.

Mixture.	3 Hours.	24 Hours.	6 Days.	12 Days.	18 Days.
1. Superphosphate and bonedust ..	0·0	0·0	0·0	2·8	2·8
2. Superphosphate and Coral Queen guano	0·0	3·3	5·3	5·3	7·0
3. Superphosphate and Chesterfield guano	11·2	16·9	44·8	54·9	62·0
4. Superphosphate and basic slag	57·6	77·5	85·4	86·7	88·1
5. Superphosphate and kainit ..	0·0	0·0	4·1	6·9	6·9
6. Superphosphate and slaked lime	94·3	100·0	100·0	100·0	100·0
7. Superphospate and crushed limestone	11·2	80·2	87·3	91·5	85·9

Superphosphate and Bonedust. — In this mixture the amount of retrogression is small and proceeds but slowly. The citrate soluble phosphoric anhydride is increased at the expense of the insoluble phosphate. This is probably due to the solvent action of ammonium-citrate on tricalcic phosphate before mentioned. The low degree of retrogression in the case of the bonedust mixture may to some extent be due to the protection to the tricalcic phosphate afforded by the ossein present. Doubtless bonedust is the best form in which to use tricalcic phosphate for mixing with superphosphate.

Superphosphate and Coral Queen Guano.—The sample of Coral Queen guano used contained 63·9 per cent. of tricalcic phosphate and 1·1 per cent. of calcic carbonate, together with about 8·8 per cent. of iron-oxide. Like bonedust, this manure appears to be slow in its action, only 7 per cent. of the soluble phosphoric anhydride being reduced after eighteen days. The amount of citrate soluble phosphate is considerably above that, due to retrogression, as in the case of bonedust, and the proportion is higher than that in the latter, due to the greater solvent action of the citrate-solution on the guano.

Superphosphate and Chesterfield Guano.—This guano is characteristic in containing a high percentage of calcic carbonate (37·9 per cent.), and, as may be expected, retrogression is considerable, and has proceeded not only to the stage dicalcic phosphate, but beyond this, to form insoluble tricalcic phosphate.

Superphosphate and Basic Slag.—The influence of basic slag on superphosphate is due to two causes—the action of calcic oxide and the action of proto- and per-salts of iron. As is shown later, calcic oxide is very active in retrogression, and the oxides of iron produce reduction of the worst kind. Table B shows that within three hours over 50 per cent. of the acid was in an insoluble form. The production of phosphates of iron has increased the proportion of citrate soluble compound considerably.

Superphosphate and Kainit.—The action of kainit is due mainly to the salts of magnesium present The retrogression is small, only about 7 per cent. of the acid being reduced in eighteen days.

Superphosphate and Slaked Lime.—The retrogression of superphosphate with slaked lime is particularly rapid, 94 per cent. of the soluble phosphoric anhydride being reduced within three hours, and the whole amount present within twenty-four hours. When mixed considerable heat is evolved and moisture evaporated. It is mainly the dicalcic phosphate that is formed at first, although probably with longer time this would further revert to the form of tricalcic phosphate.

Superphosphate and Ground Limestone.—The effect of calcium-carbonate, although not so great as that of slaked lime, is yet considerable. When mixed with superphosphate carbon-dioxide is at once evolved, and within twenty-four hours 80 per cent. of the phosphoric anhydride present is converted into a form in which it is soluble in ammonic citrate.

No. 9.—PROPOSAL TO FORM IN AUSTRALASIA A BRANCH OF THE BRITISH CHEMICAL SOCIETY.

By F. M. Allan.

That an association of those interested in analytical chemistry, at any rate, is required was clearly demonstrated in the presidential address of Mr. Brownlie Henderson on adulterations of food and the use of preservatives. The statements made there as to the extent to which adulteration of food is carried on can be borne out by all who are engaged in analytical work as well in New Zealand as in Australia.

At present analytical chemists have no status in Australasia; and, although a Chemical Society would not, from the nature of its constitution, have the same weight as a body composed solely of analytical chemists, it would be a step in the right direction, and the recommendations of such a society would carry more weight than those of isolated analysts with the Legislatures of the various countries. When the time is ripe for it the public analysts might then form themselves into a special section.

To the members generally of the society the advantages to be gained would be—

1. It would surely be quite possible to arrange that each member would receive a copy of the Transactions of the British Chemical Society.

2. Nuclei of libraries could be formed in the capitals of each country, the principal one being in the capital of the Commonwealth, whence books could be sent to the members.

3. Annual conferences for the discussion of all matters of interest to the society and for the reading of papers could be held at the same time and place as the meetings of the Australasian Association for the Advancement of Science.

Besides public analysts, the society would look for its members among professors and teachers of chemistry, analysts connected with Governments and with various industries and manufactures, managers of factories, gasworks, mine-managers, students, &c.

The above is merely a brief outline of the proposal for the purpose of obtaining the opinions of those present on the matter. If the idea is favourably received a committee might be appointed—

1. To communicate with the Chemical Society in order to ascertain their views.

2. To discover what support the society would be likely to have.

3. To draw up a rough draft of the constitution of the society, to be presented at the next meeting of the Australasian Association for the Advancement of Science.

Section C.

GEOLOGY AND MINERALOGY.

PRESIDENTIAL ADDRESS.

By W. H. Twelvetrees, Government Geologist of Tasmania.

(Delivered Thursday, 7th January, 1904.)

ON SOME ASPECTS OF MODERN PETROLOGY.

It is the custom for your President in his annual address either to review broadly the geological work of the day, or to put together some thoughts on any subject to which he may, for one reason or another, have more or less specially devoted his attention. I have ventured to choose the latter course taking the somewhat specialised subject of modern petrology, partly because I have for many years followed its progress, though haltingly, and with the mind of a learner; partly because you have not yet had a presidential address on the subject; and partly because its position at the present time is deserving of more attention than it generally receives from geologists.

I must warn you first of all that as a systematic science it is as yet immature, being in the throes of a process of evolution. Much of its current doctrine is open to argument, and its progress is attended by severe conflicts of opinion. This is inevitable; without it the science would only mark time and then surely recede. I confess that many shrink from the science as an unattractive one, but my conviction is that this is often due to the unfortunate mode of its presentation. If it is divorced from geology it ceases to have a *raison d'être*. This happens when the cabinet petrographer treats rocks from a strictly quantitative mineralogical standpoint, ignoring them as geological units, and taking no interest in them as parts of rock-masses. The geologist, however, is interested not only in the individual varieties met with in any one mass, but also in the mutual relationships of such masses, and in the facts connected with their distribution in different areas. Petrology thus becomes a wider science than is involved in the purely mineralogical study of rock-specimens.

Our ideas respecting the genesis of eruptive rocks have in modern times increasingly favoured the assumption that an evolution of rock-species has taken place by some process of differentiation. The particular mode of differentiation in any case is a matter for discussion, and even the homogeneous magma, which the differentiation hypothesis postulates as a primordial condition, is challenged as being a dubious assumption. Becker's objections to the existence of reservoirs or masses of homogeneous lavas and to differentiation by slow molecular flow are forcible. He goes on to claim that different rock-types are due to original differences in the composition of the globe. Here we are involved in large questions. Has there ever been such a thing as a universal homogeneous magma? and, if so, has it remained homogeneous in spite of heterogeneous wall-rocks which it has attacked and assimilated in making its way to the surface? The theory of differentiation in place by molecular flow only has received a severe shock, and other processes have to be called in to account for the results. But, though the absolute homogeneity of this magma rests possibly on unproved assumptions, and the controlling ancestral factors in the birth of a given rock-species may have originated in the pre-natal history of the magma itself, it is sufficient for practical purposes if the fact of differentiation be admitted. Once, however, this admission is made, then the inference follows that genetic bonds unite the geologically contemporaneous eruptive masses of any district in a petrographical complex.

Professor Judd, recognising a certain community of characters in the igneous rocks of a given district, launched the happy term "petrographical province." He referred to "petrographical provinces within which the rocks erupted during any particular geographical period present certain well-marked peculiarities in mineralogical composition and microscopical structure, serving at once to distinguish them from the rocks belonging to the same general group which were simultaneously erupted in other petrographical provinces."*

The consanguinity of all the contemporaneous rocks in a single province has been powerfully sustained by Professors Iddings and Brögger, and need not here be further dwelt upon. If it be a sound doctrine we shall find the relationship declaring itself by outward and visible signs. There will be minute resemblances traceable in the various rocks of a country. On the other hand, it does not follow that rocks of provinces widely distant from each other will be always specifically extinct, for almost identical rocks may be produced on opposite sides of the globe. We are often too ready

* Q.J.G. Soc., 1886, vol. xlii., p. 54.

to conclude that the magmas are the same, until some extreme result shows that the identity is not absolute. Even in our granitic and dioritic rocks, often supposed to be universally uniform, there is no worldwide identity, as witness Spurr's alaskites and belugites, and the well-known granodiorite, besides other instances which need not be mentioned. Mr. Card's investigations go to prove distinctions between the lamprophyric rocks of New South Wales and those of Europe —distinctions sufficiently marked to make the European textbooks useless for naming purposes. The elaeolite syenites of Tasmania are distinct in type from those of Scandinavia and Brazil. Professor J. W. Gregory states* that the sölvsbergites of Mount Macedon, Victoria, though resembling those of southern Norway, have not been derived from an identical magma. He also calls attention to and bestows a new name (geburite dacite) on the Mount Macedon dacites, which contain nearly 50 per cent. more alkalies than typical dacite. In Africa, too, we have a new type of sodic lava in the same author's "kenyte," from Mount Kenia, apparently related to pantellerites, but containing olivine; and a similar type of rock containing anorthoclase, aegerine augite, soda hornblende, and olivine is mentioned as characteristic of country east of Lake Victoria.† It is known also in Antarctica.

In the study of rocks chemical investigations must go hand-in-hand with optical analysis, and neither must receive undue prominence. The natural limitations of each should be recognised. Much is often learned from the optical characters of rock-slices which could not possibly be revealed by the methods of the chemical laboratory. With the enormous power conferred on students by the microscope the last half of last century witnessed perhaps too exclusive a reliance on optical methods. Both chemical and field investigations retreated somewhat; but a healthier spirit has set in during the last few years, and increasing drafts have been made on chemistry and geology. The rock-analyses which are now proceeding in the laboratories of the Geological Survey of the United States are the most valuable, perhaps, which have ever been undertaken, and will lay an obligation upon all geologists who have occasion to make use of the results. Now, when chemical composition is largely regarded as being the basis of rock-classification, it is instructive to note the movement of opinion since twenty years back. At that time it was objected to on the score of its neglecting the history of a rock, and possibly associating igneous rocks and their derivatives. The reply to this would be that for such discrimina-

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* "Geology of Mount Macedon." By Professor J. W. Gregory. Proc. Roy. Soc., Vict., April, 1902.

† "Geological Notes from Tanganyika northwards." By M. Ferguson. Geol. Mag., Aug., 1901, p. 369.

tion we must use other methods. In any case, caution is necessary, for some of the changes wrought by the processes of metamorphism may be chemical ones. In a broad sense, nevertheless, and applied to unaltered eruptive rocks, the chemical analysis enables us to refer them to their appropriate magmas. On the other hand, chemical composition *per se* cannot be broken up into such divisional characters as could be used for systematizing. We can only employ it in a practical way by connecting it with magma: we must then connect mineral composition with the consolidated rock. In what precise way we do this is regulated by our subjective views, and hence the appalling confusion. Besides, the divisional boundaries in any system must be arbitrary, and thus one system after another has put forward its claims to sway our thought. Shall this empiricism be accentuated by an endeavour after greater precision? I would rather urge that the vagueness which we find in nature shall be frankly recognised by a correspondingly elastic classification and terminology. If you turn from this as a counsel of despair, I sympathetically resign to you the task of threading the maze which contemporary systems have constructed.

The application of the microscope to the study of rocks has steadily grown in importance, and the polarising microscope of to-day is a very different instrument from the cruder form of thirty years ago. New methods of optical examination have sprung into existence, and improvements are still appearing on the horizon. The young student of to-day is enviable, for he starts easily upon a plane to which some of us have struggled painfully. It is this instrument which has given birth to micro-chemical methods of great promise in the future; it has enabled us to make use of staining processes; the birefringence, the pleochroism, the extinction angles, the optical character, the formation, the decomposition of minerals in a rock-slice are brought within the range of observation by its aid. Microscopical methods have proved so reliable that no one would now dream of labelling an eruptive rock with a name before examining a thin section of it upon the stage of a microscope.

CLASSIFICATION AND NOMENCLATURE.

These are at present largely exercising the minds of petrographers. A loudly expressed desire for uniformity in both is being heard. As yet, however, international agreement is an unrealised dream. The text-books which appear from time to time show great divergencies, and the proceedings of the International Geological Congress held in Paris, 1900, disclosed fundamental differences of opinion. When the resolution of the Petrography Commission was put before the section, recommending that the character of the larger groups (such as families) be based upon mineral composition, supported by chemical composition and structure, although it was passed, a strong minority urged that such groups should be founded primarily on chemical composition. The Congress considered that the large groups should remain without alteration, so as not to hinder either subsequent classification or their subdivision into minor groups. The French committee was strongly in favour of the nomenclature of the large groups being based exclusively on mineralogical composition and on structure, and of petrographers being left at liberty to select the names for the secondary divisions from existing systems.

The discussions in Paris disclosed such varying views as the following: 1. Nomenclature should be based on the collective relations of rocks—viz., geological *rôle*, mineral and chemical composition, and structure (Becke and Iddings). 2. Nomenclature should be based primarily on structure, secondarily on mineral composition (Fédoroff). 3. Classification and nomenclature should be based on mineral composition which corresponds with chemical composition, and on structure (Karpinsky). 4. Nomenclature should be based primarily on mineral composition, and secondarily on chemical composition (Duparc). 5. Classification should be based in the first place on chemical composition (Loewinson - Lessing and Brögger). 6. The basis of classification should be mineralogical composition corresponding with chemical composition (Michel Levy).

Assuming some general agreement as possible as far as principles are concerned, the formation of the nomenclature opens a wide field for argument applied to new rocks. Should it be geographical — *e.g.*, "alaskite"? Should it be mineralogical—*e.g.*, "ilmenite-bronzitite"? Should it be descriptive — *e.g.*, "biotite-granite"? or univocal — *e.g.*, "granitite"? Should it express structure, as "grano-phyre"? or texture, as "aphanite"? Should it express phase of consolidation, as "augite porphyry"? It may be doubted whether the time is ripe for the authoritative formulation of a universal nomenclature.

One thing is certain, that uniformity of usage throughout the world is not attainable by resolutions adopted by any congress, however truly international its character. The study of rocks has been approached in different countries from different sides, and the history and literature of the science in each country have accentuated the several methods of investigation and fixed the terminology. Authors in the respective countries naturally adopt the principles with which their minds have been saturated; and not even the decisions of a congress will be accepted as authoritative. But, short of this, the expression of international thought must be hailed as a useful guide, and with repeated efforts some advance may be made towards the desired end.

Attempts made hitherto in Australasia to classify eruptive rocks have followed English lines in using the SiO_2 percentage as the controlling factor. Attention to the felspathoid rocks, however, would lead us to doubt the soundness of this principle, for its application would result in grouping together in one and the same division rocks which we find are rarely associated in nature. Rosenbusch separates his foyaitic-theralitic magmas from the granito-dioritic ones, and it follows that the rocks derived from these respective magmas should be separated also. Among us, Mr Stanley Jevons has taken this view, and has propounded a classification of the alkali rocks in accordance with it. I was not aware of his scheme when I put forward a tentative classification of igneous rocks in Tasmania, at the last Congress, framed under the influence of the same ideas. I believe these principles are destined to meet with growing acceptance. Professor Lacroix, in his recent monograph on alkaline rocks in Madagascar, adopts them in so far as he subdivides his families into alkaline and normal sub-families. These ideas invest petrology with geological interest; they satisfy the laws of rock-association for which Rosenbusch and Brögger have strongly pleaded; and for introduction to the study of eruptives they as far surpass the purely mineralogical schemes of cabinets and museums as in the domain of botany the natural system does that of Linnæus.

Neglecting the wider questions, however, if Australasian petrographers could arrive at some agreement among themselves as to names for Australasian igneous rocks, it would relieve our literature of much confusion. A beginning, such as has been undertaken by this section, will surely lead towards the goal, however slowly. It is possible that if the views of those who have especially studied the eruptives of their several States are obtained and compared, an approach to an agreement may be in sight. Opinions on classification may differ widely, and yet a uniform nomenclature may not be so altogether utopian as in our timid moments we are apt to apprehend.

In classifying, a point for decision is whether the mode of occurrence of a rock should receive any expression; in other words, are we to arrange our rocks in any way expressive of their occurrence as effusives and plutonics, or are we to leave this entirely out of consideration? The field geologist is generally found on one side, the cabinet geologist on the other. The latter, with some reason, objects that in nine cases out of ten the mode of occurrence is unknown to him, and any classification dependent upon that factor is useless to him. The field geologist, on the other hand, prefers to group his specimens as parts of rock-masses. The two views are diametrically opposed, and until some mutual readjustment takes place the two schools must agree to differ. A compromise has been attempted in the divisions "holocrystalline," "hemicrystalline," and "vitreous" in lieu of "plutonic," "intrusive," and "effusive," though the correspondences of structure with mode of occurrence are not thorough.

In recent years Osann (1900–2) has published an attempt at a chemical classification of eruptive rocks, in which he has in the main adopted the families established by Rosenbusch, erecting types within each family on the basis of chemical analyses. Once we admit the Rosenbuschian families to be natural ones, the rest is more or less a matter of detail. The American criticism of them is that they are too vaguely defined to be of use for systematic work. The weakness of Osann's system appears to consist in using chemical criteria for sub-classification in lieu of mineralogical ones.

In July, 1901, Mr. Stanley Jevons published a preliminary note on nomenclature and a scheme of classification of the plutonic alkalines, based upon mineral composition. The families are mostly logical extensions and variations of the Rosenbuschian ones, defined by the presence of index minerals. Jevons boldly includes alkali granites and alkali syenites (under the names of "aligranites" and "alisyenites") in the alkaline series; the other series being the calc-alkaline. All who appreciate the factors of rock-association and petrogenesis will recognise in this essay a well-considered attempt to give them proper weight in classification.

The new American classification by Messrs. Cross, Iddings, Pirsson, and Washington is intended to replace all other systems wholly and finally. The authors plead an indisposition to remodel existing systems, and claim for their scheme that it includes rocks of like chemical composition in the same division and recognises quantitative proportions of standard minerals in a rock. It has been elaborated with great care, and cannot be dismissed summarily. There is much in it that is admirable, but the novelty of it and the revolution in terminology which it introduces are startling. It will take time to familiarise ourselves with these new concepts and to consider whether we can do more than concede to the system a place in academic petrography. The real question, as it seems to me, which concerns us now is whether we can use it to advantage as a practical working-instrument. It will stand or fall as it responds or not to that test. The next few years will show whether this thoughtfully prepared scheme meets with international acceptance.

It arranges igneous rocks in five classes, based on the relative proportions present in each class of two great mineral groups called "salic" and "femic," the salic being siliceous and aluminous minerals, the femic being ferro-magnesian ones. These two groups are represented by five classes with arbitrary divisional lines. In two of the classes the salic minerals exceed in amount the femic, in two others the femic exceed the salic, and in the remaining class the proportions of the two are equal. The class names are—

1. Persalane: extremely salic ...	$\frac{\text{Sal.}}{\text{Fem.}} > \frac{7}{1}$
2. Dosalane: dominantly salic ...	$\frac{\text{Sal.}}{\text{Fem.}} < \frac{7}{1} > \frac{5}{3}$
3. Salfemane: equally salic and femic	$\frac{\text{Sal.}}{\text{Fem.}} < \frac{5}{3} > \frac{3}{5}$
4. Dofemane: dominantly femic ...	$\frac{\text{Sal.}}{\text{Fem.}} < \frac{3}{5} > \frac{1}{7}$
5. Perfemane: extremely femic ...	$\frac{\text{Sal.}}{\text{Fem.}} > \frac{1}{7}$

The sub-classes and minor divisions are founded on mineralogical ratios. All are worked out with logical completeness and much ingenuity.

It is necessary to mention that this classification is chemico-mineralogical, based on a standard mineral composition of the magma, as distinguished from the actual one, and is quite independent of the actual crystallization. The standard and actual mineral composition may differ, but the analysis of the rock will enable the standard composition, or the "norm," as the authors term it, to be calculated, and in extreme rocks the standard minerals will agree closely with the actual ones.

In addition to magmatic names, a further nomenclature is introduced to indicate the actual mineralogy and texture of the rocks. The uncouth terminology throughout is repellent, but is really no inherent part of the scheme. It could be varied, even replaced, and the classification would remain unaffected. Hence we need not take it seriously. To pursue it now into its many ramifications is hardly necessary. The system may be a finished and flawless product, but sentiment, tradition, use, combine in consolidating our attachment to past and familiar modes of speech.

It is too early yet to criticize it seriously: all that I am in a position to do at present is to allow a floating thought to crystallize. The one idea which will not be suppressed is that this carefully devised scheme is more suitable for museum-shelves than for real and active geological work. There is a want of adjustability in it detrimental to the expanding science of petrology. For undeniably the science is widening its basis. The growing study of petrogenesis and the laws of association will, it can be foreseen, make their impress on the petrology of the future. Any system which, aiming at precision, tends to cramp and confine the science will surely fail to exercise any permanent dominant influence on petrologic thought.

It is not easy to select a substitute for this comprehensive scheme. I fear we have not yet reached the time for complete systems. We are not yet agreed on our definitions, hence our classifications must needs be provisional. Even so, their formulation does no harm. It brings the salient features of each to the notice of students all over the world, and we are able to see just how much or how little real agreement exists among us. I think we all have a fair idea of what we understand by the various rock-families, even if we cannot agree on our definitions of them. Their limits may be somewhat vague, but this is in harmony with the facts, and is an imperative feature in the requirements of the science.

For the present I incline to the use of an elastic working-system for geologists, disturbing existing usage as little as possible. The Rosenbuschian families are largely used by British and European petrologists; they are more or less familiar to all of us. Drawing my inspiration from this great German master, but with a modified arrangement, I find the following simple scheme responds fairly well to geological needs :—

A. Lime-alkali Rocks.

1. The granite-rhyolite family.
2. The syenite-trachyte family.
3. The diorite-andesite family.
4. The quartzdiorite-dacite family.
5. The gabbro-basalt family.
6. The peridotite-pikrite family.
7. The pyroxenite family.

B. Alkali Rocks.

1. The alkaligranite-quartz keratophyre and pantellerite family.
2. The alkali syenite-keratophyre and alkali trachyte family.
3. The monzonite-latite family.
4. The elaeolite and leucite syenite-phonolite and leucitophyre family.
5. The essexite-trachydolerite family.
6. The theralite-tephrite family.
7. The ijolite-nepheline basalt family.
8. The missourite-leucite basalt family.

There is really not much that is original in this scheme. The families, though some of them are still under the fire of criticism, are formed on principles adopted by Teall, Brögger, and some American authors — that is, they are independent of the geological occurrence, age, and structure of the rock. They embrace the plutonics with their volcanic equivalents and their whole apparatus of accompanying dyke rocks. They are based practically on their mineralogical composition : other factors, such as occurrence or structure, may be expressed in subdivisions. Thus it is manifestly desirable to separate basalt from gabbro in subdividing : basalt stands for the effusive form of the gabbroid magma, or denotes its microlitic or vitreous structure. In each of the families it matters nothing from a genetic point of view whether the rock is deep-seated, intrusive, or effusive ; and mere structure does not affect its parentage. In subdivisions mineralogical criteria may well be used.

If petrologists cannot agree on their principles of classification, they must try to do so in their nomenclature, though, logically, the former ought to be settled before the latter can be adjusted. But we cannot begin *de novo*, and there are so many names which enjoy general currency, and so many more which are entering the science almost daily, and quietly winning acceptance, that a totally new scheme will have little chance of surviving. A sifting of existing names seems all that can be done in respect of the past ; for the future we can only influence cosmopolitan opinion by our practice. Hence the question, By what principles is our practice to be guided ?

The first and most natural idea is to make use of some mineral, chemical, or structural characteristic of the rock itself—*e.g.*, anorthosite, labradorporphyrite, leucitophyre, felsogranophyre, soda granite. I think that authors who try this plan will experience difficulty. Loewinson-Lessing has made some valuable suggestions in the direction of what he calls philonomic nomenclature—that is, a nomenclature which is expected to indicate the systematic position of the rock and the features distinguishing it from other members of the same group or family. He adopts Professor Brögger's terms "leucocratic" and "melanocratic," intended to denote differentiated rocks, or those intermediate between two families, either rich in felspars or dark silicates, or *vice versâ*, and for which otherwise new names would have to be invented. And he goes further, and extends this principle in suggesting such terms as "felspathocratic," "pyroxenocratic," &c. Another alternative is a system of artificial code names devised on some mnemonic system, but such names are repugnant. A further plan is to resort to geographical or locality names. An objection to this is that there are more localities than one for the same rock. There is some force in this, but it is not altogether convincing, for restriction to one locality is not necessarily involved in the use of its name; and I think the plan is also an aid to memory. I must confess, however, that I see no general demand for inflexible schemes of nomenclature. They only tie a millstone round the neck of this young science. Instead of framing comprehensive schemes for receiving fresh additions, it would be better to devise something to keep down or diminish our name list, which is already becoming unwieldy.

The American authors previously referred to have recommended a dual nomenclature for igneous rocks, one set of terms to be used by field geologists, the other to be founded on the actual composition as ascertained by microscopical and chemical analysis. The bases of identification in the field are to be texture, colour, and, to some extent, mineral composition. The field geologist will thus have to content himself with such names as "granite," "syenite," "diorite," "gabbro," "peridotite," "felsite," "basalt," the various "porphyries," "obsidian," "pitchstone," &c.; while the laboratory petrologist, after carrying out his analysis, will make use of systematic names such as "adirondackiase," "yellowstonose," baltimoriase," &c., as the case may be. Some careful workers, both in America and Australia, have cast in their adhesion to this proposal. Still, there is reason to doubt whether it is really any advance upon present practice. Geologists in the field rarely venture to use any other names than the common ones before their rocks have been submitted to proper examination. Some rocks may be difficult to distinguish megascopically—*e.g.*, andesite and trachyte. In such cases it is unwise to be prematurely precise: the general term "intermediate lava" would possess sufficient meaning for distant geologists, and for local workers temporary locality-names would suffice.

TEXT-BOOKS.

A proper presentment of our science depends to a great extent upon our text-books. Considering first those in the English language. apart from the numerous excellent papers scattered through our geological literature, we have the following:—

Rutley's Study of Rocks. 1879.
" Rock-forming Minerals. 1888.
" Granites and Greenstones. 1894.
Teall's British Petrography. 1888.
Hatch's Introduction to the Study of Petrology. 1891.
" Text-book of Petrology.
Coles' Aids in Practical Geology. 1890.
Harker's Petrology for Students. 1902.
Luguer's Minerals in Rock-sections. 1898.

In England Rutley's "Study of Rocks" formed for a long time the only available text-book. When it was first issued, in 1879, it was an excellent introduction to the young science. Great strides have been made since then, and it has been outdistanced by newer works. The "Rock-forming Minerals" of the same author is a book not sufficiently known, and contains much valuable information. It needs amplification to meet modern requirements. "Granites and Greenstones" is practically a series of mineralogical tables, with a rock-classification on the SiO_2 basis. It has formed a very useful book for teaching purposes. It, too, could be expanded to accommodate recent additions.

Teall's "British Petrography," which appeared in 1888, still remains a thesaurus of information respecting English eruptives. The classification is principally mineralogical, and the author states that it is adopted for convenience of description. It is therefore not a contribution to systematic petrography; nevertheless it is natural enough not to interfere with the profit derivable from study of this truly admirable work. So much sound general information is imparted that the student cannot afford to be without a copy of the work. Under each group are useful definitions of nomenclature; full descriptions of the minerals; description of the rocks as they occur. The groups are—(1) Ferro-magnesian rocks, (2) plagioclase felspar rocks, (3) orthoclase felspar rocks, (4) felspathoid rocks, (5) limburgite and magma basalt, (6) vitreous rocks, (7) fragmental volcanic rocks. The author in his preface asks his readers to concentrate their attention upon the rocks rather than their names, and expresses his opinion that, as rock-masses are subject to so much variation, any laboratory classification is inadequate for the expression of broad geological facts. The illustrations of micro-structure are well drawn and coloured. The appearance of this book marked an epoch in petrographical science in England.

Cole's "Aids in Practical Geology," written first in 1890, has seen three editions. The major part of the book is occupied with the examination of minerals and rocks, and is a veritable *vade mecum* for the student who is beginning petrographical work. The classification of igneous rocks is into holocrystalline, hemicrystalline, and glassy divisions, advancing from acid to basic types within each division.

Hatch's "Introduction" and "Text-book" are concise works on the subject, somewhat elementary, and with a classification based on the SiO_2 principle. The rocks dealt with are mostly British. The descriptions are simple and lucid.

Luguer's "Minerals in Rock-sections" is an admirable work, which cannot fail to be of great use to both teacher and student.

Harker's "Petrology for Students" appeared in 1895, and has gone through three editions. The classification of igneous rocks is into plutonic, hypabyssal, and volcanic, proceeding from acid to basic in each section. This little book is the only English work which brings before the student the eruptive rocks of foreign countries. It is essentially a guide to the study of rock-slices. It forms a handy work of reference, but would have been more complete if its scope had included the megascopic characters and more of the field relations of rocks. Information respecting the latter is ardently desired by English students.

Luguer's "Minerals in Rock-slices" is a useful modern work, well suited both for teaching purposes and the student. It has several features very acceptable to the learner.

Dr. Hatch has prepared an English edition of Professor Rosenbusch's Petrographical Tables for the microscopical determination of rock-forming minerals, a valuable little book of reference.

Professor Gregory has also translated F. Loewinson-Lessing's Tables for the determination of the rock-forming minerals (1893). These tables have been prepared for elementary students, and are designed to lead up to the identification of an unknown mineral by means of its observed characters. In ordinary mineralogical tables the reverse method obtains: a known mineral is given and its characters detailed.

In Germany the great works which dominate the field are—

Lehrbuch der Petrographie. F. Zirkel. 3 vols. 1893–4.
Mikroskopische Physiographie der Mineralien und Gesteine. 2 vols. 1895-6. H. Rosenbusch.
Elemente der Gesteinslehre. H. Rosenbusch. 1898.

Zirkel's large work is of the voluminous and comprehensive nature which characterizes the genius of German research; nothing is neglected or left out. The classifications of igneous rocks adopted in it is mainly based on the minerals (felspars, felspathoids, and quartz), secondarily on structure, and lastly on geological age. He says in this connection (vol. i., p. 829), "The two principal points of view from which the classification and nomenclature of eruptive rocks can be undertaken most advantageously are in the first place mineral composition and structure, both moments of a positive nature, independent of hypothesis and available for every isolated hand-specimen. As a further base of division, geological age can be used where it is suitable or practicable." This monumental work is a complete guide for students. A feature in it is its conflict with the system adopted by the other great leader of petrology in Germany, H. Rosenbusch. Developments in this conflict have been unhappily marked by a tone of controversy out of place in the domain of science.

H. Rosenbusch has conferred an inestimable boon on petrographers by his important works above named. The first volume of the Mikroskopische Physiographie — viz., rock-forming minerals—has been translated into English by Professor Iddings, and is, I suppose, known among students wherever the English language is spoken.

The third edition of the second volume (Massige Gesteine), 1896, is the latest enlargement of the 1887 edition. Rosenbusch's classification is that of geological occurrence: deep-seated rocks, dyke rocks, and effusives. His further divisions are founded on chemical composition as expressed in the minerals present. It is to be regretted that no English translation exists of this luminous work.

Rosenbusch's Elemente has gone through two editions. It is a highly philosophical work, expounding the author's views in an enchanting manner. In it all igneous rocks are represented as belonging to one of three magmas—(1) the foyaitic-theralitic magma, (2) the granito-dioritic magma. (3) the gabbro-peridotitic magma. These conceptions have the most far-reaching influence on schemes of classification.

To German works should be added "Petrographisches Praktikum," by Dr. R. Reinisch: "I., Gesteinobildende Mineralien," 1901; "II., Gesteine," 1904. Part II. of this useful little work has just been issued. The author practically follows Zirkel in his arrangement of the igneous rocks, but subdivides his families into alkali and alkali-lime sections. He groups his eruptives as follows: (1) With dominant alkali felspars; (2) with dominant soda-lime felspars; (3) felsparless, with nepheline, leucite, or melilite; (4) felsparless, without felspathoids. The work is not put forward as a petrographical text-book, hence thorough systematizing is not to be expected. The grouping brings together unexpected associates, such as elaeolite, syenite, and quartz porphyry in group 1; andesite and nepheline tephrite in group 2. Much useful information is given concisely under the heading of each rock.

In France the works having the most important effect on this science are—

- Minéralogie Micrographique. F. Fouqué et A. Michel-Lévy. 1879.
- Les Minéraux des Roches. A. Michel-Lévy et A. Lacroix. 1888.
- Structures et Classification des Roches Éruptives. A. Michel-Lévy. 1889.
- Tableaux des Minéraux des Roches. A. Michel-Lévy et A. Lacroix.

The structure and the minerals of rocks are employed by French authors as the factors in classification. Granitoid and trachytoid structures form two main divisions; further divisions are based on the felspars, and are subdivided according to the dark silicates present. The latest conclusions in France, however, are embodied in the proposals of the French Petrographical Committee, which recommended three main divisions, viz.: (1) felspathic rocks; (2) rocks without felspars; (3) rocks without white constituents—*i.e.*, without felspars or felspathoids. The subdivisions represent granular, microgranular, and microlitic types.

Mention must be made of the success of French authors in the difficult task of interpreting felspars in rock-slices. In the "Minéralogie Micrographique" Fouqué and Lévy considered this problem with good results; and the latter in his "Étude sur la Détermination des Feldspaths dans les Plaques Minces" gave improved maxima of some of the extinction angles previously stated, and showed that it is often possible to arrive at trustworthy conclusions from the haphazard sections of crystals in our rock-slides. The author says, with a good deal of truth, that the determination of felspars by the use of the microscope has been the touchstone of petrographic progress, and adds, "The value of a petrographic study may be gauged by the care bestowed by the writer on the determination of the felspars."

Among recent foreign petrographical works, not the least is the issue by the International Committee of Petrography of the Eighth International Geological Congress of F. Loewinson-Lessing's Petrographic Lexicon.* Before its publication, proofs were submitted to the members of the committee, and a great number of terms added by English and continental petrologists. It now constitutes a body of terminology which no student can afford to ignore. It gives definitions of between three and four thousand terms in use in Europe and the United States. It is launched fairly as a new edition of the work originally published 1893–98, and the committee hopes that it will aid in avoiding the creation of synonyms, and will contribute to precision in definition. A mass of information is assembled in it for our easy inspection, and we must cordially welcome it as a great attempt.

ANTARCTIC PETROLOGY.

Turning from general considerations to matters nearer home, we note an event of more than ordinary interest in the publication in 1902, in the British Museum Report on the Collections of Natural History made in the Antarctic Regions

* Lexique Pétrographique. F. Loewinson-Lessing. Paris, 1900. Congres Geologique Internationale. Comptes rendus. Deuxième fascicule.

during the voyage of the "Southern Cross" (London, 1902). of a report on the rock-specimens by Mr. G. T. Prior. Mr. Prior had previously described basalts, granitic and phonolitic rocks, from Possession and Franklin Islands, collected during the voyages of the "Erebus" and "Terror" in 1839-43,* and he has now given us the results of his recent examination of specimens from Cape Adare, Geikie Land, Newnes Land (foot of Mount Melbourne) foot of Mount Terror, and from sundry islands (Possession, Duke of York, Franklin, and Coulman). These are said to form a fuller series of Mr. Borchgrevinck's collections from Cape Adare, Victoria Land, and Possession Island made in 1895, and described in that year by Professor David and Messrs. Smeeth and Schofield.† A few specimens (mostly basalts) left at the Tasmanian Museum, at Hobart, from the 1898 voyage, have been described by W. A. Macleod and O. E. White.‡

Professor David and colleagues recorded aplite, aegerine-trachyte, augite andesite, basaltic andesite, olivine dolerite, olivine basalt, limburgite, and mica schist. Mr. Prior has now identified granite, essexite (doubtfully), quartz felsite, hornblende basalt, phonolitic trachyte, and kenyte. The basalts are supposed to belong to recent flows. The granites and schists are Lower Palæozoic, and are, as we know, continental rock. They show that continental conditions have prevailed in Antarctica.

The basalts, chiefly hornblende basalts, are not normal basalts, but occupy a place somewhere in the alkaline series, and are apparently associated with aegerine trachytes and kenytes. They are poorer in Mg and Ca than ordinary basalts, but richer in K, Na, and Al. They are a little more acid than ordinary hornblende basalts, and more basic than trachydolerite, with which their analysis otherwise corresponds.

These different lavas, it is suggested, belong to one period of eruptions of recent date. The essexite, a plagioclase-olivine-augite-biotite rock, is suggested by Mr. Prior as the possible plutonic analogue of the hornblende basalts and kenytes.

The kenyte-like rocks are compared with phonolitic rocks from the top of Flagstaff Hill, Dunedin. The latter contain anorthoclase, hornblende, augite, olivine in a groundmass of felspar laths and feathery tufts of aegerine-augite (Prior), and are also stated to be of Tertiary age.

In the southern part of Tasmania there is also a province of alkali rocks, elaeolite syenite, essexite, &c., with soda

* Min. Mag. 12., pp. 69-91.
† Proc. Roy. Soc. N.S.W., 1895, pp. 461-92.
‡ Proc. Roy. Soc. Tas., 1900-1, pp. 38-41.

amphibole and pyroxene, haüyne, &c., but without olivine. Appearances indicate for them a pre-Tertiary date. Near Hobart, however, is Tertiary melilite basalt; on the central Tiers, at the Shannon, melilite and nepheline basalts of Tertiary age also occur; and on the north-west coast Tertiary trachydolerite and limburgite are found. Consequently, while the Victoria Land volcanic system may be prolonged northwards to New Zealand, eruptions of related magmas took place in the same period in Tasmania. The latter would be on a line north-west from South Victoria Land, but due north from Adélie Land. At present the alkali rocks within the Antarctic Circle nearest to New Zealand or Tasmania are those at Cape Adare.

A highly interesting find from Antarctica is a block of garnetiferous aplite from Possession Island, carrying tourmaline. Professor David and his collaborators also called attention to black tourmaline and topaz in a similar aplite from Cape Adare. From these minerals it is almost safe to infer that tin-ore is present also.

Holding our session in Dunedin, surrounded by occurrences of nepheline volcanics, a few of which were petrologically expounded in a tentative way by the lamented Professor G. H. F. Ulrich at the 1891 meeting of this association at Christchurch, a reference to the recent discoveries of alkaline rocks in Australia is doubly interesting. Some years ago felspathoid rocks were looked upon as rarities, or, at all events, were considered as of restricted occurrence, but lately they have been constantly turning up in unexpected quarters. But, first of all, I invite your attention to the mention made of the alkaline rocks of Dunedin by Professor P. Marshall, D.Sc., in the "Handbook of Dunedin," published for the use of members of this association. He refers to nepheline syenite, basanite, phonolite, tinguaite, kenyte, &c., all members of the wonderfully varied alkaline division. There is evidently a complex here which may render Dunedin petrologically classic. Having regard to its relations with Antarctica, Dr. Marshall's work among this rock-group is one of the most important attempts which could just now be undertaken in the whole field of Australasian petrology. Moreover, its extreme interest and importance are not Australasian simply, but worldwide.

In 1890 Mr. W. Anderson and Professor T. E. David described leucite basalt from Byrock and El Capitan, in New South Wales. (Rec. Geol. Survey N.S.W., vol. i., pt. 3, 1890.)

In 1901 Messrs. Guthrie and Woolnough and Professor David described a tinguaitic rock from Kosciusko, N.S.W. (Proc. Roy. Soc. N.S.W., 1901.)

In 1902 Mr. G. W. Card described intrusive nepheline basalt from the Capertree Valley, N.S.W. (Rec. Geol. Surv., vol. vii., 1902, p. 40.)

Mr. B. Dunstan has recorded nepheline basalt from the Dawson River district, Queensland.

Messrs. Card, Mingaye, and H. P. White have described analcite-basalt from a dyke near Fernhill Station, in the Sydney district. (Rec. Geol. Surv. N.S.W., vol. vii., 1902, p. 94.)

Rev. J. M. Curran has described (Journ. R. S. N.S.W., 28, p. 217–231) a felspathoid basalt from a boss at Bondi, near Sydney. Mr. Card and colleagues, after examination, suggest analcime as the felspathoid present. In this paper they also refer to a small patch of nepheline basalt of Post-triassic age as capping the Peaks, Upper Burragorang.

Messrs. Card and Jaquet in their Geology of the Cambewarra Mount, N.S.W. (Rec. Geol. Survey N.S.W., vol. ii., pt. 3, 1903, p. 103) describe a whole series of alkaline rocks under the general names "trachyte," "monzonite-porphyry," "hornblende lamprophyre," &c. In the same volume (pp. 236–37) Mr. Card describes nepheline-bearing basalt from North Dural.

Mr. Rule identified Victorian phonolites many years ago, and his identification was supported by Mr. Dennant.

In Victoria also, Professor Gregory (Geology of Mount Macedon, Proc. Roy. Soc. Vict., 1902, vol. xiv., p. 185) has described alkali dacites, trachy-phonolites, sölvsbergites, and alkali andesites at Mount Macedon. Nosean is stated to be present in the andesites and phonolites.

Outside Australia, in the Pacific, A. Lacroix ("Matériaux pour la Minéralogie de Madagascar," p. 133–34) mentions nepheline monzonite (essexite) and pulaskite from Tahiti.

Putting together the Pacific occurrences and those in Australia, Tasmania, New Zealand, and Antarctica, alkaline rocks, and especially products of the monzonitic and essexitic magmas, seem widely spread in this quarter of the globe.

CONCLUSION.

We have as yet no Australasian school of petrography, but just as each of the American, English, German, and French schools has an individuality of its own, so will authors in Australia and New Zealand surely leave the impress of their work on contemporary thought. In the past Professors David and Ulrich, Messrs. Selwyn and Howitt, inaugurated, as it were, the study, and the work which is now being done by Mr. G. W. Card in New South Wales, and Dr. Gregory in Victoria, must be recognised as of the first rank. Each of hese is worthily doing his part in laying the foundation-stones of the future edifice of Australasian petrology. Others are helping in the work, and as one after another is admitted into the working ranks we see the time coming when, as a corporate Australasian brotherhood, we shall join hands with our brethren across the seas in every land in consolidating the structure of our glorious science.

I think that if from some vantage point we could watch simultaneously the work of petrologists all over the world, we should note at the present time two leading characteristics. Firstly, the attempts being made to solve genetic problems, to create what Harker calls a natural history of igneous rocks, and to apply the knowledge thus gained to the interpretation of rock-masses. The rock-specimen is in this light valueless, except as an introduction to the rock-mass. In this aspect we see petrology closely welded to geology. Secondly, and what may be described as the opposite pole, is a serious endeavour now in progress to arrange rocks strictly in accordance with individual analyses, incidentally discrediting geological relations and glorifying the individual specimen. The two aspects are for the moment mutually conflicting. Let us hope that each of these attempts will give us and leave us with something which we could ill afford to be without, and that the eclectic petrology of the future will be a large gainer from the debates of the present. Imbued with this spirit, we petrologists almost instinctively feel ourselves standing now on the brink of a larger knowledge, a wider grasp of the principles of our young science, for which we claim some degree of attention from every one who feels any interest in the comprehensive aims and scope of modern geology.

No. 1.—TRACHYDOLERITES NEAR DUNEDIN.

By Dr. P. MARSHALL.

In the brief account of the geology of Dunedin, published in the handbook compiled for this meeting of the Association, it will be noticed that some of the volcanic rocks of the district are classed as kenytes. The map attached to the handbook shows that a large area is covered by the rock thus classed.

The rock kenyte was so named, from the typical occurrence in Mount Kenya, by Professor Gregory. The local rock was classed with it, because in many of its features there is a marked resemblance to the kenyte as described in the *Quarterly Journal of the Geological Society.* The author has, however, since the classification was made, had an opportunity of reading the paper by Mr. Prior on the rocks of the rift valley of East Africa. In this paper it is shown that kenyte is properly included as a somewhat divergent type of the trachydolerite class, as described by Professor Rosenbusch in the second edition of his "Gesteinslehre." To the general description of trachydolerite therein given the local rock conforms more nearly than to the more specified description of kenyte.

It is therefore proposed that this rock should be called trachydolerite, and, in view of the somewhat unsatisfactory present state of petrological classification and nomenclature, it is not considered advisable to separate it from rocks that must be considered more normal types of trachydolerite by any specific name.

Descriptions of various specimens of this rock are given below—

A 53, C 77.—Flagstaff, east slope.

Hand-specimen, dark green, sometimes with blue tinge, and almost black. Very dense, but occasionally phenocrysts of nepheline, olivine, pyroxene, and rarely sanidine, may be seen.

Section: Nepheline perfectly transparent, with rounded outlines—sometimes $\frac{1}{4}$ in. in diameter. Pyroxene phenocrysts seldom idiomorphic, usually brown in interior portions, surrounded by a more or less irregular border of aegerine augite in which there is much included magnetite. Olivine usually rounded, often stained by limonite, especially along the margins and cracks. Often associated with brown augite, and like it surrounded by a thin and irregular coating of grains of aegerine which is never stained by limonite.

Groundmass: Small microlites of sanidine rather numerous, showing a fluidal structure in their arrangement. Nepheline in very small hexagonal prisms, often giving rectangular sections. Aegerine abundant, partly as prisms, but more often granular. Cossyrite rather abundant, moulded on the nepheline squares and sanidine microlites. A little magnetite, generally grouped with cossyrite. In the transparent portions an isotropic substance, with highly irregular outline, moulded like the cossyrite on the older minerals.

A 59, C 81.—Below Ben Rudd's house.

Similar to above, but olivine more stained by limonite, and mantle of aegerine less regular.

A 62, C 83.—Quarry near reservoir.

A few crystals of sodalite in addition. These are almost idiomorphic, and contain a number of liquid inclusions with gas-bubbles. They are arranged along intersecting planes that are apparently dodecahedral. Felspar microlites much less frequent, and base largely isotropic. In one crystal of aegerine there is a fairly large inclusion of sanidine.

A 76, C 95.—Near Morrison's Creek, Leith Valley.

Sodalite phenocrysts rather more numerous, with many gaseous and liquid inclusions. Many aggregates of aegerine and magnetite evidently represent resorbed amphibole. Nepheline phenocrysts large and clear. Olivine surrounded by a dense border of aegerine and magnetite, and is often associated with resorbed amphibole. A few large apatite prisms.

A 97, C 125.—*Idem.*

Much nepheline in groundmass. Little cossyrite, but some magnetite.

A 141, C 125.—Leith Valley, below third bridge.

A large rounded crystal of sanidine. Nepheline slightly weathered with the development of numerous liquid cavities.

A 150, C 185.—Halfway Bush.

A few rounded sanidines. Much brown amphibole, usually much resorbed. Very little cossyrite. Aegerine augite very pale.

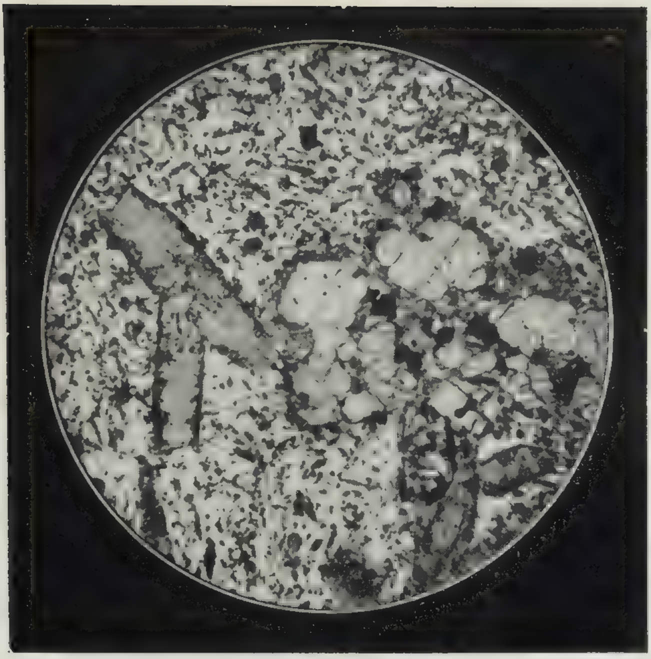


Fig. 1.
SECTION C 95, LEITH VALLEY. x 35

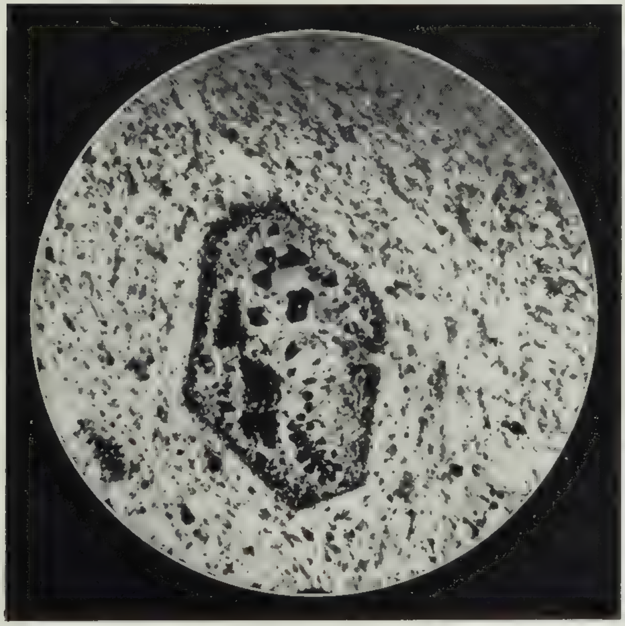


Fig. 2.
SECTION C 194, MOUNT CARGILL x 35

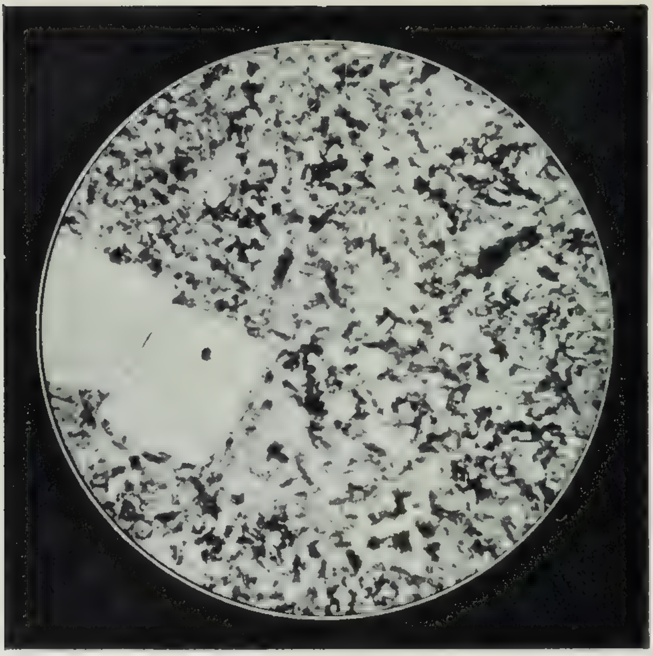


Fig. 3.

SECTION B 152, FLAGSTAFF. × 35.

Fig. 4.

SAME AS FIG. 3, BUT NICOLS CROSSED. × 35.

A 163, C 194.—Main Peak, Mount Cargill.

Much felspar in groundmass. Very large nepheline phenocrysts. Olivine much serpentinised. More than usually regular fringe of aegerine round the brown augite. Much resorbed amphibole. Little cossyrite. Much nepheline in groundmass. A few sodalite phenocrysts.

B 53, 54, 152.—Junction of Whare Flat and Ben Rudd Roads.

Much coarser than any of the above. Sanidine phenocrysts more numerous and more idiomorphic. Cossyrite abundant. Nepheline very abundant in groundmass, which is a good deal coarser than is usual. Sanidine comparatively rare in groundmass, which is therefore nephelinitoid.

A 151, 153.—Flagstaff summit.

Hand-specimen, dark green, showing abundant phenocrysts of sanidine, and others of olivine, pyroxene, and nepheline.

Section: Sanidine usually idiomorphic — in one instance enclosing a sodalite crystal. Nepheline more frequent and more idiomorphic than in the fine rocks. Olivine and augite very similar to their development in fine rocks. Cossyrite less abundant. Sodalite not uncommon.

From these descriptions it is at once seen that the absence of plagioclastic felspar and the presence of cossyrite and abundant nepheline distinguishes the local rock from typical trachydolerites. On the other hand, the absence of anorthoclase and the presence of nepheline, cossyrite, and sodalite distinguishes it from the species kenyte.

The following table shows the differences in mineralogical composition in the three:—

	Trachy-dolerite (Rosenbusch).	Kenyte.	Local Trachy-dolerite.
Sanidine	1	1	1
Anorthoclase ...	1	1	?
Plagioclase ...	1	...	...
Arfvedsonite ...	1	...	1
Cossyrite	...	...	1
Augite	1	1	1
Aegerine	1	?	1
Olivine	1	1	1
Nepheline	1	...	1
Sodalite	1	...	1
Apatite	...	?	1
Magnetite	1	?	1

The structure of the rock agrees satisfactorily with that of the trachydolerite, but it is much more differentiated in the groundmass than kenyte. As the descriptions show, there are some specimens whose groundmass is distinctly trachytoid, and others that are as distinctly nephelinitoid. A glassy groundmass is not common, though it is considered almost typical in the kenytes. Chemically the relationship is also seen to be close by the following analyses: –

	I.	II.	III.
SiO_2	53·12	53·80	51·86
TiO_2	0·25	0·31	...
Al_2O_3 ...	20·48	18·46	19·87
Fe_2O_3 ...	5·13	6·22	6·30
FeO	1·50	0·40	3·11
MgO ...	1·88	1·05	2·33
CaO	4·29	2·53	3·77
Na_2O ...	6·20	7·09	4·88
K_2O	4·88	5·46	6·20
H_2O	2·25	4·39	1·48
P_2O_5	0·43	0·53	0·36
Cl	0·28	Mn 0 33	Cl 0·51

I. Rosenbusch: Gesteinslehre, Zweite Auflage, p. 355; Trachydolerite Bauya Columbretes.

II. Prior: Min. Mag., vol. xiii., p. 249.

III. P. Marshall. 1903.

From such a close analytical resemblance it would be natural to expect as close a mineralogical similarity as actually exists, and it is at once evident that chemically, at least, these rock-types are closely related.

The order of crystallization in the local trachydolerite is a matter of some interest, and though easily made out from the preceding descriptions deserves a concise statement. It is in general as follows: Olivine, arfvedsonite, apatite, augite, sodalite, sanidine, nepheline, aegerine, cossyrite, nepheline, sanidine. The relative order of nepheline and sanidine cannot be definitely settled.

The rounded form of the olivine and its usual fringe of aegerine grains—remarks that apply almost equally to the brown augite—the partial or complete resorption of the amphibole, and the usual rounded form of the earlier generation of sanidine and nepheline indicate that these minerals were not stable chemical compounds under at least some of the conditions attending some of the phases of eruption. It is hard to imagine that in a magma so poor in magnesia, olivine would crystallize when other elements capable of combining with the magnesium-silicate were present in abundance. The brown augite, also, among the crystals of the earlier generation, could hardly have been formed in a magma containing such a high percentage of alkalies, from which apparently nepheline was at the same time crystallizing. The coarse rock of Flagstaff differs from the ordinary type more in its larger crystals of sanidine, and to some extent nepheline, than in any other character. This in itself indicates that these two minerals were formed after the olivine and augite, and this conclusion is strengthened by the rather numerous inclusions of aegerine in the sanidine. The nephelinitoid development of the groundmass in some moderately coarse specimens from the Whare Flat Road, on the shoulder of Flagstaff, is noteworthy, but no analyses have yet been made with the object of deciding whether this is due to any chemical difference. The field occurrence seems to suggest no reason for this difference. Cossyrite is less frequent in the coarse- than in the fine-grained rocks.

Geologically it seems fairly evident that the specimen described from the summit of Flagstaff represents a slowly cooled portion of the magma, and it may fill the pipe from which part of the lava flowed. There is, however, a large mass of lava that from its position cannot have flowed from this source, even after due allowance has been made for denudation. This is particularly true of the large lava-flows extending from the summit of Mount Cargill to the Leith Valley. The structure of the summit of this mountain would seem to indicate that some of this lava at least has issued from a fissure extending along the mountain's summit. The microscopic structure of the rock in this position, though it does not negative this supposition, does not offer it any special support.

The occurrence of this rock on two of the highest points of the district suggests by itself that it is one of the latest products of eruptive activity. In general it seems to overlie the rocks with which it is in contact. Thus, in the Kaikorai Valley it closely overlies the basalts that there rest on the Oligocene sandstones. In the Leith Valley it overlies a trachytoid phonolite that in turn rests upon a dolerite. On the north-east flanks of Flagstaff it appears to be overlaid by basanite and dolerite, but the actual junctions are covered by vegetation. In Mount Cargill itself the rock appears to be pierced by a trachytoid phonolite, a nephelinitoid phonolite, and a basalt.

Until some of these doubtful points are cleared up, the exact relative period of eruption of the trachydolerite must remain a matter of doubt, though it was certainly one of the later of the many periods of activity.

EXPLANATION OF FIGURES.

Fig. 1. Section C 95, Leith Valley.—Aggregate of crystals of brown augite and olivine. Two crystals at top brown augite: they have a narrow border of aegerine, showing black in the photo. Groundmass sanidine (anorthoclase ?), nepheline, aegerine, cossyrite. × 35.

Fig 2. Section C 194, Mount Cargill summit.—A resorbed amphibole, replaced by aegerine, augite, and magnetite. Groundmass as in Fig. 1, except for smaller quantity of nepheline. × 35.

Fig. 3. Section B 152, Flagstaff.—Two generations of nepheline; crystal of first generation on left. Base nephelinitoid cossyrite in groundmass black, aegerine dark grey. × 35.

Fig. 4. Same as Fig. 3, but nicols crossed.

Fig. 5. Section A 114. —Sodalite crystal in base of same type as in Fig. 1. × 45.

Fig. 6. Portion of Fig. 5 enlarged to 500 diameters. Shows liquid inclusions, with gas-bubbles in sodalite.

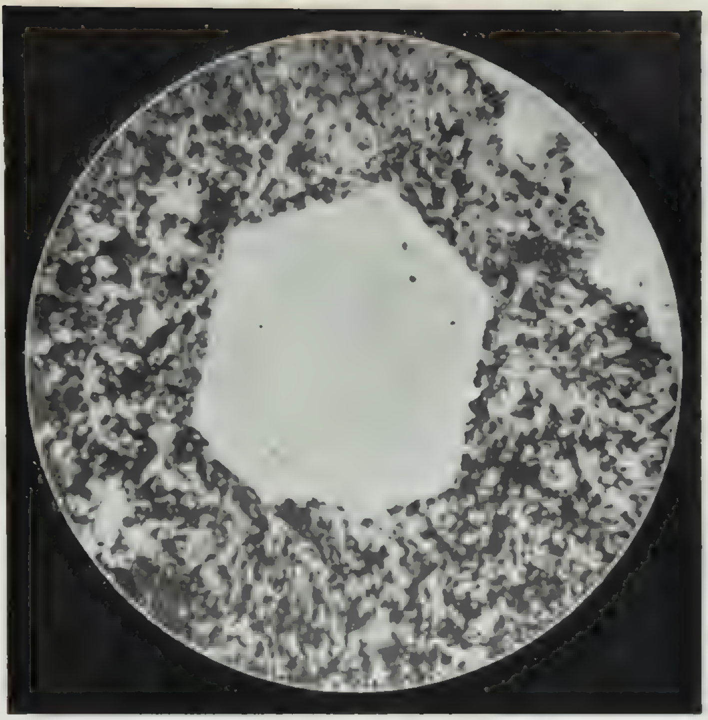


Fig. 5

SECTION A III. × [illegible]

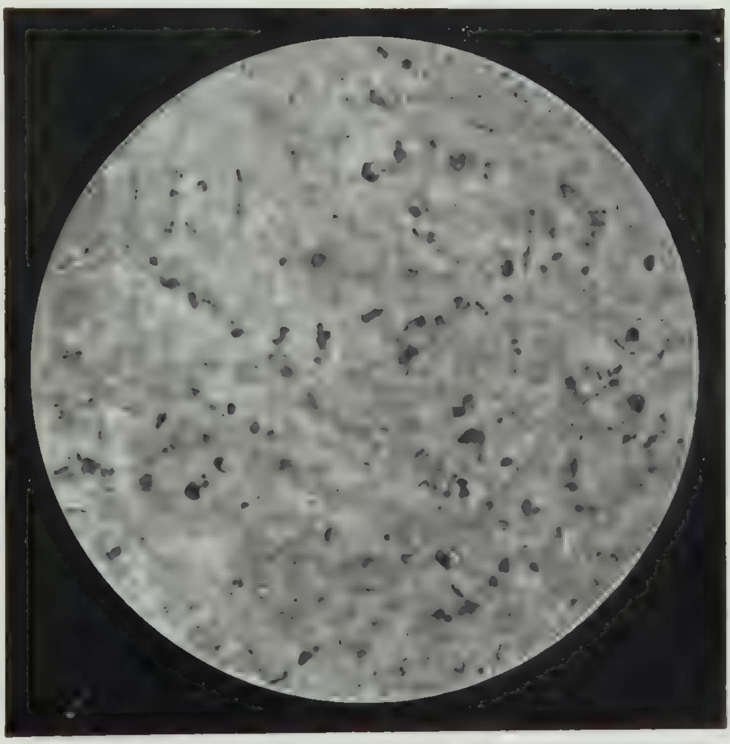


Fig. 6

PORTION OF FIG. 5. × 500

No. 2.—SOME INTERESTING FACTS CONCERNING THE GLACIATION OF SOUTH-WESTERN NEW ZEALAND.

By E. C. Andrews, B.A.

INTRODUCTION.

Previous to my visit to the West Coast Sounds and Lake Wakatipu of New Zealand in the beginning of 1903, I had had no personal acquaintance with glacial phenomena. Having made a special study of geographical forms in eastern Australia, and having ascertained that plateau-reduction by stream-action moves along very slow lines, I was prepared, from the evidence given by leading geologists as to the duration in time of the Great Ice Age, to assign a very minor modification of the larger "facts of form" in any locality to the agency of subaerial activities. Observations taken in January, 1903, in the West Coast Sounds, and in the beginning of this year (1904) along the Lake Te Anau-Milford Sound Track and at the head of Lake Wakatipu, have caused me to think differently, and to assign to ice-action a pronounced influence on pre-glacial topography.

From observations conducted in Australia* it was at once evident that the type forms of that locality presented marked variations in appearance from those of New Zealand, and that also in places where the two regions might be considered to be in, approximately, homologous stages† of development. Thus, in the ordinary life-history of streams the lateral branches of wide-bottomed valleys have their channel-grade nicely adjusted to those of the main stream at the points of intake.

Along the West Coast of New Zealand, however, as at Milford Sound, broad main valleys are observed to have wide, almost horizontal, floors as much as 1,500 ft. below sea-level.‡ Side valleys enter the sounds, and these in turn possess broad horizontal floors, almost vertical sides, and end against the main divide of the country in bold inaccessible walls. There is no undivided plateau existing, the eastern and western waters are separated by excessively narrow, deeply-set divides only, which form almost inaccessible walls from 3,000 ft. to 3,500 ft. in height. Therefore, here a late mature stage of plateau-dissection has been reached. Numerous lateral branches, however, instead of entering these U-shaped cañons

* Especially New England.

† It must be remembered, however, that the present cycle of erosion in New Zealand is in a much more advanced stage than the present one of New South Wales.

‡ It must be remembered that these sounds have not been bottomed in the deepest places.

"at grade,"* are seen to be hung or perched on ledges along the cliff-sides, and from these shelves, as much as 500 ft. and 600 ft.† above the intaking fiord or valley, the contained streams precipitate themselves into the main salt- or fresh-water channels. "Perched valleys" was the name which suggested itself to the writer on first seeing these strange cañons. Since writing a few rough notes on the philosophy of observations conducted in the area under consideration, I have received a note from Professor W. M. Davis, of Harvard College, Cambridge, Massachusetts, a portion of which I here quote:

"Your brief account of the New Zealand fiords makes me hope that you will write more fully about them. In particular, what you say about the 'perched valleys' interests me, as bearing on the general problem of glacial erosion (see some articles of mine in 'Appalachia,' and Proc. Boston Soc. Nat. Hist., 1899). What you call 'perched valleys' probably correspond to what we call 'hanging valleys.' They are shown in great perfection in Norway and Alaska, as well as in the Alps and other strongly glaciated regions. It is coming to be agreed by many observers that these hanging valleys, in their relation to the main valleys over which they 'hang,' constitute a much stronger argument in favour of glacial erosion than lakes do. One of the most interesting points here is the homology between glacial and river erosion. . . . . This demonstration of glacial erosion was, I think, first clearly stated by Gannett ('Lake Chelan,' Nat. Geogr. Magazine, Washington, 1898). It was also stated by Professor Penck in 1899, and came to my mind independently the same year on seeing some hanging valleys in the Alps. I had previously been disposed to set a small value on glacial erosion, but was completely converted by the perched or hanging valleys that I saw in Switzerland and Norway in 1898 The falls of Lodore come, I think, from a hanging valley. If you find all this applicable to New Zealand I shall be much interested. . . ."

On the receipt of Professor Davis's letter I remodelled my notes, especially in the matter of phraseology. The study of this glacial report‡ gives me confidence now in views which at an earlier date I felt diffidence in expressing. It was the violent contrast presented by New Zealand fiord topography with Australian geographical types which impressed me at first, and which later caused me to furnish a glacial explanation of the facts. On my first trip to Lake Wakatipu the unexpected appearance of the huge cañon bereft of spurs,

* That is, having their channel-slopes nicely adjusted to that of the main stream at the points of intake.

† Exceptionally the ledges are 2,000 ft. in height.

‡ W. M. Davis. "The Geographical Journal," 189[illegible]

the sides rising up in bold, almost unbroken cliffs, the rectilinear cliff-bases, the giant moraines impounding the deep waters of the lake, and the dome-shaped mountains around, suggested at once the influence of a hitherto unknown factor (to me). But what was my still greater astonishment at seeing deep cañons hung up along the great spurless walls of Milford and other sounds, as also at the head of Lakes Wakatipu and Te Anau, in an environment of wide valley and utterly dismantled plateau! Clearly here was expressed the operation of some cause other than ordinary steam-action. When, in addition to this, I discovered that similar conditions obtained in the European Alps, the Alaskan and Norway fiords, and other strongly glaciated regions, while regions of no glaciation have not such features, it seemed very probable to me that the great and hitherto and unknown factor was glaciation.

Professor Hein spent the greater portion of the summer of 1902 in New Zealand (Alps), and it will be interesting to note the conclusions arrived at by him. The report of G. K. Gilbert on the Alaskan glaciers is not yet to hand, but it may be expected to bear out the views advanced by Professor Davis for the first time for European regions.

In conclusion, it will be seen that this paper supports the theory of glaciated rock-basins advanced by Andrew Ramsay many years ago.

EPITOME.

In the cycle of erosion preceding the present one a high plateau had been dissected to the early-old-age stage, and subsequently deformed to constitute a flexed upland in the period immediately preceding the Tertiary sedimentation. The rocks of the central area of elevation consist of highly inclined slates, shales, claystones, limestones, and schists, while in the western portion they comprise extremely resistant types as granite, syenite, diorite, hornblende, augite, and mica gneisses, and the crystalline schists.

Dissection of this later plateau was then carried on east of the present divide to very late maturity,* and west of the same line to the stage of maturity only. At this point glacial conditions supervened, the ice-masses filled the valleys and probably extended over the lower plateaus, whose unreduced portions were grooved and covered with tarns: the long rambling spurs of the stream-formed cañons were, in great measure, shorn off by the descending glaciers and converted into cliffs aligned parallel to the main axes of their respective

* By "maturity" is designated the stage at which the main and tributary stream-channels show perfect harmonizing of slope, no pronounced waterfalls or cascades breaking the even flow of the streams; thenceforward they are always *at grade*, with gradually diminishing slope.

valleys; while by the differential action of glacial erosion along the main and tributary valleys the lateral cañons were turned into "hanging valleys," opening out on to the main water-courses in cliffs at times more than 2,000 ft. in height, the main floor of the cliff-base being commonly horizontal or of negligible slope.

The glacial period, which appears to be referable to more than one ice visitation from the forms assumed by the cliffs, probably reached an immature stage of development only, since lateral and main valleys exhibit such marked variations of channel-slope, especially in the most unexpected positions to wit, the points of intake—while the fiord-outlets are also more generally contracted than their more inland portions.

From a consideration of post-glacial activities such as the rearrangement of moraines, the lowering of impounded waters* with formation of lake and river terraces, the incising of steep cañons within the grand outer glacial and pre-glacial examples, the formation of lake deltas, and the general freshness of appearancce of the glaciated surfaces, the age of the last great ice period is referable probably to the Post-Pliocene period.

GEOMORPHOLOGY.

The following short notes are based on observations taken in the West Coast Sounds, and the overland walks from Lake Te Anau to Milford Sound and from Lake Wakatipu to Martin's Bay respectively. For sake of simplicity we will group them into

(1) Notes on the plateaus:

(2) Characteristic features of recent southern alpine New Zealand topography (with summary of localities);

(3) A brief description of the walks from Te Anau to Milford and Wakatipu to Martin's Bay, to illustrate the association of the recent topographical features.

(1.) *Notes on the Plateaus.*

From Milford Sound to Preservation Inlet the even-topped ridges and mesas appear to represent the survivals of a former huge plateau, decreasing from a height of 6,000 ft. at Te Anau and Milford to something like 1,000 ft. at Preservation Inlet. Northwards, as in the neighbourhood of Lake Wakatipu, the general level has risen to 7,000 ft. Above the surviving ridges and peaks still higher points rise, as Mounts Tutoko, Earnslaw, and Aspiring. Eastwards the old plateau-slope was possessed of considerably less angular value

* Lakes Wakatipu, Te Anau, Manapouri, &c.

PLATE I. GLACIATION OF SOUTH-WESTERN NEW ZEALAND.—ANDREWS.

SUTHERLAND FALLS, 1,904 FT. HIGH.

PLATE II. GLACIATION OF SOUTH-WESTERN NEW ZEALAND. ANDREWS.

SINBAD VALLEY. MITRE PEAK (5,600 FT.), FORMING ITS NORTHERN WALL.

STIRLING FALLS, 504 FT. HIGH.

than to the west, although here dissection has so far advanced as practically to efface the former plateau-outlines. Westwards the margin of the plateau is terminated abruptly by a gigantic sea escarpment possessing a fairly rectilinear base suggestive of faulting.

These incomplete observations evidence the existence of a plateau which had been dissected to early old age by the force of subaerial erosion in the stage preceding the present cycle, which latter, from its characteristic development in certain West Coast areas, we will call the cañon cycle. The almost plain-like surface which resulted near sea-level was deformed probably in the very beginning of Tertiary time to form a plateau rising gradually from south to north with down-folded eastern and western limbs.

(2.) *Characteristic Features, and Summary of Localities containing such Forms.*

(*a.*) *Hanging Valleys.*—These remarkable topographical facts consist of cañons which have fairly even channel-slopes almost to their points of discharge into the main stream. Instead, however, of flowing evenly into the larger stream, they descend thereto either in cascade form or as sheer waterfalls. The most magnificent example of all—the Sutherland Falls—may be taken as a type. Here, a valley some 3,000 ft. in depth presents almost inaccessible sides to the continued stream. A lake feeds the hanging-valley stream, which in turn is fed by a glacier. The stream suddenly changes its even flow and precipitates itself over a cliff 2,000 ft. in height (Pl. I.) into the main-stream channel. As in other valleys of this type the lip is higher than the portion immediately upstream, which is occupied by a tarn* or small lake. It is this appearance of being hung or perched along the cliff-sides which has earned for them the name suggested by Gilbert.

Examples.—The Sinbad (Pl. II.), Stirling (Pl. III.), and Bowen Falls in Milford Sound. These, as also Pl. I., are magnificent examples, while smaller valleys of this type are hung up along the Te Anau Lake, Arthur, and Clinton valley walls. Two fine instances are Loch Katrine and Lake Alice in George Sound. Wet Jacket and Crooked Arms may also be instanced; also along the slopes of Lake Wakatipu. An especially fine occurrence is the upper Routeburn Valley, above the Government Hut.

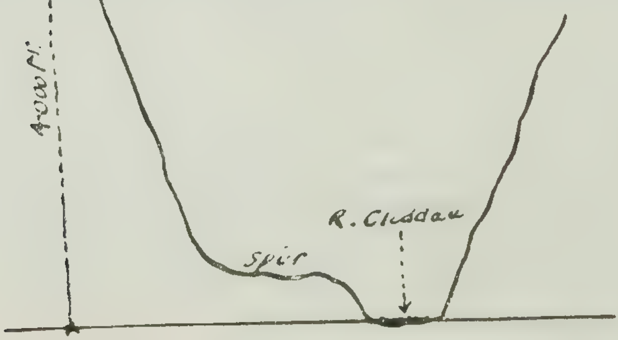
(*b.*) *Rectilinear Cliff-bases.*—This is another remarkable

* In some cases, however, the tarn is absent, although others situated higher than the discharging-lip occur.

feature which forces itself at once upon the attention of the observer. The mountains composing the sides of the valleys or lakes of the Wakatipu and Milford Sound type may be notched and broken by deep ravines stretching to the water's edge; they may even appear as almost isolated beehive and sitting-lion shapes, yet their immense bases almost invariably preserve a wonderful alignment.

Examples.—Magnificent in this connection are the slopes of Earnslaw to the Dart River, the Humboldt Range to Wakatipu, as also the slopes of Crichton and the Remarkables to Wakatipu. Still finer examples are the walls of Milford Sound (Pls. III. and IV.), the ramifications of the Arthur and Clinton River cañons (Pl. V.).

(*c.*) *The Total or Partial Truncation of Spurs.*—The absence of spurs or their almost complete disappearance is another peculiarity of the Sounds district. Consider Plates V. and VI. representing the cañons of the Upper Clinton and Arthur Valleys respectively in this connection. In other places the spurs appear to have been present, but the upper portion where anchored into the mountain-mass alone remains, the remnants presenting precipices thousands of feet in height to the valley below (Pl. VII.). Frequently at the junction of two streams a low remnant of a spur is seen, giving the idea of some huge planing force at work which has almost pushed away the barrier formed by an advancing spur across the mouth of a large valley (Fig. 1).



MILFORD SOUND. THE [illegible] WALL. THE LION (4,300 FT.) AND PEMBROKE PEAK (6,700 FT.) ON THE LEFT

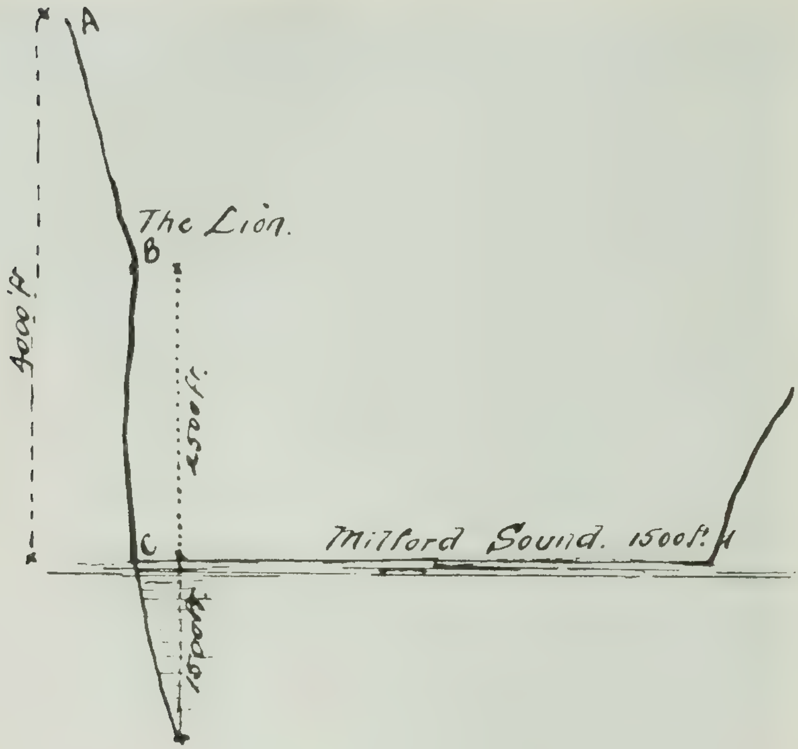
Sitting-lion and Titan-beehive shapes are also the expression of this apparent mutilation of once long rambling spurs. (Pl. IV.).

Localities.—Milford Sound (Pl. IV.). Possibly the best locality is Smith Sound, along Hall's Arm, Crooked and Wet Jacket Arms.

(*d.*) *Double Cliff-slope.*—Along the Milford and Arthur River walls the lower portion is often observed to be absolutely perpendicular for as much as from 1,000 ft. to 2,500 ft. in height. Above these rise the characteristically steep slopes (50 deg. to 60 deg.) of the Sounds for other 3,000 ft. (Fig. 2,

a). Usually the sides rise for some 4,000 ft. or 5,000 ft. in this steep fashion (about 50 deg. or 60 deg.), but this set of conditions at a lower level has also to be accounted for. The steep slopes are in alignment, and cannot be disposed of as ordinary stream-slopes—in fact, they are totally different, for the reasons just set out in the previous paragraphs.

Localities.—North side of Milford (Pl. IV. and Fig. 2, *a*),



portion of southern wall (Fig. 2, *b*) Lower Arthur River at Sheerdown, also near Sutherland Falls.

(*e.*) *Fairly even Bottoms of Lakes and Sounds.*—Take Wakatipu as an example. Soundings by Messrs. Lucas and Hodgson, of Cambridge, England, have proved this lake to have a fairly even floor, with depressions near the discharging-end and the centre, thus presenting the features of a glaciated-valley floor. Notice the wonderful evenness of width evidenced by plans of this lake not at all resembling the anastomosing series of bays shown by the partial drowning of a stream-developed valley. Similarly the plans of the sounds show several deep basins having tremendously precipitous sides, rectilinear bases, and flattish floors. The points of discharge to the sea are the shallowest, and the deepest portions of the basins are fairly centrally disposed, and it is here that the sides appear to fall so precipitously (Fig. 2, *a*).

(*f.*) *Contraction of Sound-entrance.*—Besides being shallowest at the points of discharge seawards, the sounds are likewise here narrower than some distance up-stream.

THE CLINTON VALLEY, FROM MACKINNON PASS (3,500 FT.).

THE UPPER ARTHUR VALLEY, WITH MOUNTS HART AND DANIELS

(3.) *The Association of the Features just described as seen along the Lake Te Anau - Milford Sound and Lake Wakatipu - Martin's Bay Tracks.*

Lakes Te Anau and Manapouri are seen to be remnants of a once very large water-basin, having the Takitimo Range as one of its shores. Its successive lowerings are indicated by numerous lake-terraces lying many miles from either of the present lakes.

The Clinton and Arthur Rivers are respectively tributaries of Te Anau and Milford Sound. The special features of the Clinton Valley are: A general U shape in cross-section, a horizontal floor or one of negligible slope some half a mile in width near its head, steep bordering cliffs from 60 deg. to 80 deg. slope and from 3,000 ft. to 5,000 ft. in height above the valley, a characteristic absence of those rambling spurs which are so inseparably associated with stream-developed valleys, and valleys hung up along the walls of the spurless cañon and terminating in steep walls facing the main valley (Pl. V.). The famous Mackinnon's Pass, 3,500 ft. in height, separating the valleys of the Clinton and Arthur Streams, presents a similar cross-section to that of the Clinton. On one side is the steep Mount Hart (Pl. VI.), on the other the almost perpendicular slope of the giant Balloon Peak, both peaks being continuous with the approximately horizontal saddle of the pass. The pass itself is a mere knife-edge, deeply set in the plateau, and presents almost inaccessible slopes to the Clinton and Arthur Valleys. As it is a type of the pass between western and eastern waters in this region, it gives the reader some idea of the thorough dissection to which the plateau has been subjected.

The Arthur Valley is a study in the perpendicular. It originates in the coalescence of two valleys hemmed in by walls of appalling magnitude. Both end (as is also the case with the Clinton Valley) in enormous cirques or amphitheatres thousands of feet in depth. Their termination against the main divide is marked by a wall some 5,000 ft. in height, perfectly inaccessible, except in two notches—viz., the Mackinnon Pass and the Sutherland Falls—and the total length of this rectilinearly disposed rampart, which includes Mounts Daniels, Hart, and the sky-piercing Balloon Peak, is over five miles (Pl. VI.). The spurless character of the Arthur is even more emphasized than is that of the Clinton, yet in places remnants exist of what were evidently at one time rambling spurs. They have been truncated, and present precipitous faces to the main channel. In other places, as at the points of discharge of the Mount Edgar Stream and the Cleddau-mouth, the spur has been planed off almost entirely (Fig. 1, *a* and *b*). Excessively interesting are the double slopes of the Sheerdown and other hills near the Arthur-mouth. The upper portion slopes steeply for some 3,000 ft. or more at an angle of about 60 deg., while the base is composed of a sheer precipice from 1,000 ft. to 1,500 ft. in height (Pl. VII.).

Milford Sound is, however, unique even in these valleys of marked topographical features. What is shown in a moderate degree by the Arthur and Clinton is here strongly accentuated —viz., the alignment of cliffs, the double slope along the northern sound-wall, the depth of the side valleys and their marvellous regularity and steepness of slope from base to summit, being perfectly inaccessible* and having a marked rectilinear disposition of cliff-bases, the wealth of hanging valleys, the truncation of spurs, and the basin-like character of the sound.

Lake Wakatipu commences at once from its foot at Kingston to show its imbricated slopes and its wonderful alignment of cliff-slopes. Its walls are not sharp like those of the sounds, but retreat at an angle of generally less than 45 deg. Its walls are more compact than those of the valleys just described, and one may travel along a rectilinearly disposed bordering escarpment-base for many miles at a time without need of deviation to avoid cross-cutting valleys. The Remarkables are magnificent examples of the influence of rock-dip on scenery. Here also the descending glacier appears to have separated into two streams. Higher up, as the head is approached, a couple of marked rectilinear bases come into view, the more notable one being the Humboldt Range. Numerous facets and small hanging valleys are seen aligned along the sides, the facets having their bases continuous with the cliff-bases and tapering to nothing higher up. This is so strongly suggestive of spur-truncation as to appeal to even the most negligent observer. Other splendid facet formations occur along the slopes of the Walter and Afton Peaks. Not a solitary spur advances into the lake to break the even sweep of the scarp-bases the lake-basin is simply a spurless chasm.

Following the delta of the Dart for some ten or twelve miles along the straight base-line of the Humboldts, a side stream comes in named the Routeburn. Along this to the Lake Harris Saddle (5,000 ft.) occur some of the most perfect hanging valleys and U-shaped cañons conceivable. At the Government Hut the Routeburn appears to end in a hanging valley, and the writer on approaching felt dismayed at having to account for so singular a phenomenon. At the last moment, however, the main U-shaped valley swung round to the right, revealing the hanging valley of Lake Harris as an

* *Examples.*—Harrison Cove (eastern wall), Sinbad Valley, Cleddau River.

PLATE VII. GLACIATION OF SOUTH-WESTERN NEW ZEALAND.—ANDREWS.

THE SENTINEL, CLINTON VALLEY.

PLATE VIII. GLACIATION OF SOUTH-WESTERN NEW ZEALAND.—ANDREWS.

THE ARTHUR RIVER WHERE IT ENTERS MILFORD SOUND; SHEERDOWN TO THE RIGHT.

ordinary tributary. Lake Harris occurs in this hanging valley some 1,500 ft. above the Routeburn. It is a small rock-basin, with a probable depth of over 100 ft.

The trigonometrical stations (6,000 ft. and 7,200 ft. respectively) on the saddle reveal a deep spurless chasm to the west many miles in length, named the Hollyford, which flows at a height of about 200 ft. above sea-level. The other side of the chasm is formed by the inaccessible wall of the Darrans, Mount Christina, and Mount Tutoko, 9,000 ft. in height. This is possibly one of the grandest views obtainable anywhere of a deep spurless cañon, as well as furnishing one of the most sublime spectacles on earth.

The perpendicular valley-slopes and inaccessible passes of Milford region and the gentler slopes and ragged ridges of the Wakatipu area are referable in great measure to the excessively hard and homogeneous nature of the Milford rocks and the folded, unstable, and alternately hard and soft character of the Wakatipu rocks.

PREVIOUS LITERATURE.

Lendenfeld* notes the characteristic scratches on rocks in West Coast Sounds as showing the recent age of glaciation. He mentions the plateau, the average depth of the sounds, their basin-like character, their contracted outlets, and the slight stage of filling of the sounds. He considers the cañons as originally formed by streams and modified by glacier-action, and that subsidence afterwards converted the valleys into sounds. He appears to have furnished as correct an explanation as yet offered of glacial phenomena, especially as regards the youthful nature of the latest phase of the ice age. He does not, however, advance enough facts to support his conclusions. For example, he makes little or no mention of the hanging valleys, the wonderful cliff-slopes, and the comparison with stream-developed forms is not dwelt on at all by him.

Hutton† suggests two ages for ice period, and discusses elevation as a sufficient cause for ice age. He demonstrates unmistakably the origin in the first place of the cañons by stream-action, and later modification by ice-action. He appears to consider that the maximum extension of ice was in Pliocene time, and that the ice age in New Zealand is much older that is usually thought to be the case. Also that the present depth of the sounds (2,000 ft. ?) argues corresponding former elevation.

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* Procs. Linn Society, New South Wales, Vol. ix., 1884–85, pp. 806–8.

† "The Geological History of New Zealand." Trans. and Procs. N.Z. Institute. 1899, pp. 173–80. Aus. Ass. Adv. Science, 1893, pp. 232–42.

Hector* considered Milford Sound as a fiord originally occupied by a glacier. He noted the hanging valleys, and referred them to old ice-channels whose mouths were planed off by the main ice-stream after the glaciers had disappeared from the side valleys by returning warm conditions.

Von Haast† believed that "numerous lakes met with on both sides of the high alpine chain of New Zealand were formed by the action of glaciers." He claimed that the lakes were wholly the result of ice-action and independent of rock-structure. He postulated an elevation to account for the cold period, and a plateau-reduction to the extent of 2,000 ft. to explain the retreat of the ice age. Haast always held that the ice age was in Post-tertiary time, and, in common with Von Lendenfeld, that its cessation is probably not more than several thousands of years since.

Hochstetter‡ is in accord with the views of Von Haast. Thus both he, Von Haast, and Lendenfeld are utterly opposed to the claim for antiquity advanced by Hutton.

PHILOSOPHY OF OBSERVATIONS.

The plateau which survives now as ridges and mesas from Wakatipu to Preservation Inlet probably marks the old-age stage of erosion of the surface originating in the Mesozoic folding of southern New Zealand. Differential elevation then ensued, which carried the plain-like surface (developed near sea-level) of the closing cycle of erosion to considerable heights. It is very probable that early Tertiary sedimentation was induced in this area by the deformation. Cañons early became the expression of the cutting-action of the streams on the raised area, and during Eocene time a series of anastomosing and graded watercourses were developed in the area. Subsidence ensued to close the Eocene erosion, the wide-bottomed valleys were deeply drowned, and thick masses of Oligocene age were deposited on the Eocene valley-floors. This has, it seems to me, been admirably demonstrated by Hutton§ in his reply to Von Haast's|| assertion that the cañons of the New Zealand Alps are due entirely to ice-action. Hutton, it will be remembered, claimed that the cañons were determined primarily by stream-action, and modified to some extent only by glacial activities.

Later movements occurred from time to time since the Oligocene sedimentation, the algebraic sum of which, at the

* Sir J. Hector: Q.J.G.S., Vol. xxi.; Geol. Mag., Vol. ii., 1870.
† Q.J.G.S., Vol. xxi., Vol. xxiii.; Geology of Canterbury and Westland.
‡ "New Zealand," 1867.
§ "The Geology of Otago," pp. 86-94.
|| "Geology of Canterbury and Westland," pp. 177-92.

WET-JACKET ARM

present time, is strongly in favour of elevatory forces, as is shown by the plateau-remnants 6,000 ft. and 7,000 ft. high.*

A late mature stage of development appears then to have been induced in this raised topography, as is evidenced by the complete state of dissection existing even in the heart of the ranges.

Then came the Great Ice Period of the Southern Hemisphere in recent times. Ice accumulated on the ridges, and gradually filled the gigantic ravines of the central plateau. The old water-channels had occupied but an insignificant fraction of the great cañons, but at the period of maximum ice-intensity the whole valley, thousands of feet in depth, became the ice-channel. Inasmuch as the movements of ice-streams are analogous to those of water-streams, it will be noted that increase of volume is accompanied by a wonderful increase in power of transportation out of all proportion to the increase of volume. In the case of the ice-stream, the great increase of volume would be accompanied by a wonderfully increased efficiency of corrosion. Every portion of the immense valley-sides, as also the floor, would be subjected at the same time to the swift and awful scour of the moving mass, a mass in all probability exceeding a mile in thickness.

Let us now consider the appearance of a maturely developed river-system in a region of high relief, and then from the observed order of ice predict the resultant forms in this region of mature stream topography under stress of intense glacial activity.

In the thousands of instances which have come under the writer's notice, where valleys appear undoubtedly to have been the result of stream-action, the earlier-graded stages are marked by fairly wide valleys drained by winding streams. Numerous tributaries enter their channels for considerable distances from the points of intake, being unaccompanied by cascades or waterfalls. The lower inter-stream areas are also characterized by long rambling and even overlapping spurs in places, withal, however, allowing of the development of important aggradation-flats or flood-plains. These spurs advance from the plateau-level in the form of descending ridges, a slightly steeper descent marking the lower portions of those spurs which the meandering stream may be actively cutting back. These natural slopes were utilised by the early settlers in bringing their teams from valley to plateau. Many of the spurs employed are about 3,000 ft. in height, and thus

* In this connection we have, as in our other geographical studies, considered the heights of the plateaus under consideration above sea-level as being due to land-elevation, and not to a local lowering of the sea-surface, since all the important movements that have come under our notice are differential (warps), and as such due to earth-movements.

no formidable slopes are evidenced for the ascents of maturely developed valleys in eastern Australia.

Now, if a deep valley of such a type as here described be gradually filled by an ice-stream it is not difficult to predict some of the resultant forms under the new conditions. The descending mass, many millions of tons in weight, drags the enormous rocks attached to its under-surface against all parts of its large channel. The maximum velocity and weight occur along the deepest portions, the direct issue of which is that here also the maximum efficiency of the glacier as regards corrosion is found. Little by little the lower spur-ends yield under the ceaseless planing action. The upper portions are at the same time rounded and worn by the ice, but the maximum assault is delivered in the neighbourhood of the free ends of the spurs. The spurs will retreat gradually from the valley-base towards the plateau, presenting precipitous facets to the valley instead of gentle slopes. All this time the glacier is rapidly lowering its channel along the line of its maximum action.

Moreover, after a while the momentum of the ice-mass will tend to induce a rude alignment in the truncated spur-bases, the arrangement being fairly parallel to the main axis of the valley. This alignment of cliff-bases resulting from the retreat of spurs will become accentuated with their mutilation, and, as is to be expected from considerations of momentum, will be more emphasized in regions of intense glaciation. If the motion be continued long enough the spurs will entirely vanish, and a long evenly sloping inaccessible chasm* with horizontal (?) floor and rectilinearly disposed bordering walls will result as in the case of Sinbad Valley, Harrison Cove, and the Arthur Valley at Milford Sound. If the ice-action be stopped before the completion of its work spur-remnants will be common (Pls. IX., X, and XI.). From the spots where they are anchored into the plateau they will advance slightly with undiminished height, and end in cliffs thousands of feet in height (Pl. VII.). According to the strength of the ice-sheet the spurs of neighbouring valleys even may show endless variations in stages of preservation. Thus Milford and Wakatipu, with their high and enormous gathering-grounds, show spur-truncation and cliff-alignment in a marvellous degree as compared with certain of the more southern sounds.

The side valleys, not possessing such strongly moving ice-streams, will be unable in the initial stages to cut their channels down at the same rate as the main one, and, with the deepening of the main channel and the retreat plateau-

* This should also be the case if the cañon be due to ice-action alone. Here, however, no spur-remnants should occur, except in regions of local hardness.

HALL'S ARM: PARTIAL TRUNCATION OF SPURS.

wards of the main-valley spurs, those portions of the tributary channels situated immediately higher than the sphere of maximum cutting along the main channel will be left standing high above the main-valley floor, thus giving pronounced discordances of channel-grade at the points of intake. Doubtless the glaciers of the side valleys would, in the ordinary course of events, be the first to vanish under the influence of warmer conditions, while the main glacier still dug its way deeper along the central chasm, thus still further accentuating this want of harmony in side and main valley slopes. In the sounds one sees every stage of this spur-truncation as shown in the various plates accompanying the report.

These predicted resultant forms are based on the analogy between water and ice motion, and point to the youthful nature of the glacial dissection, since the association of wide basins like those of Wakatipu (fifty-five miles long and almost uniformly three miles wide) and Milford, with non-harmonizing side valley-slopes, would be impossibilities on the assumption of stream-development. It is highly probable, as suggested and discussed for the first time by Professor W. M. Davis,* that maturity of glacial dissection would result also in the perfect accordance of lateral and main stream channel-slopes at the points of junction. In Milford Sound, side valleys (as Harrison Cove) enter apparently "at grade," but as the fiord in the near neighbourhood is over 1,000 ft. deep (Fig. 2, *a*), and considerable infilling in places has ensued in post-glacial times, it is impossible to at present predict the amount of variation of slope at their points of discharge into the rock-basin of Milford.

The original valley-mouths would be the latest points invaded by the ice-streams and the first to be forsaken on the return of warmer conditions. Therefore these places underwent least glaciation. Up the sounds the retreating glaciers still dug their way into the rock after having forsaken their old points of discharge, hence the occurrence of the huge rock-basins of the sounds and lakes.

Similarly for the hanging valleys. Here, after the severance from the main ice-stream, the glaciers of the lateral channels would retreat slowly and scour their beds differentially, giving rise to a set of sequential features analogous to those of the main channel. Thus tarns would occupy these depressions excavated by the glaciers of the hanging valleys, and yield the phenomena of channels possessing dams or lips over which the tarns discharge into the main waterway.† In many examples of hanging valleys noted by the writer, however, the tarn occupies a much higher position than the

* W. M. Davis. Bull. Comp. Zool., Harvard Coll., Camb.
† *Ibid.*

point of discharge into the main valley. This would point to more rapid recession of the glacier, with a halt at a much later period, or even a partial advance along its old tracks.

The ice-streams of Milford Sound, Lakes Te Anau, Manapouri, and Wakatipu must have been of enormous thickness, since their beds have been excavated from 1,500 ft. to 1,700 ft. in places below sea-level, and the cañon-sides (5,000 ft. and 6,000 ft. in height), also exhibit the same shearing action from bases to summits. The glaciers appear to have spread over the associated plateau-remnants, as is suggested by a photograph taken by E. H. Willmot, Government Surveyor at Queenstown, New Zealand.

The higher steep slopes of the cañons terminating in precipices from 1,000 ft. to 2,000 ft. in height (Pls. III. and VIII., Fig. 2, *a* and *b*), and arranged parallel, approximately, to the main axes of the large valleys, are peculiar, and may be referred provisionally to a later and minor phase of the great ice period in New Zealand. Hector* is, however, of the opinion that the hanging valleys, which are specially emphasized by this lower precipice of the northern wall of Milford, are due to the work of the main glacier after the retreat of the side glaciers. He does not in this connection discuss the significance of the marvellous higher slopes of the sound. To him, however, appears to be due the credit of having first attempted a glacial explanation of the occurrence of the hanging valleys in New Zealand.

With regard to the age of the Great Ice Period in New Zealand, the writer is in accord with the view advanced by Lendenfeld, Von Haast, and Hochstetter, a view which has also more recently gained much support from the observations of Professor David in southern New South Wales,† where the ice-marks and moraines have a very fresh appearance.

With regard to the claim for great subsidence in post-glacial times by many writers owing to the depth of the sounds, the writer is unable to see its necessity. Base-level of corrosion for a glacier, especially if 5,000 ft. or 6,000 ft. in thickness, is not limited in depth by the level of the surface of the water-body into which it flows. It has abrasive power so long as not more than nine-tenths of its volume are beneath the water-surface. Hence it seems possible for an ice-stream to have abrading-power at depths exceeding those of the sounds. Water, on the other hand, loses its motion by diffusion on descending to the basin into which it discharges, and thus loses its power of corrosion below such surfaces (except as shallow pools). Subsidence in recent times appears

* Q.J.G.S., Vol. xxi.
† T. W. E. David.

STEEP SIDES (3,000 FT. TO 4,000 FT.); AND PARTIAL TRUNCATION OF SPURS.

undoubted for associated areas as evidenced by the drowned valleys, but not to anything like the extent required by the depths of the sounds (+ 1,700 ft.).

DESCRIPTION OF PLATES.

Plate I.—Sutherland Falls, 1,904 ft. high: The river is seen issuing from a "hanging" valley 3,000 ft. deep. A great wall 5,000 ft. high faces the main valley, and the famous falls form a low notch therein.

Plate II.—Sinbad Valley: A hanging valley 5,000 ft. deep, possessing inaccessible bordering cliffs having a uniform slope. Mitre Peak (5,600 ft.) forms its northern wall.

Plate III.—Stirling Falls, 504 ft. high: The hanging valley here shown has inaccessible sides some 4,000 ft. to 5,000 ft. deep. The noteworthy feature here shown is the perpendicular wall facing the sound (Milford) and continuous across the direction of the Stirling Falls. Thirty yards from the base of the falls the sound is 1,500 ft. deep.

Plate IV.—Milford Sound—the Northern Wall: The alignment of the great cliffs is noteworthy. The Lion (4,300 ft.), Pembroke Peak (6,700 ft.), and the Stirling Falls are seen on the left.

Plate V.—The Clinton Valley from Mackinnon Pass (3,500 ft.): The horizontal floor, the spurless chasm, and the plateau-like appearance of the highest points are well shown.

Plate VI.—The Upper Arthur Valley: Mounts Hart and Daniels are seen, each showing an inaccessible wall 5,000 ft. high to the valley. Note the absence of spurs on the left-hand wall.

Plate VII.—The Sentinal, Clinton Valley: A bold cliff from 3,000 ft. to 4,000 ft. above the valley, and evidently a truncated spur.

Plate VIII.—The Arthur River at its point of discharge into Milford Sound: In the distance appear the bold cliffs of the sound; on the right is shown the lower perpendicular slope of Sheerdown. Above this Sheerdown rises for other 3,000 ft. at an angle of about 60 degrees.

Plate IX.—Wet Jacket Arm: Showing the less truncation of spurs than in Milford and Wakatipu.

Plate X.—Hall's Arm: Partial truncation of spurs.

Plate XI.—Steep cliffs (3,000 ft. to 4,000 ft.) and partial truncation of spurs.

No. 3. SOME ROCKS FROM MACQUARRIE ISLAND.

By Dr. P. Marshall.

The rocks here described were collected by Mr. A Hamilton, the present Director of the Colonial Museum in Wellington, some years ago. The collection, which consisted of pebbles gathered from the foreshore, was handed over to the Otago University School of Mines. During the past year slices have been cut from these specimens, but no descriptions of them have hitherto been given.

DIABASE.

C 344, 347. Hand-specimen a dark rock, evidently well crystallized, though the minerals are not easily distinguished.

Section holocrystalline, in part aphitic. Minerals: Labradorite, dusty with decomposition-products, crystals generally small and much twinned, the last mineral to crystallize; augite pale brown, darker on the margins, often idiomorphic, but sometimes forming small aphitic plates; serpentine abundant, apparently formed from olivine, a little reddish-brown mica associated with the serpentine, probably anomite; iron-ore, magnetite, and ilmenite fairly plentiful.

DOLERITE.

C 348. Hand-specimen dark, showing abundant large crystals of felspar.

Section: Large felspars, partly idiomorphic, much stained by limonite in the cracks, which are very numerous. Extinction-angle high-labradorite. Groundmass in small quantity composed of felspar microlites and augite of a pale-brown colour. Small specks of serpentine represent olivine. There are also some larger crystals of olivine much serpentinised. Iron-ore not abundant, generally changed to limonite. Zeolitic matter plentiful.

PORPHYRITE.

C 371, 345, 346. Dark-green rock with very large felspar crystals.

Section: Large felspar crystals well twinned on albite and pericline laws. Extinction-angle indicates labradorite. Groundmass very dense, composed of plagioclase-laths imbedded in a pale-green augite. In C 346 a few crystals of chromite.

OBSIDIAN.

C 372.—Dark glassy rock, easily fractured.

Section: Light-brown glass, much fractured. Perfectly homogeneous in fresh portions, without any sign of microlites or crystallites. Along the cracks much serpentinous matter that may be original or introduced.

SERPENTINE

C 373.—A pure serpentine with some iron-ore. The rock is apparently the weathered product of an olivine diallage rock.

A comparison of these rocks with New Zealand specimens may be interesting.

The diabase closely resembles many of the Dunedin dolerites, but is, of course, much less fresh, and the pyroxene is more idiomorphic and paler in colour.

The dolerite is very similar to the well-known olivine andesite of Lyttelton Harbour.

The porphyrite is not at all similar to any New Zealand rock with which I am familiar.

The obsidian is a purer glass than any New Zealand specimens, though these are abundant in the Bay of Plenty district.

I can offer no details in regard to the geological occurrence of the Macquarrie Island rocks, except the fact that the porphyrite is clearly a dyke, for some of the selvage where it penetrates diabase is to be seen on one of the specimens.

No. 4. ON THE FIXING OF DATUM-MARKS ON THE COAST-LINE FOR THE MEASUREMENT OF THE SECULAR MOVEMENTS OF THE LAND.

By Professor JAMES PARK, J.G.S., Director Otago University School of Mines.

THE existence of raised beaches and submerged forests on our coast-line furnishes conclusive evidence of movements of the land relatively to the level of the sea in comparatively recent times.

Investigations in northern Europe have shown that secular elevation or depression is excessively slow, amounting to a few inches or, at most, a few feet in a century, a movement too slow to be perceptible in the lifetime of a single individual. It has further been shown that a period of subsidence is sometimes followed by a period of elevation, or *vice versâ*, or that either elevation or subsidence may be followed by a period of rest.

A submerged forest on a marine littoral is regarded as conclusive proof of subsidence, but at the present time we have no means of determining whether this negative movement is still in progress, or has been succeeded by a positive movement or a condition of equilibrium.

In a paper on "The Secular Movements of the New Zealand Coast-line," which I had the privilege of placing before the New Zealand Institute in 1901,* I discussed this subject in its more academic and economic aspects, and therefore need not traverse the same ground again. In that paper I urged the necessity of fixing permanent datum-marks at suitable places on the coast-line of Australia and New Zealand, so that in the distant future definite and exact knowledge might be obtainable as to both the direction and extent of the secular movements affecting our maritime areas.

The complaint is frequent that the depth of water in some of our principal harbours is less than it was forty years ago, when the Admiralty Coast Survey was made. Whether this shoaling is due to mere silting or to slow persistent secular elevation of the land is a problem that cannot now be solved in the absence of coast bench-marks for observation and reference.

I would again urge that a series of coast-marks should be fixed, with a cut or mark on each, to indicate a systematic mean sea-level. A uniform standard method of determining

* Trans. N.Z. Inst., Vol. xxxiv., p. 440.

mean sea-level should be agreed upon and used throughout Australia and New Zealand, in order to facilitate subsequent verification. In time the scheme might be extended to include the principal islands of the Pacific. These coast-marks would also provide a base-level datum for future hydrographical, bathymetrical, and geodetical determinations on a more scientific and exact basis than that now in use.

In Australia and New Zealand the height of places and objects above sea-level is determined by the measurement of vertical angles referred to a base-line reduced to an approximate sea-level. Experience in older countries has shown that the varying conditions of the atmosphere, more especially at the low angles at which such vertical angles are measured, render the angular error due to refraction so uncertain and variable that heights measured by vertical angles can only be regarded as close approximations.

Hence there is no present means of detecting changes of elevation of places inland from the sea, nor will it be possible to do so until initial base-level marks have been fixed on the coast-line for reference and verification. When this is done, it will then be possible to revise the existing geodetical surveys on the model of the refined methods of spirit-levelling from verified bench-marks adopted by the geological survey of the United States of America.

This is a debt which we owe to posterity, and as the subject is one of national importance it should be undertaken by the State. When performed it will form the foundation and starting-point of observations that will extend into the coming centuries.

No. 5.—NOTE ON SOME AXIAL LINES OF ERUPTION IN TASMANIA.

By W. H. Twelvetrees.

When the explorer gets away from the west coast, any linear directions of eruptive force are not very pronounced, though here and there they may be discerned. One reason for this is, I think, that the evidences of the older lines have been destroyed by the Mesozoic intrusions of diabase. This intrusive mass does not seem to follow any particular linear direction, but occupies irregularly the eastern and central portions of the island, lifting the Permo-carboniferous and Mesozoic sediments together with the granite which was underlying these. To what height the forces with which the granite-eruptions were associated had already raised the Silurian and older rocks we do not know, but we do know that these older sediments were subsequently depressed to sea-level, and formed a floor for the Permo-carboniferous strata. After the accumulation of these and the following Mesozoic deposits the diabase-intrusion took place, and would seem to have raised the land now occupied by the Eastern and Western Tiers to a great height above the level of the sea. The whole of the present elevation may not be due exclusively to the diabase, because, in the north of Tasmania, it is certain that, in Tertiary times, the land has risen several hundred feet.

It is, at any rate, easy to see that the great irregular intrusion of diabase may very well have obliterated any signs then existing of axial lines of disturbance; still, here and there indications are observable.

GRANITE AXIS ALONG THE EAST COAST.

That there is an axial development of granite along the east coast of Tasmania is apparent from a glance at the map. From Flinders Island to Maria Island a narrow strip of granite country runs north and south, skirting the sea front. In the north-eastern corner of the Island this strip widens out, and nourishes an important tin industry.

LINE OF GRANITIC INTRUSION AT ANDERSON'S CREEK.

Along a north-west line at Anderson's Creek, west of Beaconsfield, for a couple of miles at intervals, there are outcrops in serpentine of white binary granite, the intergrown quartz and felspar constituents often showing graphic structure. These are isolated occurrences, but I have seen a white-mica-granite specimen from near Holwell, a few miles further south. In the same zone at Anderson's Creek there is a ridge of dark granite or gneissoid-looking rock intrusive in the serpentine N.N.E.-S.S.W. for a distance of about a mile.

Mr. Card determines it as aplitic tourmaline, bearing biotite granite. Along its contact with the serpentine large bodies of chromiferous magnetite and limonite have been developed.

LINE OF GRANITIC INTRUSION EAST OF THE DIAL RANGE.

Along a north-and-south line close to this range intrusive quartz porphyry and granite impinge on the Silurian slates and sandstones. The contact is marked by a brecciated-rock zone of considerable width containing iron and copper pyritic ores. These intrusive masses are doubtless in connection with the main body of the granite west of Riana, and stretching to the Blythe River and the Hampshire Hills.

ALKALI BELT AT PORT CYGNET.

This belt, which is now familiar to many of us, is a complex, comprising numerous related rock-varieties. These are plutonic, elæolite, and alkali syenites, with local variation products, essexite, mica-nephelinite, jacupirangite, akerite, &c., as well as intrusive porphyries such as tinguaite porphyry, sölvsbergite porphyry, elæolite syenite porphyry, alkali syenite porphyry, &c., all of which traverse the lower marine fossiliferous mudstones, sandstones, and shales of the Permo-carboniferous.

The width of the belt is between two and three miles. It is believed to extend south-west across the River Huon to Desolation and Surges Bay. At the Regatta Ground a promontory of elæolite and alkali syenite projects into the bay or arm. About half a mile south of this is a dyke of tinguaite porphyry 5 ft. in width, and bearing north and south. One hundred yards further south is another dyke of similar rock, 2 ft. wide, bearing N. 20 deg. W. Further south still is a dyke of garnetiferous mica-sölvsbergite, 2 ft. 6 in. wide, and bearing N. 10 deg. W. These dykes are intrusive into Permo-carboniferous pebbly mudstone. This alkali zone extends north-east to Little Oyster Cove, and I have quite recently found that essexitic rock exists as far north as Margate, on North-west Bay.

MELILITE BASALT ON THE SHANNON TIER.

Small cones of this rock protrude through the Mesozoic diabase at the edge of the Tier. These attain a height of 30 ft. to 50 ft. above the surrounding surface; they are probably of Tertiary age. I have seen three of these cones along an east-and-west line of about half a mile, and I am told that further east there are one or two more. If this is the case, the line of eruption is slightly crescentic, following the face of the Tier, and not far within the boundary of the diabase. The idea has suggested itself to me that the cones are possibly situated on the diabase boundary-line. The largest one, north of White's farm, is a double one, and consists of bluish compact melilite basalt, breaking with a conchoidal fracture. This is known locally as the Haystack, and, as it stands in a small clearing, it can be seen from a good distance on the Hunterston Plain. No ashes are preserved, and the cone is probably a surviving neck. Between the two cones, and at the base of the north side of the larger one, the grass conceals a very coarse nepheline-augite rock = nephelinite, composed of augite in long prisms and light-coloured nepheline. Much of the nepheline has decomposed into radiating snow-white natrolite or hydronephelite, and Mr. Petterd has identified some beautiful zeolitic needles as Thomsonite. The long prisms of augite were surmised to be tourmaline on the first discovery of the rock. It was thought that some useful mineral might be disclosed, and accordingly a little work was done at this spot. The coarse nephelinite seems to penetrate and fill the joints of the finer basalt, presumably by a process of segregation, for the two rocks must be contemporaneous. It would be interesting to prove whether it underlies the cone. It varies occasionally into a rock of finer grain. Proceeding west along the edge of the Tier, over diabase rock, for half a mile, a smaller melilite basalt cone is met with, about 30 ft. high, with a north-and-south basal diameter of 120 ft. and 50 ft. east-and-west. This may be called the Beehive, and about 100 ft. west of it is a still smaller cone, not more than 12 ft. high, which is the Anthill. Some varieties of the rock contain nepheline as well as melilite, and could be called "nepheline-melilite basalt."

MELILITE BASALT.

A Tertiary melilite basalt occurs also at Sandy Bay, Hobart, and at the last meeting of this Association I picked up some basalt on the road, on the opposite side of the Derwent, between Bellerive and Frederick Henry Bay, which proved to be similar. This year I have also found a melilite basalt at Margate, south of Brown's River. The directions of these occurrences cannot be stated at present. It is not known whether separate vents existed, or whether they belong to the lava emitted by a single cone.

It is highly probable that occurrences of melilite basalt will be noted at points intermediate between Hobart and the Shannon.

[Paper 6 is printed in the Report of the Glacial Committee, and 7 in Report of the Structural Features Committee.]

CORAL-REEF ROCK RISING IN TERRACES UP TO 700 FT. ABOVE SEA-LEVEL, SOUTH OF HAVANNAH HARBOUR, EFATE (SANDWICH ISLAND), NEW HEBRIDES.

No. 8. PRELIMINARY NOTE ON THE GEOLOGY OF THE NEW HEBRIDES.

By D. Mawson, B.E.

Communicated to the Australasian Association for the Advancement of Science, by Professor David, B.A., F.G.S., F.R.S.

In this paper it is intended to summarise the results of recent geological explorations in the New Hebrides by the author.

Early in 1903, by the kind offices of Captain E. G. Rason, R.N., H.M. Deputy Commissioner for the New Hebrides, and at the suggestion of Professor David, I arranged to spend the winter months in this pursuit. Accordingly on the 3rd April, in company with Mr. W. T. Quaife, who, also under the auspices of Captain Rason, was proceeding to make botanical and zoological collections, I set out for the Port of Vila in the Island of Efate. On the 11th we passed the Loyalty Islands, whose high limestone cliffs, already examined by a geologist,* have still to undergo the more critical examination of present-day theorists. We arrived in Vila, the commercial centre, on the 13th, and for the next few days were occupied in establishing ourselves with Captain Rason and unpacking the necessary apparatus.

A great field was now open before us, for, although Europeans have had knowledge of the group for almost three centuries past, since the landing of Quiros† at the Bay of San Felipe, in the north of the Island of Espiritu Santo in 1606, nothing has yet been gleaned as to the true nature of the rocks forming this extensive chain of islands. It was therefore with great interest that we pursued our investigations for the next six months.

We first acquainted ourselves with the raised coral reefs and underlying foundation-rocks in the vicinity of Vila: then, widening our scope, we camped at Havannah Harbour, where a most important series of raised reefs was examined. At this locality an immense thickness of submarine tuffs, usually composed of fragments of white pumice up to 4 in. diameter, but occasionally appearing as a well-bedded, fine-grained, mouse-grey deposit with average grain-size 0.02 mm., forms the formation-rock on which is built an extensive series of raised coral reefs. Interbedded with the fine grey submarine tuffs is a slightly yellow variety somewhat greasy to touch, and very similar to the Fiji soapstone. This rock

* Rev. W. B. Clarke, Quart. Jour. Geol. Soc., Vol. iii., p. 61 (1847).
† The Geographical Journal, Vol xx., No. 2, p. 201.

had already been noted by Commodore Goodenough in his journal,* where he makes reference to a waterfall in the interior of Efate where "the water runs over a soapy earth like that at Suva, Fiji." The joints of this rock are stained by manganese. Occasional *Foraminifera*, the most conspicuous of which is a *Globigerina* attaining a diameter of 0.25 mm., are scattered through it, proving its deep-sea origin. The raised coral reefs, forming a veneer seldom exceeding 100 ft. in thickness over pumiceous submarine tuffs, appear as terraces of which at least nine were traced, culminating in Mount Erskine, 1,270 ft. (see illus.). The submarine tufaceous beds were ascertained to reach a height of almost 1,000 ft., and had a section been obtainable it is expected that they would be found to extend to an even greater height. These observations at Havannah Harbour were later on supplemented by a detailed examination of the hills to the south of Undine Bay, where raised coral reefs were found capping the highest peaks and overlying submarine tuffs and agglomerates. A fragment of limestone taken by me from a raised reef in this locality over 2,000 ft. above sea-level was found on examination to be part of a large coral, evidently *in situ* in the old reef. This specimen was crystallized, and in an advanced state of dolomitisation, making it impossible of specific identification.

On the 25th May we proceeded north in H.M.S. "Archer" to the small Island of Uripriv, situated off the east coast of Malekula. From Uripriv we worked our way up the coast with centres at the small Islands of Rano and Atchin, examining the mainland as far as circumstances would permit.

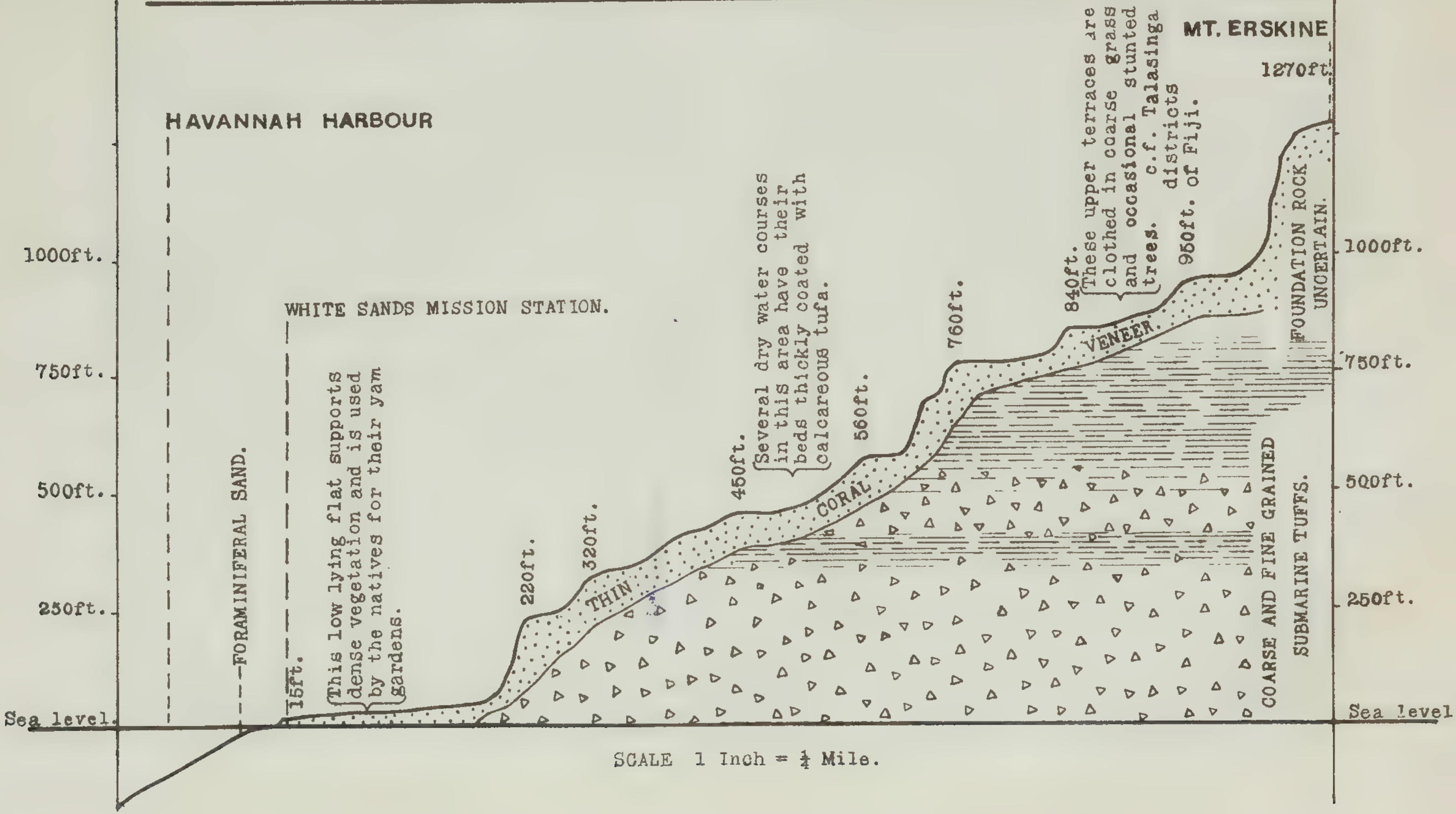
The Natives of Malekula are the most uncertain of any of the inhabitants in the Group, having not yet abated from cannibal habits; indeed, war was raging between the Natives of Rano and Wala at the time of our visit. For this and other reasons we were unable to examine this region very thoroughly. The most important discovery was that of a bed of nummulitic limestone several hundred feet thick underlying the foundation-rocks of the recent raised reefs.

On the 3rd June we again embarked on H.M.S. "Archer," which had just returned from a punitive expedition to the west coast. After visiting the wreck of the "Mambare" on Tutuba Island, and taking leave of Captain Rason at Malo Island, where official business required his presence, we proceeded to the mission settlement of Tangoa, situated about the centre of the south coast of Santo. From this centre we made several excursions to the west coast, on one occasion reaching as far north as Wuss.

* "Journal of Commodore Goodenough," London, 1876.

HILLS OF ANDESITE AGGLOMERATE CAPPED BY RAISED CORAL-REEF ROCK, RISING TO 2,300 FT. ABOVE SEA-LEVEL, LOOKING SOUTH FROM SCOTT'S PLANTATION, UNDINE BAY, EFATE (SANDWICH ISLANDS), NEW HEBRIDES.

SECTION OF THE RAISED CORAL REEFS HAVANNAH HARBOUR



It was from Tasiriki, situated about three miles north of Cape Lisburn, that Quaife and myself made an attempt to reach the summit of the highest mountain in the Group known as Santo Peak, but whose native name is Losumbunu. This peak, 5,520 ft. high, is situated almost due north of Tasiriki, distant about twenty miles, crowning a series of lofty mountains which rise up in ridges from the coast. As no European has yet traversed this stretch of mountains, or even reached its flanks, it was with great enthusiasm, notwithstanding discomfort from drizzling rain which had not ceased since early the day before, that we started out on the 11th June with three Native guides. These guides were the best obtainable, selected by the Rev. F. Bowie, whose hospitality we had been enjoying since our arrival at Tangoa. They were bushmen from near the south slope of Losumbunu, and professed to have visited the top of the mountain on several occasions for the purpose of catching flying-foxes, a delicacy much esteemed by them for culinary purposes.* In this undertaking we were destined to be greatly disappointed, for, although two well-fought attempts were made to reach the goal, we had to abandon the project after arriving at an elevation of 4,300 ft., and just a mile and a half to the south of the peak. Our disappointment, however, was soon lost in the satisfaction of having made interesting and valuable collections from the lofty summits of Lobweri and Talapone.†

The geology of this region can be summed up as follows: Three well-defined unconformable series of sedimentary rocks, all of submarine origin and more or less tufaceous, are intruded in places by a rock varying in character from that of an andesite to a syenite, and overlie massive beds of an andesite agglomerate. A splendid section of these rocks is to be met with on the Wai Bubo, about two miles inland. Here the oldest series is represented by well-bedded *Orbitoides* limestones, radiolarian shales, and coarse calcareous submarine tuffs, dipping at an angle of 50 degrees, and constituting in all several hundred feet in thickness of sediments.‡ The second series is represented by well-bedded gritty rocks, dipping 28 degrees, containing occasional *Globigerina*, but composed almost wholly of mineral fragments. These beds, which are about 300 ft. thick, are capped by a variable thickness of a soft fine-grained light-yellow *Globigerina* ooze. This *Globigerina* ooze, dipping at an angle of 8 degrees, constitutes the most recent of the three unconformable series

* Later on we found that these hunting expeditions after flying-foxes were to the top of Talapone, a peak attaining a height of 4,300 ft., situated about three miles south of Losumbunu.

† Mr. W. T. Quaife, communicating with me recently, mentions that amongst the orchids collected in this locality, and at present being examined at Kew, five new species have been recognised.

‡ On the Wai Malicolico this same series is dipping at an angle of 70 degrees.

which were traced from Cape Lisburn on the south to the north of Wuss, being as far north as I had opportunity of observing. The vast number of the fossil foraminifer *Orbitoides* occurring in the oldest of these rocks indicates their probable age as that of Eocene. These discoveries are specially interesting in the light of recent geological investigations in the islands of the Pacific, amongst which that of Mr. W. G. Woolnough, B.Sc., F.G.S.,* in Fiji, and, more recently still, a report on the geology of New Caledonia by M. Piroutet,† deserve special mention.

On the 1st August the last section of our work was commenced, when we paid a short visit to the Banks and Torres Groups in H.M.S. "Archer," returning to Vila on the 15th instant, after making several short calls at passing islands. We had intended spending some time examining the huge volcano of Ambrym, but had eventually to abandon the idea. This volcanic island, eighteen miles in diameter, represents the cone of a volcano. The original crater-ring is seven miles in diameter, but this old crater is now partially extinct; two small active vents occupy positions in the old crater near its north margin 2,000 ft. below the highest portions of the lip. These vents are continually active, and at night often present a fine spectacle as seen from the deck of a passing ship. Occasional flows of lava proceeding from fissures in the old cone, several of them reaching to the sea, have occurred in recent years, the last being recorded in 1894. It is worthy of note that earthquakes, which are of common occurrence, seem to be most frequent, so far as observed, at sunspot minima, as many as forty shocks being felt in one night at Vila in February, 1902.

Amongst the eruptive rocks of the New Hebrides and Banks Groups many types of basic and intermediate magmas are represented, usually by their volcanic varieties. The later eruptive rocks have much the same facies, usually containing large idiomorphic crystals of plagioclase, often 3 mm. diameter, giving extinctions close to that of labradorite, in addition, a variable amount of similarly disposed pyroxene.

Much of the beach-sand, particularly on the north coast of Aoba, is composed of a mixture of magnetic-iron particles and small grains of olivine, thus indicating the existence of large areas of a basic olivine-bearing rock in that neighbourhood.

The absence of acid types of rocks is strong evidence in favour of the recent origin of the land-surface represented by the islands of the New Hebrides and Banks Groups.

* Proc. Linn. Soc. N.S.W., 1903, Pt. 3, pp. 457–540.
† Bull. Soc. Géol. France, Vol. iii. (1903), p. 156.


I
II
III
IV
WALLACE'S
AUSTRALIAN REGION
PAPUASIA
ORIENTAL REGION

Section D.

BIOLOGY.

PRESIDENTIAL ADDRESS.

By Colonel Legge, R.A., F.Z.S., M.B.O.U., F.R.A.S. (Ceylon).

(Delivered Thursday, 7th January, 1904.)

THE ZOOGEOGRAPHICAL RELATIONS OF THE ORNIS OF THE VARIOUS SUB-REGIONS OF THE "AUSTRALIAN REGION," WITH THE GEOGRAPHICAL DISTRIBUTION OF THE PRINCIPAL GENERA THEREIN.

In thanking the Council of this distinguished Association for the high honour they have conferred on me by my election to the President's chair of this section, I am mindful of the graceful compliment thus paid, on the occasion of the last Congress, to my State, but at the same time I cannot but wish that some more able scientist had been elected to fill this important office. At the time of my election and acceptance of the office I fear I did not realise the responsibilities which attach to it, one of the chief being the preparation of an address to the ladies and gentlemen whose labours are devoted to the very comprehensive science of biology. In this respect I cannot hope to in any way equal the efforts of the distinguished men who have filled the office on the occasion of past meetings, and therefore the indulgence of members of the section must be craved in regard to my shortcomings. It is likewise patent to me that, being but a specialist in one branch of science—ornithology—the subject-matter of such an address as it has been my endeavour to prepare cannot appeal generally to my hearers, hence the difficulty I feel in making my remarks of general interest to my audience.

In dealing with the zoogeographical relations of the several areas—or sub-regions, as they will be styled—of the portions of the globe which come under our consideration, the great "Australian Region," as distinguished by that eminent scientist and naturalist, Dr. A. R. Wallace, in his great work "The Distribution of Animals," will principally engage our attention. As there are, however, no clearly defined limits to the range of many of the genera which inhabit the Western Division or Sub-region of the Australian Region, as distinguished from the adjoining Oriental Sub-region

(Indo-Malaya), this latter area will frequently come under consideration, as, indeed, will also the Indian Sub-region further to the westward, and from which so many forms of bird-life extend eastwards towards our region and penetrate it to a greater or less extent.

On referring to the map of the region in question, you will observe that it contains four divisions or sub-regions namely, (1) Australasia, (2) Austro-Malaya, (3) Polynesia or Oceania, and (4) New Zealand. Each of these sub-regions has its specialised forms, of more or less interest, Polynesia perhaps taking the lowest rank in this respect. Austro-Malaya has its Birds of Paradise (*Paradiseidæ*), Crowned Pigeons (*Gouridæ*), and Long-tailed Kingfishers (*Tanysiptera*), all found in New Guinea; Australia its Lyre-birds (*Menuridæ*), Mound-raisers (*Megapodidæ*) not quite, however, confined to it its Emus (*Dromæidæ*), and Plain-wanderer (*Pedionomus*); New Zealand its peculiar Starling (*Heteralocha*), aberrant Pitta (*Xenicus*), Sheep-killing Parrot (*Nestor*), and, lastly, among many others to be hereafter mentioned, its wingless *Apteryx;* Polynesia its extraordinary Pigeon of the Samoan Group (*Gnathodon*), and nocturnal crane-like-form *Rhinochetus* of New Caledonia.

By reference to the map before you the extent and limits of these sub-regions will be seen. It might be thought that the boundaries of the Austro-Malayan Sub-region were somewhat artificial, but on perusing Wallace's definition of it in the above-mentioned work, and, I might also say, after working out the "distribution" of the birds in it, it is at once plainly seen that many families and genera are characteristic of the area exactly within those boundaries, either as specialised groups or as representatives of Australasian forms ranging beyond the continent into it. It may be here mentioned that it will be advisable in this paper, when speaking of the Continent of Australia, to use the term "Australian," which includes Tasmania, as distinct from "Australasian," which refers to the whole region comprising the four subdivisions above mentioned.

The centre or focus of distribution of the various genera peculiar to this sub-region is New Guinea and its islands lying to the west, the ornis of which is entirely New-Guinean in character, and often identical, these islands sharing with the Papuan mainland in the species found there. From this centre the New-Guinean forms range, often somewhat sparingly, to the Eastern Group, comprised of New Ireland, New Britain, and the Solomons, and westward to the Moluccas, Celebes, and the Lombok-Timor Chain. Within these limits the genera and species of a Papuan character are fairly evenly distributed: but in Celebes and Timor there is the addition of an Indo-Malayan and often an Oriental element, furnished by species which penetrate Austro-Malaya sparingly, their representatives coming into these islands and ranging no farther. This will be seen when the geographical distribution of the birds of the region is dealt with in this paper. It is right, further, to notice here that the ornis of Celebes has a remarkably individual character. Not a few genera are confined to this remarkable island, such as *Gazzola*, *Meropogon*, *Artamides*, and some half-dozen athers. Many species of both Indo-Malayan and Austro-Malayan genera are peculiar to the island, and coupled with this individuality is a strong affinity to the Oriental Region as above remarked, inasmuch as thirty-seven Indian genera are found in it, some of which also extend to Africa. In speaking of Celebes, Wallace writes, in his "Distribution of Animals," that "its fauna presents the most puzzling relations, showing affinities to Java, to the Philippines, to the Moluccas, to continental India, and even to Africa, so that it is almost impossible to decide whether to place it in the Oriental or the Australian Region." The strangest characteristic, however, in connection with the Celebean ornis is the fact of its being, as it were, the halting-place of Oriental genera, such as *Spizaetus* and *Pernis* (both Raptores of powerful flight), *Coracias* (a typical Roller largely located in Africa), *Buceros*, *Budytes*, *Monticola* (Rock-thrushes), and *Turtur* (Turtle-doves). Why should none of these pass onwards to the Moluccas, the Island of Gilolo not being far distant from the long eastern arm of Celebes, and the southern arm of which is not far from the intervening Islands of Bouru and Sulus? The answer must surely be that its remarkable mountainous and forest-clad character in some parts, and its open country in others, furnishes, in connection with its large area, an appreciable resting-place for such forms as those enumerated above. More remarkable perhaps is the manner in which the same *rôle* is allotted to the much smaller Island of Timor, where in not a few instances the direct range of species from the Oriental Region to Australia is arrested. Two noteworthy instances of sudden arrest of range are those of *Circaetus* (Serpent Eagle) and *Ruticilla* (Redstart).

The chief interest, however, as regards the character of the Austro-Malayan ornis centres in New Guinea. In this vast and wonderful island—the land of the Birds of Paradise and the giants of the *Columbæ*, the aforementioned Crowned Pigeons—we are sure to find, in addition to members of genera, perhaps common to it and Australia, peculiar forms of the same sub-families or groups revealing special characteristics and solely confined to it or its coastal islands. Of these may be mentioned among Pigeons, *Eutrygon* and *Otidiphaps;* Kingfishers, *Sauromarptis;* Honey Buzzards, *Henicopernis;* Lories, *Hypocharmosyna;* Lorikeets, *Cyclopsittacus;* Drongos, *Dicranostreptus;* Babblers, *Eupetes;* and so on.

So rich, however, is the avifauna of New Guinea that in spite of the numerous specialised forms found in the country its ornis has a considerable affinity with that of Australia. In the order *Passeriformes* this is especially the case; Australian genera range into New Guinea, and genera well represented within her limits extend also to the northern parts of Australia. This affinity would be much more marked were it not that the physical features and vegetation, and consequently the food-supply, are very different in the Northern Territory from what obtains in New Guinea. Tropical vegetation is almost confined to the scrubs and bush in the peninsula on the hills continuous with the cordillera of Australia and the coastal flats bordering the great Gulf of Carpentaria. It is chiefly in these areas that the ultra-tropical forms which stray from the adjoining Malayan Islands to Australia are found. Further west in the Northern Territory, and round the great bight containing Cambridge Gulf, the country is of a more open and typical Australian character, and is in such marked contrast as regards topographical features to the Malayan Islands, Timor excepted, that the avifauna of this extensive littoral tract has but little affinity with that of New Guinea. We shall see, however, that it has some relation with that of the Timor Group and the Tenimber Islands in the matter of affinity of genera; but, as to the range of the Oriental and Indo-Malayan forms alluded to, the breadth of the Arafura Sea, 250 geographical miles at its narrowest part, and perhaps the less tropical character of the vegetation, combined with the absence of mountainous country similar to that of Timor, effectually stop nearly all further extension in the direction of Australia. I am referring here to present conditions as affecting immigration of species to the continent from Timor, and not to those which originally gave the ornis of Timor its character. This is fully dealt with by Wallace in his notice of the avifauna of this Group, in which he shows that the Australian element is derived from the former proximity of the island to Australia, inasmuch as most of the Arafura Sea is shallow from the continental shore to within a score of miles of Timor, proving pretty conclusively that there was formerly land-connection up to that point. He also demonstrates the probability that after the island had received its Australian element it acquired a Malayan one through the subsequent elevation of the present Timor Chain—Lombok, Flores—which divides it from Java.

In the Admiralty Islands and the New Britain - New Ireland Group the character of the ornis is distinctly Papuan, and the same may be said in a slightly less degree of the extensive Solomon Chain; but apparently the avifauna of this Group is, so far, less known than that of the more northern islands, and, like that of the interior of Papua, awaits very considerable extension when the hostility of the Natives can be overcome and the mountain wilds explored.

The affinities of the Papuan genera among passerine birds will be further dealt with when speaking of Australia; but it will be right to allude here to the special New Guinea family *Paradiseidæ*, containing the most beautifully and fantastically plumaged birds in the whole Region. Though a few genera are found in the western islands—Waigiou and the Moluccas—others are restricted to New Guinea, among which are *Seleucides*, *Drepanornis*, *Epimachus*, *Astrapia*, *Paridigalla*, *Parotia*, *Lophorhina*, and *Xantholemus*, the latter a bird of wonderful plumage. It is not only, however, Birds of Paradise which are pre-eminent as regards beauty, for we find the same remarkable coloration and character in the Kingfisher and Parrot families; and Wallace, in comparing the plumage of Malaccan and Amazonian birds with that of Papuan, finds a higher proportion of beautiful birds in it than in either of the two former, both localities celebrated for the beauty of their ornis.

In addition to the peculiar character of so many of the Papuan genera, it should be mentioned here that the affinities of many genera are with the Malay Archipelago; and, further, as we shall notice in the geographical distribution, there are others which are allied to Oriental genera and do not appear in the other islands of Austro-Malaya. This brings us, before passing to the Polynesian Sub-region, to the question of the boundary-line between the Austro-Malayan and Indo-Malayan Sub-regions, the latter belonging, as many of you know, to the Oriental Region, comprised of the Indian and Indo-Chinese Subdivisions, as well as Indo-Malaya. This dividing-line must appear to those who have not entered into this interesting subject of geographical distribution as somewhat arbitrary. Such is not, however, the case. Between the Islands of Bali and Lombok there is a deep strait, which formerly and prior to the elevation of the so-called Timor Chain—Lombok, Flores, Sandalwood Island, and others—must have been wide, and so effected a division between the fauna of the two sub-regions.

Northward of this chain is the great island of Celebes, already referred to as possessing, in addition to its strange affinities with the Sunda Chain and Borneo Group, a distinct relation in its ornis with the rest of Austro-Malaya. Further than this, the avifauna of the island possessing less affinity with that of the Philippine Group than of the Austro-Malayan Area it has been placed in the latter, and thus forms a very material portion of its eastern boundary. Hence we have the line passing, as it is shown on the map, from Lombok northward, between Borneo and Celebes, and thence eastward to the south of the Philippines.

The Polynesian Sub-region, which covers a vast area composed of small islands assembled in groups more or less separated from one another, is noted for the paucity of the genera and species inhabiting it in proportion to its size. It has affinities with Austro-Malaya, its neighbouring sub-region, many genera extending from the latter through the intervening islands to the Fijis and Samoa, and some to the Society Islands. Among these may be mentioned *Pinarolestes*, *Pachycephala*, *Myzomela*, *Aplonis*, *Ptilopus*, and *Phlogœnas*, which reach the Fijis. Some of these are Australian forms, which, added to others also ranging from Australia into Polynesia and poorly represented in Austro-Malaya, combine to establish a fairly strong affinity with the continent. New Caledonia and the Loyalty Islands, together with the New Hebrides, form a distinct group, the same genera in some cases ranging through it. This subdivision of Polynesia has distinct affinities with Australasia, such genera as *Acanthiza*, *Myiagra*, *Rhipidura*, *Eopsaltria*, *Pachycephala*, *Zosterops*, *Artamus*, *Halcyon*, *Trichoglossus*, *Ptilopus*, *Chalcophaps*, and other continental forms being found in it. Fiji has relations with this group, but is, perhaps, better associated with the Samoan Islands. The Fijis, however, possess many Austro-Malayan and Australasian genera in common with some interesting forms peculiar to the Group, such as *Chrysœnas*, a beautiful genus of Pigeons, and *Lamprolea*, belonging to the *Timeliidæ*, or "Babbling Thrushes." Mention, too, must not be omitted of a Honey-eater, *Leptornis*, which with its three existent species, allies Samoa and Fiji with New Caledonia. As we pass further to the east into the isolated Society Islands, Marquesas, and Low Archipelago the birds decrease in genera and species. Two genera of Pigeons, *Ptilopus* and *Phlogœnas*, the latter a typical Polynesian form, exist there; and one interesting genus of Parrakeets, *Cyanoramphus*, found also in New Caledonia and New Zealand, is located in the Society Islands. In the Samoan Group we have that strange and aberrant form of Pigeon, *Didunculus*, which, while it affords a noteworthy instance of isolated location as belonging to a family allied to the extinct Dodo of the Mauritius, is also an example of one of the specialised forms which characterize the Australian Region. In this respect one might also mention that singular form *Rhinochetus*, of New Caledonia, which will be again alluded to.

The Carolines, Marshalls, and Ladrones, lying to the north of Austro-Malaya and widely separated from that sub-region, have affinity with it and Australia through various passerine genera, as also the picarian genus *Caprimulgus*, located in the Pelew Islands.

Among their passerine birds, perhaps the most notable instance is that of *Acrocephalus syrinx*, a Reed-warbler, and a resident species of what is a typical Australian and Austro-Malayan migratory form. *Aplonis* is another genus which creates affinity with Austro-Malaya. *Lalage*, a well-distributed genus of Caterpillar-catchers, and located in Austro-Malaya somewhat freely, is represented by a species in Ponapé. The Fly-catchers *Rhipidura* and *Myiagra*, Honey-eaters *Myzomela* and *Erythrura*, the Wood-shrike *Artamus*, the Pigeon *Ptilopus*, and, finally, *Megapodius* are genera which connect this distant archipelago with Austro-Malaya and Australasia.

The next and final subdivision to be noticed is the Sandwich Islands, which present one of the most singular instances of a scanty ornis in the tropical regions of the world. Something over a dozen genera exist in these large islands, and these comprise an extremely small number of species, only about thirty being known. Two species of Owl are recorded, which will be noticed hereafter. A Fish Eagle (*Polioaëtus solitarius*) is restricted to the Group, with no nearer congeners than the ordinary Malayan species *P. ichthyaëtus*, located in Celebes, this being a most singular instance of isolation. The Group likewise possesses a Raven endemic to it. The genera peculiar to the Islands do not ally them in any marked manner to the rest of Polynesia, but endow them with a strong individuality. The Fly-catchers are represented by the genus *Chasiempis*, one species of which, however, has been discovered in Rarotonga. Then there is a singular Honey-eater, *Moho*, with two species. Several genera of Finches, *Loxops*, *Chloridops*, *Rhodocanthis*, *Psittacirostra*, *Hemignathus*, *Himatione*, are all endemic to the Group, and a curious form of Wood-shrike, *Phœornis*, is also located in the Islands, allying it remotely with other parts of the Australian Region. Recently a new species of *Hemignathus* and *Loxops* have been described by the Hon. W. Rothschild. These birds and the finch-like genera above enumerated have been placed in a distinct family, *Drepanididæ*, which accentuates the specialised character of the Hawaiian ornis. The same naturalist has described a new genus in the family *Meliphagidæ*, *Palmeria*, the species being named *P. mirabilis*.

I have referred in detail to the ornis of this interesting Group on account of its remarkably distinct and specialised character. The presence of so many endemic genera is thought to be evidence of the great age of the Hawaiian avifauna. Wallace points out too that, as the flora of the Islands partakes in the highlands of a "north temperate" character, it may have been originally derived from a North American source, as between that continent and the Group sundry small islands still exist; but he at the same time points out that the "absence of any American forms of vertebrata renders it certain that no actual land-connection ever took place."

Before passing on to the Australasian Sub-region it is interesting to note that the genus *Merula* (Blackbirds) is scattered throughout Polynesia, and is only present in the form of two species in Malaya Java and the Philippines; and, further, that it does not exist in the Australasian Sub-region, that it reappears in the New Zealand Subdivision, having passed by way of New Caledonia to Norfolk Island and Lord Howe Island. It is likewise noteworthy that the genus *Graucalus* (Cuckoo-Shrike) does not pass into Polynesia, though so well represented in Australia and Austro-Malaya, four species being found in eastern Papuasia New Ireland and the Solomons which are on the confines of the Polynesian Region.

We now come to the most important division of the "Australian" Region namely, the Australasian Sub-region.

It may be advisable, before dealing with the distribution of families and genera in connection with the avifaunistic relations of the continent with its surrounding areas, to take a short analytical view of the character of its ornis.

In treating of the geographical distribution of species it is right to state that it is not the intention to deal with any but land-birds, including the *Fulicariæ* (Rails), *Alectorides* (Cranes and Bustards), *Herodiones* (Spoonbills, Storks, and Herons), under this head. In regard, therefore, to the various orders included in the above category namely, the *Accipitres*, *Passeriformes*, *Picariæ*, *Psittaci*, *Columbæ*, *Gallinæ*, *Hemipodii*, *Fulicariæ*, *Alectorides*, and *Herodiones* we find that the ornis of Australasia is made up of the following elements:

1. A large proportion of genera peculiar to it, including among their ranks three families containing specialised Australian forms namely, *Atrichidæ* (feeble-winged forest forms), *Menuridæ* (Lyre-birds), and *Pedionomidæ** (Plain-wanderers).

2. Typical Australian genera, more or less strongly represented in Australia, and extending likewise into Austro-Malaya and Polynesia.

3. Representative species of genera more or less typical of

* I have separated *Pedionomus* as a member of a distinct family for reasons hereafter stated.

Austro-Malaya, and extending to the Australian continent, where they are for the most part confined to the north.

4. Genera of more or less wide range passing through Malaya and penetrating to Australia, and some of which are exclusively Oriental.

In the first series are the following genera:

ACCIPITRES.—*Urospizias*, *Uraëtus* (sub-gen.) *Lophoictinia*, *Gypoictinia*, *Hieracidia*.

PASSERIFORMES.—*Strepera*, *Struthidea*, *Corocorax*, *Sphecotheres*, *Pterodocys*; (Fly-catchers) *Smicrornis*, *Sisura*; Bowerbirds) *Ptilonorhynchus*, *Scenopaeus*, *Prionodura*; (Babblers) *Stipiturus*, *Sphenura*, *Amytis*, *Chthonicola*, *Acanthiza*, *Orthonyx*, *Pycnoptilus*, *Hylacola*, *Psophodes*, *Cinclorhamphus*, *Calamanthus*, *Eremiornis*, *Ephthianura*; (Titmice) *Xerophila*, *Sphenostoma*; (Crow-Shrikes) *Gymnorhina*; (Shrike-Tits) *Falcunculus*, *Oreoica*, *Heteromyias*; (Honey-eaters) *Acanthorhynchus*, *Melithreptus*, *Plectroryhnchus*, *Meliornis*, *Manorhina*, *Anthochæra*, *Entomyza*; (Flower-peckers) *Pardalotus*; (Weaver-Finches), all the eleven genera except *Munia*, *Aidemosyne*, *Taeniopygia*; (Scrub-birds) *Artrichia*; (Lyrebirds) *Menura*; (Kingfishers) *Syma*.

PSITTACI.—(Parrakeets and Lorikeets) *Polytelis*, *Platycercus*, *Barnardius*, *Psephotus*, *Neophema*, *Nanodes*, *Melopsittacus*, *Pezoporus*, *Gropsittacus*; (Cockatoos) *Calyptorhynchus*, *Licmetis*, *Callocephalon*; (Cockatoo-Parrakeets) *Calopsittacus*.

COLUMBÆ.—(Pigeons, Doves) *Lopholæmus*, *Phaps*, *Histriophaps*, *Petrophassa*, *Geophaps*, *Lophophaps*, *Ocyphaps*, *Leucosarcia*.

GALLINÆ. (Game-birds) *Synaecus*, *Lipoa*, *Catheturus*.

HEMIPODII.—(*Pedionomidæ*), *Pedionomus*.

FULICARIÆ. *Tribonyx*, *Microtribonyx*.

PLATALEÆ. *Carphibis*, *Platibis*, &c.

An examination of the above list shows how many of the characteristic genera of the sub-region are peculiar to it. This is particularly the case in the *Timeliidæ* (Babblers) in so far as the smaller and ground-loving forms are concerned. The same, and to a greater extent, is observable in the *Meliphagidæ*, the most characteristic family of the birds of the Region. The Honey-eaters are so numerous and so widely distributed over the adjacent sub-regions that we shall find when we come to the next series, Nos. 2 and 3, that other genera, such as *Myzomela*, *Glycyphila*, and *Ptilotis*, which are strongly represented in Australasia, establish a marked affinity with Polynesia and Austro-Malaya. The whole of the Flower-peckers of Australia are almost confined to the genus *Pardalotus*, the sole other representative being a *Dicæum*. The Weaver-Finches offer another instance of the Australian individuality of the passerine families.

Passing on to the Parrots (*Psittaci*), which are the next most typical Australasian group to the Honey-eaters, we see how strongly the endemic genera muster. In one sub-family, *Phabinæ*, of the Pigeons, out of seven genera located in Australia, six, as enumerated above, are endemic to the sub-region. In the "game birds" the peculiar genera chiefly belong to the almost exclusively Australian family *Megapodes*, or Mound-raisers. In the *Hemipodes* we only have that remarkable and puzzling form *Pedionomus* as endemic to the continent. In the Rails, which are chiefly made up of Oriental and Malayan genera, we only have two peculiar to Australia, as noted above.

In the second series we have genera preponderating in Australia, allying it to Polynesia and Austro-Malaya, as also slightly to New Zealand. They are the following:-

PASSERIFORMES. (*Paradiscidæ*) *Ptilorhis;* (*Prinopidæ*) *Grallina*, *Collyriocinchla*, *Pinarolestes;* (*Muscicapidæ*) *Micræca*, *Petræca*, *Gerygone*, *Pseudogerygone*, *Malurus*.

TIMELIIDÆ. (Babblers) *Chlamydodera*, *Sericornis*, *Cinclosoma*, *Drymædes;* (Crow-Shrikes) *Cracticus;* (Shrike-Robins) *Eopsaltria*, *Pachycephala*, (*Certhiidæ*) *Climacteris*, *Sitella;* (*Meliphagidæ*) *Glycyphila*.

PICARIÆ. *Podargus* and *Dacelo*.

PSITTACI.- *Cacatua*.

COLUMBÆ.- *Gropelia*.

HERODIONES.- *Notophoyx*.

Through certain of the above genera affinity is established with Austro-Malaya alone, instances being *Grallina*, *Cracticus*, *Micræca*, *Malurus*, *Sericornis*, *Cinclosoma*, *Sitella*, *Podargus*, *Dacelo*, *Cacatua*, which do not range much beyond Australian territory; while a few others, such as *Pachycephala*, *Petræca*, *Climacteris*, range into Polynesia, or beyond the boundaries of our region into Indo-Malaya. It will be found, therefore, that representative Australian forms which range beyond the continent as a rule are restricted to Austro-Malaya for the most part, only a few species of such genera extending beyond its limits.

In the third series we have genera preponderating either in Austro-Malaya or in that area and Polynesia combined, and some of which establish a general affinity between the various sub-regions almost more than the second series. Of these may be mentioned *Rhipidura* in particular. This is a thoroughly representative "Australian" form, and has been included in this list in spite of its ranging to India, as it has its headquarters in Polynesia and Austro-Malaya, being also strongly represented in Australia. Out of fifty-two species only six range beyond the confines of our region--two to India and four to Indo-Malaya. *Rhipidura*, furthermore, extends to the New Zealand Sub-region.

The following is the series: —

PASSERIFORMES. (*Paradiseidæ*) *Phonygama*; (*Muscicapidæ*) *Pœcilodryas*, *Machærorhynchus*, *Arses*, *Piezorhynchus*, *Monarcha*; (*Meliphagidæ*) *Myzomela*, *Ptilotis*; (*Timeliidæ*) *Æturædus*, (*Sturnidæ*) *Calornis*.

PSITTACI. — *Glossopsittacus*, *Cyclopsittacus*, *Microglossus*; (*Halcyones*) *Alcyone*, *Tanysiptera*.

It will be observed that the Fly-catchers muster strongly in this list. Some genera, as *Pœcilodryas*, *Machærorhynchus*, *Arses*, *Monarcha*, *Piezorhynchus*, come to Australia from Papuasia, the two latter also from other parts of Austro-Malaya. The true Honey-eater genera ally us with both Polynesia and Austro-Malaya, and are very representative Australian forms.

In the fourth series we have a great number of genera of wide distribution which connect both Australasia and other sub-regions with the Oriental, and in a measure with the African regions. These are the usual accipitrine birds, *Circus*, *Astur*, *Accipitris* (Harriers, Goshawks, and Sparrow-hawks), and Indian genera of small Eagles and Kites: *Nisaëtus*, *Milvus*, *Baza* (a typical Oriental Falcon): *Elanus* (an Oriental and Ethiopian Kite); and the widely distributed genera *Falco*, *Cerchneis* (Kestrel), and Osprey (*Pandion*); also *Strix* (Barn-owl), ranging to Africa, and *Ninox* (Hawk-Owl), which is so well represented in Australia. This latter may correctly be styled an "Australian" form ranging to India, as the preponderance of species is in the former area. Then follow numerous passerine genera as follows: *Corvus*, *Corone*, which are cosmopolitan, our Raven, as we have seen, extending to the Sandwich Islands; *Oriolus* ranges from Africa through Europe and Asia; *Graucalus* and *Lalage* among the Cuckoo-Shrikes, the latter extending to Africa; *Myiagra* (Fly-catchers) from India. In the *Turdidæ*, *Acrocephalus* and *Geocichla* extend to us from Palæarctic and Oriental Regions, and, entering ours, spread through Austro-Malaya, but do not enter Polynesia. Among the Timeline genera we have three representatives, *Megalurus*, *Cisticola*, and *Pomatorhinus*. The first might perhaps have been included in the third series, as two species out of eight are only found in the Oriental Region: the second is represented by a roving species, one of many scattered throughout the Old World, and the only one entering our region. *Pomatorhinus* is interesting as being an Oriental Babbler well represented in Australia, but not elsewhere in Austro-Malaya except New Guinea. The family of Sun-birds is represented by our single species of *Cinnyris*, an abundant form in Africa, ranging through the Oriental region to Austro-Malaya, and just reaching Australia in the north. In the Flower-peckers, *Dicæum* is our only external form, and comes to us from India. Then follow

Hirundo, *Petrochelidon*, *Anthus*, *Mirafra*, and *Pitta*, the first three wide-ranging genera, the last two Oriental, the latter with a wandering species which has found its way to Africa.

Among picarian birds our fourth series includes *Collocalia*, *Caprimulgus*, *Eurystomus*, *Merops*, *Halycon*, *Cacomantis*, *Eudynamis*, *Centropus*, and in the *Columbæ*, the genus *Columba*. Most of these are Indian forms, among which *Centropus*, the large, lark-heeled non-parasitic Cuckoo, is really more Malayan than Indian. In *Collocalia* we have another genus with a wandering species, *C. francica*. The next four are widely ranging, some species being located in Africa. *Cacomantis* and *Eudynamis* are Oriental, and *Columba* cosmopolitan.

In the game birds (*Gallinæ*) we have a distant migrant in *Coturnix*, the typical Quail, while *Excalfactoria* and *Turnix* are Oriental. Our next representatives are in the *Fulicariæ* (Rails, &c.), in which we have members of wide-ranging genera in *Crex*,* *Gallinula*, *Fulica*, *Porzana*, while *Porphyrio*, *Hypotænidia* are Oriental. The presence of a Moor-hen and coot, as also the Rails (*Porzana*), in Australia brings this sub-region into line with the distant parts of the globe inhabited by this genus, which extends to the Sandwich Islands; while *Porzana*, one of the most retiring and skulking forms in the order, has found its way among the islands of Polynesia.

In the *Alectorides* (Cranes and Bustards) we have two genera one, *Antigone*, ranging from the Palæarctic Region (Caspian Sea) through the Oriental Region to Australia, but not found in Polynesia or Austro-Malaya, its absence from the latter area being remarkable at first sight, but accounted for by topographical conditions not being favourable to its habits; and the other, *Eupodotis*, a member of the noble family of Bustards, located in Africa as well as India. This genus reappearing in Australia, and not inhabiting the intervening sub-regions in Malaya, is an instance of perplexing geographical distribution, but can probably be explained in the same way as the Cranes' absence from that area.

Finally, we have to deal with the *Platalea* and *Herodiones* (Ibises and Herons). In both these orders we have genera of wide distribution, ranging to Australia mostly by way of the Oriental Region. In the first, examples of these are *Ibis* and *Platalea*, neither of which extend to Polynesia. In the second, genera of wide range also pass into Australia, the examples being *Ardea*, *Herodias*, *Nycticorax*, *Ardetta* (Reed-bitterns), *Botaurus* and *Butorides* (Green Bitterns).

* Personally I place but little credence in this Palæarctic genus having found its own way to eastern Australia. It may have been a bird captured at sea, liberated in Sydney.

It is but natural that in such a wide area as our continent Herons and Bitterns should be found, but it is none the less interesting that we should possess European genera, such as Night-herons and true Bitterns, which extend into Polynesia and New Zealand. The same wide range in our region is applicable to the little Bitterns, *Ardetta* and *Butorides*, which extend through Polynesia, and in the case of the latter even to the Galapagos Islands. *Demiegretta* is also a connecting-link with Polynesia.

Before concluding our synopsis of the carinate birds of Australia allusion must be made to a further element in their ranks, which is that of migratory species, which enter the sub-region during the summer season only. In this category are *Cuculus*, *Micropus*, *Chætura*, *Chalcococcyx*, and *Cacomantis* (in part), the three former migrating to us from long distances and the latter from Austro-Malaya.

We now pass, in concluding our notice of this sub-region, to the sub-class *Ratitæ*, as represented in Australia, the members of which are there contained in the order *Casuarii*, consisting of two families, *Dromæidæ* and *Casuariidæ*. These contain but one genus each. The first, *Dromæus* (Emu), is one of our typical specialised forms, endemic in Australia, and the other a scarcely less noble form, *Casuarius*, well developed in Papuasia and one of its characteristic genera. The Cassowary might be classed in this connection with the third series of carinate birds which ally Austro-Malaya with Australasia, inasmuch as one species exists in the Cape York Peninsula, representing a number of others in Papuasia.

The *Ratitæ* do not extend into Polynesia, but are represented in an interesting manner in New Zealand by the wingless form *Apteryx*.

The fourth sub-region, New Zealand, is the most interesting of the zoological divisions of the Australian Region, owing to the remarkably specialised forms it contains, and the generally aberrant character of its ornis, as compared with that of Australasia. At the same time, the northern part of the sub-region, consisting, as you see when looking at the map, of the groups, New Norfolk and Lord Howe Islands, has an ornis which is more allied to that of Polynesia and Australia, and yet has such affinities with New Zealand that it forms part of her zoological area.

In proportion to the limited number of species contained in New Zealand, its specialised forms are more numerous and striking than those of Papua, imparting to its ornis that distinctive and individual character for which it is so well known. In addition to the interesting sub-class *Ratitæ*, which materially enhances the interest centred in the large list of peculiar forms endemic in Australia, Polynesia, and Malaya, there are in New Zealand several singular and, one might say, aberrant genera of carinate birds. Among these are the local representatives of Old-World families, such as the *Falconidæ*, represented by *Nesierax*; *Corvidæ* by *Glaucopis*; *Sturnidæ* by *Heteralocha* and *Creadion* (these last birds being more sturnine than corvine); *Timeliidæ* by *Turnagra* and *Clitonyx*; *Meliphagidæ* by *Anthornis*, *Prosthemadera*, and *Pogonornis*; and *Rallidæ* by *Notornis* (unhappily extinct, it is to be feared), *Ocydromus*, and *Cabalus*. To these may be added those interesting genera *Myiomoira* and *Miro*, which appear to really represent saxicoline forms though they have been placed among the Fly-catchers.

There are also three very peculiar families, *Xenicidæ*, *Nestoridæ*, and *Stringopidæ*, the first being of much interest, though not so aberrant as the other two. The above-noticed genera and families, together with *Certhiparus*, an endemic form of Titmouse, make up the specialised groups of New Zealand carinate land-birds; but this strange individuality in the avifauna of the country does not stop here, as in the *Limicolæ* (an order not dealt with here) there are two other genera, *Thinornis* and *Anarhynchus*, in which we have the same tendency to marked specialisation.

The Australian and Austro-Malayan (as also Oriental) genera located in New Zealand are *Hieracidea* (*Falconidæ*), *Rhipidura* and *Pseudogerygone* (*Muscicapidæ*), *Porphyrio*, *Hypotænidia* and *Porzana* (*Rallidæ*), *Notophoyx* (*Herodiones*). Then, there are others of wide distribution, occurring in Australia and passing on to New Zealand, to be there represented by distinct species, such as *Anthus*, *Halcyon*, *Coturnix*, *Fulica*, and *Botaurus*. One genus also viz., *Circus* extends with the same species (*Circus gouldi*) to New Zealand, and forms a direct link. In *Hypotænidia*, New Zealand is allied to all surrounding sub-regions, as she also is in *Porzana*, *Zosterops*, and *Graucalus* (an accidental visitant), and there are, furthermore, other genera whose identical species visit the country in the migrating season, as *Chalcococcyx*, *Micropus*, and *Eurystomus*; added to these is *Urodynamis*, in which a species located in the Society Islands migrates to New Zealand in the breeding season. This Cuckoo and the broad-tailed Parrakeet, *Cyanoramphus*, ranging to New Caledonia and the Society Islands, together with the above-mentioned more widely extending genera *Zosterops*, *Hypotænidia*, *Porzana*, as also *Fulica* and *Ardetta*, are the chief connecting-links between New Zealand proper and Polynesia.

The genera connecting New Zealand with the islands in the northern part of the sub-region are *Rhipidura* and

Pseudogerygone, found in Norfolk Island, and *Nestor*, which used to inhabit the Norfolk Island group, but is now extinct in those islands. This latter is one of those forms which go to prove the former land-connection when what is now New Zealand formed part of a large continental area extending to Norfolk Island, and thence northwards to Polynesia; another form which demonstrates this connection is *Cabalus*, the singular little Rail from Chatham Island, also found in Lord Howe Island, a distinct species inhabiting each locality.

We have seen the rather scanty connection which New Zealand has with Polynesia, through the genera *Urodynamis*, *Cyanoramphus*, *Zosterops*, *Hypotænidia*, *Porzana*, *Fulica*, *Notophoyx*, and *Ardetta*, and we have now to look into the relationship of the northern part of the sub-region namely, Norfolk and Lord Howe Islands with Oceania and Austro-Malaya. *Rhipidura* connects Norfolk Island with the Fiji group, Samoans, and Carolines; *Merula* unites both the islands above mentioned with New Caledonia, Samoans, and New Hebrides; and here one might remark that it is singular *Merula* has not extended its range to New Zealand. Again, *Pachycephala* is found in Norfolk Island and the Samoans, New Caledonia, and Loyalty Islands, and likewise connects the sub-region with Austro-Malaya. Another connecting-link exists in one of the Robin-Chats, the species *Petræca multicolor* being endemic in Norfolk Island.

Although in passerine birds we find that in proportion to the magnitude of the order but few Australian and Polynesian genera affect New Zealand, the relationship is more marked in the orders *Fulicariæ* and *Herodiones*. In the first order it has been seen how many genera of the *Rallidæ* are common to New Zealand and its neighbouring sub-regions; and in quite as marked a manner do certain genera of the *Ardeidæ* connect the other subdivisions of the Australian Region with New Zealand. One of these, *Notophoyx*, an Australian genus, is represented by the same species in New Zealand, and therefore forms a direct link between Australasia, Austro-Malaya, and New Zealand. Six others, *Ardea*, *Herodias*, *Ardetta*, *Nycticorax*, *Demiegretta*, and *Botaurus*, are wide-ranging, and range with the same species from the other sub-regions into New Zealand, with the exception of the last-named, which is represented in that country by an endemic species, *Botaurus novæ-zealandiæ*. Furthermore, in the same order we have a representative of the genus *Platalea* (Spoonbill) extending into New Zealand from Australasia. The presence also of an endemic species of Pipit (*Anthus*) and a Quail (*Coturnix*) in New Zealand is highly interesting, this being the extreme southern and eastern limit of these widely extended Old-World forms.

In addition to the interest attaching to the specialised forms of New Zealand which impart so strong an individuality to its ornis, a very noteworthy feature is the affinity of its avifauna to that of the islands lying to the north, and intervening between the sub-region and Polynesia. This opens up the question of the problematical and remote origin of the fauna of the entire sub-region, which has been ably dealt with by Dr. A. R. Wallace, Captain Hutton, Dr. Finsch, and other scientists. The habitat at the present epoch of the struthious genera *Rhea*, *Apteryx*, *Casuarius*, and *Dromæus*, extending *now* from South America westwards to New Zealand and thence to Papuasia and Australia in geological times, probably by way of Norfolk Island and New Caledonia, strongly supports the generally accepted theory of partial land-connection throughout these areas. But, as New Zealand is the portion of this supposed continent in which the gigantic struthious form *Dinornis* is now extinct and *Apteryx* still existent, may we not with some reason infer that it was originally the focus of distribution of the *Ratitæ* and that the existing genera spread outwards from it? In any case direct proof is given of land-connection between New Zealand and Norfolk Island by the existence in the latter not long ago of the genus *Nestor*, though the two species formerly located there are now unfortunately extinct. The presence, likewise, of that remarkable form *Rhinochetus* in New Caledonia, which in its habits resembles the specialised form of New Zealand night-parrot *Stringops*, though it belongs to a totally different order (*Alectorides*), seems remotely to suggest affinity to New Zealand, and to support the theory of partial land-connection formerly with that country.

At the conclusion of this short notice of the New Zealand ornis it is right for me to allude with praise to the commendable efforts made by the New Zealand Government for the preservation at the various recently established settlements in Resolution Island, Barrier Island, and elsewhere of some of its specialised forms now in danger of extinction. By this means it is to be hoped that these interesting birds will be preserved from extinction, a result which, as far as the scientific world is concerned, will be hailed with the warmest approval. It may be suggested, too, that efforts might be made to try and locate any examples of your interesting species of *Coturnix*, that could be caught or otherwise procured in one of the aforesaid settlements. For there they could be preserved from the attacks of cats, which it is understood have largely contributed to their approximate extermination.

In the following outline of the geographical distribution of "Australian" families and genera, it is to be hoped that the relationship of the various sub-regions will be more fully exemplified than in the foregoing notice, which has been mainly devoted to dealing respectively with each subdivision. In fact, the subject-matter now to follow will form the major portion of this address.

In regard to the omission of the orders *Limicolæ*, *Anseres*, and *Steganopodes*, it might be proper to state again that this has been done owing to so many genera in these orders being inhabitants of either the purely littoral areas of the region or its coastal waters, and it was therefore thought expedient to confine these observations to those orders whose genera pertained solely to the land-areas of the portion of the globe under consideration.

GEOGRAPHICAL DISTRIBUTION OF FAMILIES AND GENERA.

ACCIPITRES.—Taken in conjunction with its large area, Australia contains but few birds of prey. The number of species of diurnal *Accipitres* is 28—including an accidental visitant, *Butastur teesa*—and that of nocturnal *Striges* only 14. In comparison with these small numbers, we may cite those in small areas in other parts of the world, such as the Island of Ceylon, with 32 *Falcones* and 12 *Striges;* England, with 24 of the former and 10 of the latter; and if we compare the Indian Sub-region, with its more than 60 diurnal birds of prey, our Australian list is small indeed. In fact, all the divisions of the great Australian Region are poorly represented as regards this great order. Austro-Malaya ranks not quite so low as Australia, owing to the number of species peculiar to individual islands, but Polynesia has a poor representation, and New Zealand is almost devoid of Hawks and Owls, having but 3 *Falcones* and 2 *Striges*, which contain two genera peculiar to the country. We may therefore look partly to the paucity of species in these just-mentioned surrounding areas to account for our lack of representation, but we must also have regard to topographical and food conditions for further causes. Vast districts in the interior of Australia are almost devoid of life, and contain few accipitrine birds, and in the western division of the continent somewhat similar conditions prevail. In the southern and eastern States of the continent, where most species are located, the supply of insect food, on which many of the smaller species largely subsist in the tropics, is much less than in the latter, whilst also the smaller mammals, likewise food for Hawks and Owls, are not so abundant as in other countries. We thus see that various causes exist to affect the distribution of accipitrine birds in Australia.

A strong individuality, however, is noticeable in the *Falcones* of Australia. Seventeen out of the twenty-eight species existent are peculiar to the sub-region, and include five genera belonging exclusively to it, which are *Urospizias*, *Uroaëtus*, *Lophoictinia*, *Gypoictinia*, and *Hieracidea*, each containing single species with the exception of the latter. Out of the five members of the genus *Astur* (Goshawks), three are confined to the continent, two extending beyond its shores, one of which occurs in New Caledonia. *Astur*, which is a cosmopolitan form, is also fairly distributed through Austro-Malaya, and largely extends into Polynesia: Celebes, Gilolo, Batchian, Flores, Lombok, Ceram, New Caledonia, the Solomons, and Fiji each having their peculiar species.

The Harriers (*Circus*) are represented by two species only, one of which, *C. gouldi*, is found in New Zealand, New Caledonia, and Fiji: the other, *C. assimilis*, being recorded from Celebes, though not from intermediate islands.

Coming now to the Eagles (*Aquilinæ*), our representative of the typical genus *Aquila*, which does not range nearer than India, is the fine genus *Uroaëtus*, which is confined to the continent and Tasmania. In the genera *Haliastur*, *Haliaëtus*, and *Nisaëtus* we have relations with the Indian and Malayan Sub-regions. The two former pass through Malaya to Polynesia, *Haliastur* being found in New Caledonia, and the Sea-eagle (*Haliaëtus leucogaster*) in the Friendly Islands. *Nisaëtus*, however, is not found in the intervening sub-regions between India and North Australia, which is noteworthy. Of the typical Kites, *Milvus*, the sole Australian species, is found also in Austro-Malaya, where it inhabits Celebes and Timor, and extends to Chusan. The only other species in the Oriental Region, *M. govinda* and *M. melanotis* of India, do not pass into Malaya, the latter ranging eastwards to China and Japan.

A connecting-link between Australia and the Indo- and Austro-Malayan Sub-regions occurs in the handsome Kites of the genus *Elanus*, two species of which are peculiar to Australia, and a third, *E. hypoleucos*, is found in Java, Borneo, and Celebes. In passing, it is worthy of note that, local as these three species are, the remaining two are widely distributed: one, *E. cæruleus*, through Africa, Southern Europe, and India; the other, *E. leucurus*, throughout South and Central America and as far north as the Southern States. In the doubled-toothed Falcon, *Baza subcristata*, we have a representative of a gaily plumaged genus whose nucleus of distribution is the Malay Archipelago; the Philippines, Sumatra, and Celebes having respectively species confined to them, whilst the Austro-Malayan Islands, from Gilolo to New Guinea, have two more.

The true Falcons are represented in Australia by four species, two of which, *Falco subniger* and *F. hypoleucos*, are peculiar to it; a third, *F. melanogenys*, extends to Java and the Moluccas; and the fourth, *F. lunulatus*, ranges to Flores, not having been, however, recorded from Timor.

The Kestrels (*Cerchneis*), so well known in Europe, have with us but one representative, *C. cenchroides*, which is confined to Australia; the genus, though widely distributed throughout the world, does not range eastward from Australia, and contains but one species in the sub-region between India and Australia namely, *C. moluccensis*, of Java and Celebes. It is noteworthy that this genus, ranging through the New World as well as the Old—except Polynesia—furnishes not a few species peculiar to restricted localities, Madagascar having two, Celebes two, and the Seychelles and Mauritius one each, the same isolated location occurring in the West Indies.

Our peculiar genus, *Hieracidea*, is the most interesting of the Falcons on the continent, and may be considered one of the specialised Australian forms. It has the lengthened and weak legs of a Harrier, and the habits of a Buzzard and a Kestrel, soaring frequently like the former, and "hovering" with all the steadiness of the latter genus. Its nearest relation is your New Zealand form *Harpa*, of which the two species, *H. novæ-zealandiæ* and *H. australis*, are well known, the former extending to the Aucklands.

The genus *Butastur* is the most recent addition in Australia to this order, an example, *B. teesa*, having occurred sporadically in New South Wales, which does not, however, affect the zoogeographical relations of our ornis, as that species is an Indian bird; whereas the two Oriental and Austro-Malayan species, *B. liviventer* and *B. indicus*, occurring as near as Celebes, Timor, and New Guinea, have not yet occurred in our sub-region.

The sub-order *Pandiones* (Fish Eagles), in which the outer toe is reversible, a provision of nature to insure a firmer grasp of their slippery prey, and which consists solely of two genera, is represented in our region by the small Austro-Malayan and Australian sub-species of the genus *Pandion*, and which is found throughout the continent and sparingly in Tasmania, but does not extend into Polynesia or New Zealand. The second genus, *Polioaëtus*, does not range south of Java and Celebes from India. In the latter island both the Indian and Malay Peninsula species, *P. ichthyaëtus* and *P. humilis*, are found, and from the Sandwich Islands Peale has described a third under the name of *P. solitarius*.

Before closing our review of the diurnal birds of prey, it is interesting to notice several genera of Eagles which range south from the Oriental Region to Malaya and stop short of Australia. *Neopus* (Kite Eagles), one species of which, *N. malayensis*, exists, ranges from India to Celebes through

Malaya: *Lophotriorchis*, a genus of Hawk Eagles, extends from the same quarter to Batchian, Moluccas; *Circaëtus* (Serpent Eagles) ranges from India to Timor and Flores, strangely passing over Indo-Malaya altogether. This genus might well appear in North Australia, and its absence is one of the very remarkable instances of Indo-Malayan forms that do not pass Timor to enter Australia; *Spilornis*, another form of Serpent Eagle, has its home in India and Indo-Chinese countries, and ranges eastwards into Malaya, with species peculiar to Borneo, Java, Sumatra, Celebes, the Sula Islands, and the Philippines respectively; *Spizaëtus*, a genus of Crested Eagles, extends over the Neotropical Ethiopian part of the Palæarctic and the Oriental Regions, as also part of the Austro-Malayan Sub-region as far as Celebes, where, like many others, it finishes its range.

The Honey Buzzards (*Pernis*) must not be omitted from our notice, for they, likewise, extend from India to Celebes and come no farther, being represented in New Guinea by an interesting local form, *Henicopernis*, remarkable for its long tail, and quite representative of the specialised ornis of that country.

Striges.—The members of this sub-order (of nocturnal birds of prey) in Australia only number fourteen, and are restricted to two genera *Ninox* (Hawk-owls) and *Strix* (Barn-owls). In New Zealand the paucity of species is still more remarkable, there being but two Owls in the country—one a member of a genus restricted to your Islands, *Sceloglaux*, and the other a *Ninox*. Polynesia is almost absolutely devoid of Owls, the exception being a member of the genus *Asio* (Eared Owls), located in the Sandwich Islands and confined to the group—namely, *Asio sandvicensis*. This genus is not present in Malaya; and the Sandwich Islands bird is held to be a variety of the almost cosmopolitan species *A. accipitrinus*, which has a wide distribution in America, existing also as a variety in the Galapagos Islands. Besides which there are several additional species in America, including one in North America and another in Mexico, so that we may almost infer that the *Asio* of the Sandwich Islands has spread thither from the Nearctic Region of America. Of the two Australian genera, *Ninox* is well distributed in the Austro-Malayan Sub-region, ranging into India and northward to the Philippines. In Australia we have nine species extending throughout the continent.

In Papuasia and throughout Austro-Malaya the number of species restricted respectively to islands is remarkable. Timor has its species, *N. fusca;* New Guinea two species; Celebes two; Aru Islands, Ceram, Waigiou, Borneo, New Ireland, and the Solomons, one each. The relations, therefore, between the two sub-regions in question in this species are somewhat close. In Australia we have no very large owls of the family *Bubonidæ*, with the exception of one abnormally large species of *Ninox*—*N. strenua;* the only other large congeners being *N. franseni*, Waigiou, and *N. humeralis*, New Guinea.

Neither of the large genera *Ketupa* or *Bubo*, both found in India, extend nearer us than Java and Borneo respectively; nor have we any affinity with Austro-Malaya in the little genus *Scops*, spread nearly all over the world, and represented in the last-named area by species in Ceram, Amboyna, Batchian, Bouru, the Moluccas, Celebes, and Flores, in which latter two species, *S. sylvicola* and *S. albiventris*, are found. The genus is also present in India and Indo-Malaya.

Other genera that do not range to us, or even to Austro-Malaya, from India are *Glaucidium* and *Syrnium*, neither of which approach nearer than Java and Borneo.

The second and remaining Australian genus is that containing the Barn-owls, *Strix*. This is a small group, but of wide range, owing to the extensive distribution of the common Barn-owl, *Strix flammea*, and its close allies or sub-species.

In Australia five species are recognised, one of them. *S. delicatula*, being a small race of *Strix flammea;* three *S. novæ-hollandiæ*, *S. castanops* (Tasmania), and *S. tenebricosa*—are confined to the continent; the fifth, *S. candida*, is an Indian and Indo-Chinese form, ranging into north Australia and northwards to the Philippines and Formosa, but singularly does not appear to have been found in Austro-Malaya, the intervening area. The only other genus (*Phodilus*) in the family *Strigidæ* has a remarkable distribution, being found in northern India, Himalayas, ranging into Burmah, Pegu, and southwards to Java and Borneo, taking in the Island of Ceylon, in which a rare and closely allied species, *Ph. assimilis*,* is found.

Passeriformes.—We pass now to the great order of "Perching-birds," the members of which, as you are aware, far outnumber those of any other, and through which, as we have seen above, the relations of the Australian ornis are better established with those of the adjacent sub-regions than through any other: and, further, among which we find some of the largest typical groups that are characteristic of our own continent, Austro-Malaya, and Polynesia.

The sub-order *Passeres* contains all our perching-birds, and the first family in it to be dealt with is the *Corvidæ*, or Crows. The typical Ravens and Crows are weakly represented in Australia and Polynesia, but the latter, *Corone*, has

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* "Birds of Ceylon," p. 161, pl. v.

a strong hold in Austro-Malaya; the Islands of Batchian, Timor, Celebes, Ceram, New Guinea, and the Moluccas being the habitat of different species, some of which are found in the Indo-Malayan Sub-region as well. The same sub-region, however, has several genera peculiar to it, and located in individual islands—namely, *Gazzola*, in Celebes; *Gymnocorax*, in New Guinea; and *Macrocorax*, in the western Papuan Islands. New Caledonia has also its peculiar genus *Physocorax*, which is the only Crow in Polynesia, except the Sandwich Islands bird *Corvus hawaiensis*, which is in reality a Raven.

The Australian species, *Corvus coronoides* and *Corone australis*, are confined to the sub-region. The genera *Strepera*, *Struthidea*, and *Corocorax* (Choughs) are confined to Australia, whilst *Glaucopis*, *Heteralocha*, and *Creadion* are peculiar to your sub-region, and, like so many New Zealand forms, are handsome and interesting birds. None of these crow-like forms are found in Austro-Malaya, as not even the Indian genera *Cissa* and *Dendrocitta* extend any further than Sumatra.

In the Birds of Paradise (*Paradiseidæ*) we have perhaps the most remarkable instance of the many specialised forms of that wonderful country of birds, New Guinea. In it are located eleven genera, some of which are found in the adjacent islands (such as *Diphyllodes*, *Cicinnurus*, and *Paradisea*), while some are confined to Papua itself; and other genera, *Rhipidornis*, *Schlegelia*, *Semioptera*, and *Lycocorax*, are found only in Waigiou, Batchian, and Moluccas. In Australia the genus *Ptilorhis* (Rifle-birds), with its three species, and *Phonygama* represent the Birds of Paradise, and are confined in Australia to the north-east and east of the continent as far south as New South Wales, the latter genus being also found in New Guinea. The allied form *Manucodia* is likewise confined to Papua.

In the *Oriolidæ* (orioles) we have a family of wide geographical range throughout the Old World, but more concentrated in the Indo-Malayan and Austro-Malayan Sub-regions than in any other area of the same extent. In Australia we have three species, chiefly of northern habitat, and in the Papuasian and Moluccan areas there are eight species found collectively in the Islands of Flores, Celebes, Sanghir, Aru, Timor, Ceram, New Guinea, and Bouru. In the Indo-Malayan Sub-region are four species, the most northern of which (*O. chinensis*) is in the Philippines. No orioles inhabit Polynesia or New Zealand, no member of the family as in the Birds of Paradise extending east of New Guinea.

The aberrant form of Crow, *Sphecotheres*, allies Australia and Austro-Malaya. The species of this genus range from north Australia to New Guinea and Timor. They are known with us as "Fig-birds," and one of the Australian representatives, *S. flaviventris*, is found in the Kei Islands; the other, *S. maxillaris*, is confined to the continent.

The succeeding family on our list is the *Dicruridæ* (drongos), a very peculiar group of birds, which, for the most part, resemble gigantic Fly-catchers in their mode of life. Their stronghold is in the Oriental and Australian Regions, though our continent, in spite of its being the largest division of the latter region, only contains one species, *Chibia bracteata*. *Chibia* is a genus which is almost entirely Austro-Malayan, six out of the nine species known inhabiting that sub-region, there being one other in India.

Buchanga extends from the Oriental Region as far as Lombok only, and the handsome Indian genera, *Dissemurus*, *Dissemuroides*, *Bhringa*, only into Indo-Malaya. In Papuasia, however, are two peculiar genera, *Chætorhynchus* and *Dicranostreptus*, the former being confined to New Guinea. Austro-Malaya, therefore, though rich in species of this family, is only barely connected with Australia, and not at all with Polynesia and New Zealand.

Succeeding the last family are the *Prionopidæ*, or Wood-shrikes. The first genus, *Grallina* (Mapgie-Larks), connects New Guinea and Australia, a congener—*G. bruijni*—of our well-known bird inhabiting the mountains in Papua. *Collyriocincla* is an almost exclusively Australian form, some half a dozen species inhabiting the continent and Tasmania, one only of which, *C. brunnea*, strays to New Guinea. Our allied genus of Shrike-Thrushes, *Pinarolestes*, has, however, a wider distribution from Australia to Austro-Malaya and into Polynesia as far as the Fiji Islands, in which seven species and sub-species are found. Among these, one inhabits the Tonga Group, while three are found in New Guinea and its adjacent islands. In Australia, chiefly in the north, we have three species recognised. The genus is therefore chiefly Polynesian; one additional species being also found in the Pelew Islands. Further genera exist, which prove that Papuasia is the nucleus of this family. These genera are as follows: *Rectes*, *Pseudorectes*, and *Melanorectes*, all of which are confined to New Guinea and adjacent islands, seven species of the first-named genus being located in that area. Added to this list is the Polynesian form, *Phæornis*, of the Sandwich Islands, from which islands the species *P. obscura* is recorded.

The next birds to be noticed are those of the great group *Cichlomorphæ*—thrush-like or turdiform families, which comprise a very large proportion of the Perching-birds in the Australian Region. The arrangement by Dr. Sharpe in the

British Museum Catalogue, Vol. iv., of these families will be followed here.

The first is the *Campophagidæ*, or Cuckoo-Shrikes, which is mainly distributed from India to eastern Papuasia, although species of some genera are found, as is so much the case with birds of the Oriental Region, in Africa. The genus *Artamides*, which is distributed from the Bay of Bengal (Andamans) to New Caledonia, passes Australia by, though strongly located in Austro-Malaya, some species being found as near as Timor and New Guinea. Two small genera, *Pteropodocys* and *Campochæra*, are confined to Australia and New Guinea respectively, and are followed in our arrangement by *Graucalus*, a genus with many species, strongly located in the Austro-Malaya Region and fairly so in Australia, and which extends to India, with a further group in Africa and Madagascar. Five species are found in New Guinea and its islands, of which two are confined to the mainland and two are common also to Australia, in which three further species exist peculiar to it. Celebes has its species and New Ireland likewise, while three new species have been recently described from the Solomons, this being the eastern limit of the genus.

The succeeding form, *Edoliisoma*, is still more typical of Austro-Malaya than Australia. Seven species occur in New Guinea, and single species in Celebes, the Sanghir Islands, the Moluccas, Ceram, Borneo, and Batchian respectively, while one is also peculiar to New Caledonia, which is the eastern limit of the genus, its northern range being the Philippines. We in Australia possess but one species, *E. tenuirostre*, which is also New-Guinean. A smaller Austro-Malayan genus of Caterpillar-catcher, *Lalage*, has a wider distribution than the last, having a group in Africa, and ranging from India through Malaya to Polynesia as far as the Navigator Islands, in which one species is peculiar to Savage Island. New Guinea, Celebes, Timor, the Moluccas, as also Pelew and Ponapé Islands, possess their species, and the two Australian birds, *L. tricolor* and *L. leucomelæna*, are both found in Papua. Other species occur in Indo-Malaya, Java, Sumatra, Borneo, and the Philippines. Finally, we have *Symmorphus*, passing from the New Hebrides to New Caledonia and Norfolk Island, one species, *S. leucopygius*, being confined to the latter.

Muscicapidæ: We now come to the second great family of the *Cichlomorphæ*—namely, the Fly-catchers, distributed over the Old World, and containing, as far as our regions are concerned, some genera rather artificially placed in it, such as *Malurus*, *Gerygone*, and *Petrœca*, which have not the habits and mode of life of the typical genera of the family. *Malurus*, *Smicrornis*, and *Gerygone* resemble in these respects the

Warblers, and *Petrœca*, living chiefly on the ground, recalls the Chats. Most of the genera present in Malaya, Australia, and Polynesia are peculiar to them, few Indian or Indo-Malayan forms entering Austro-Malaya, or, as you will remember, crossing the line going northward from the Straits of Lombok, between Borneo and Celebes. The exceptions are as follows: From the Indian Region—*Muscicapula* to the Moluccan group, *Pratincola* to Celebes, *Oreicola* to Timor, *Hypothymis* to Celebes, *Rhipidura* to Oceania, *Terpsiphone* to Flores, *Culicicapa* to Celebes; and the Indo-Malayan genus *Erythromyias* to Timor.

Twenty-four genera are found in Austro-Malaya, fifteen in Australia, nine in Polynesia, and four in the New Zealand Sub-region. Some of these are common to more sub-regions than one, or to all four, such as *Petrœca*, *Pseudogerygone*, and *Rhipidura*. For example, the seven Australian genera, *Micrœca*, *Gerygone*, *Pseudogerygone*, *Pœcilodryas*, *Malurus*, *Monarcha*, and *Arses*, are present in Austro-Malaya, the remaining eight being confined to Australia. In Polynesia the three first-mentioned genera are located as follows: One species of *Petrœca* in Fiji and Samoa, and another in New Hebrides; one of *Rhipidura* in each of the Islands of Fiji, Samoa, Ponapé, and Banks; one species of *Pseudogerygone* in New Caledonia. Besides these, we have in Polynesia a species of *Myiagra* endemic respectively in Samoa, New Caledonia, Carolines, Pelew, and New Hebrides, while three occur in Fiji. In the New Zealand area we have three species of *Petrœca* located if the genus *Myiomoira* be not kept distinct from it: one is found in Norfolk Island, *P. multicolor; P. toitoi* in the North Island of New Zealand, and *P. macrocephala* in the South Island and the Chathams.

Turning now to Austro-Malaya, one finds that this sub-region contains the nucleus of this family, as far as our region is concerned. *Myiagra* is found in New Guinea, the Moluccas, New Ireland, and the western Papuan Islands, one species being located in each; the extensive genus *Rhipidura* is abundant, seven species being found in New Guinea, of which four are confined to it; two in Timor; while Flores, Ceram, Bouru, Jobi, the Admiralty, and Kei Islands have each their species.

Of the nine members of *Rhipidura* in Australia one of which is peculiar to Tasmania *R. setosa* ranges through the Papuan Islands to New Ireland; a second, *R. rufifrons*, to Ternate; and a third, *R. tricolor*, has a like range to Papua, taking in Batchian and the Moluccas as well.

In Polynesia *Rhipidura* is also well represented, Fiji having four species, New Caledonia two, New Hebrides two, and the Mackenzies, Banks Island, Ponapé, Samoa, and the Pelews each one. In the New Zealand Sub-region three species occur, one of which, *R. pelzelni*, inhabits Norfolk Island. It may be mentioned that westward of our region this Fly-catcher ranges through Indo-Malaya to India.

Another genus, *Piezorhynchus*, is very abundant, twenty-three species being found in the Austro-Malayan Sub-region, extending from Timor to the Papuan Islands and to Gilolo: of these, seven are located in New Guinea and its isles with the Louisiade Archipelago. Of our three species in Australia, one is peculiar to the north of the continent, *P. gouldi;* and two others, *P. nitidus* and *P. leucotis*, occur in the Aru Islands and the Louisiades respectively.

Pseudogerygone, a genus of tiny Fly-eaters, is largely represented in Papuasia; out of twenty-four species known, eight are confined to New Guinea proper, and five more to it and the adjacent islands. Four are peculiar to the New Zealand Sub-region, as follows: Two, *P. igata* and *P. sylvestris*, to New Zealand; one, *P. albifrontata*, to Chatham Islands; and the fourth, *P. modesta*, to Norfolk Island. Out of six species in Australia, two, *P. brunneipectus* and *P. personata*, extend to New Guinea, the former being also found in the Aru Islands. The remainder are restricted to the continent, three being located in north Australia.

The genera *Gerygone*, *Arses*, *Machærorhynchus*, *Microeca*, *Pœcilodryas*, and *Malurus* are all common to Australia and Austro-Malaya, and are restricted to them. *Pœcilodryas* is chiefly a Papuan form, eight species out of the twelve known being confined to New Guinea. *Malurus* is a typical genus among the ornis of Australia, as in point of beauty it is unsurpassed. Out of the sixteen or seventeen species now recognised, all are restricted to Australia but one, *M. albiscapulatus*. *Gerygone* is better represented in Austro-Malaya than in Australia, and *Arses* and *Machærorhynchus* are chiefly Papuan, only one species of each being found in Australia.

Other genera exist in the Oriental Region, of which only one enters ours, possessing one species, *Siphia rufigula*, endemic in Celebes, and another common to that island and Indo-Malaya.

Turdidæ.—A characteristic feature of the Australasian ornis is the scanty distribution of the Thrushes (*Turdidæ*) within its limits. We may note that this occurs owing to so many of the genera of *Sylviinæ* (Warblers) and *Turdinæ* (Thrushes) being Palæarctic breeders, migrating only to the Indian or Indo-Chinese Sub-regions in the winter, and consequently not reaching either Austro-Malaya or Australasia. We have therefore only representatives of such forms as may be said to originate in the Indian regions and have representatives in Malaya, or which are resident species in Australia or Polynesia.

Among the Warblers the genus *Sylvia*, comprising those charming little Warblers which, in spite of their weak flight, migrate long distances from the Palæarctic Region southwards, are entirely absent from Malaya, though some range into India from northern Asia and the Himalayas in the cool season. The same may be said of *Hypolais* (the Tree-warbler), which also does not come farther south than India. Further, the genus *Phylloscopus* (Willow-warblers), a form more general in India than either of the above, has but one species, a Burmese form, *P. viridipennis*, which enters Austro-Malaya through the Malayan Islands, and stops at Timor. We are therefore reduced to the Reed-warblers *Acrocephalus* before we find any representatives of the *Sylviinæ* which enter Polynesia or Australia. In this genus we have the Chinese Reed-warbler *A. orientalis*, which migrates through Malaya to western Papuasia, being found in the winter in Lombok, Batchian, and Bouru; *A. syrinx*, a resident species in the Carolines (Ponapé); and two resident and peculiar species to Australia, *A. australis* and *A. longirostris*. The former, an Eastern form, is an internal migrant to the south (to breed) from the north-eastern part of the continent; the latter, which is a West Australian species, breeds in the south of that State, but its winter movements do not seem as yet to be ascertained. The Grasshopper Warbler, *Locustella*, a Palæarctic form, has one species only, *L. fasciolata*, which ranges from China into Austro-Malaya, where it is found in the Moluccas as far south as Batchian.

It is not until we come to the Thrushes, as restricted, that we find any representation of importance in the Australian Region, and then we have a rather singular distribution in it of species of the chief genera, *Geocichla* (Ground-thrushes) and *Merula* (Blackbirds and Ouzels). The former well-developed genus of some forty species is strongly represented in our region so far as Austro-Malaya and Australia is concerned, while the latter, a still larger genus of more than fifty species, is here mainly located in Polynesia, where ten species and one doubtful form (*M. ulietensis**) occur; while in Austro-Malaya there is but one species, *M. javanica*, found in Timor, as also in Java, and another located in the Philippines, making a total of two for the adjoining Sub-region of Indo-Malaya.

The islands of the Pacific in which the genus *Merula* is found are as follows: Fiji, *M. vitiensis*, *M. bicolor*, *M. tempesti*: New Caledonia, *M. xanthopus*: Loyalty Islands,

* Known only from a drawing by Forster of an Ouzel from Ulietea, Society Islands.

M. pritzbueri, *M. mariensis;* New Hebrides, *M. albifrons:* Lord Howe Island, *M. vinitincta;* Norfolk Island, *M. poliocephala;* Samoa Islands, *M. samoensis.* The distribution of *Merula* in our region is somewhat perplexing: with twelve species in the Oriental area, including only two in Indo-Malaya and one in Austro-Malaya, we have ten in Polynesia though it is absent from Australia and New Zealand and further east from the Pacific, in the Neotropical Region, sixteen species, thus leading to the inference that the Polynesian Group is an outlier from America.

Returning to *Geocichla*, we have three species in Australasia *G. lunulata* and *G. heinii*, peculiar to the continent, and *G. macrorhyncha*, restricted to Tasmania. In Austro-Malaya there are five *G. monticola*, from Lombok, also found in Java; *G. papuensis*, peculiar to New Guinea; *G. erythronota*, peculiar to Celebes; *G. peroni*, restricted to Timor: and *G. interpres*, in Lombok, as also in Java in the adjoining sub-region. The genus is largely represented in the Oriental Region, and two species are located in the Palæarctic Region; and finally we find it allying the Australasian and Austro-Malayan Sub regions.

The Nightingales (*Erythacus*) range only as far as Borneo from Asia, but the Redstarts (*Ruticilla*), extending from China and the Himalayas southwards, reach Timor, where *R. aurorea* is found. The Rock-thrushes (*Monticola*) also extend southwards as far as Celebes, where one species, *M. solitaria*, is located. Neither of the two last interesting forms reach Australia, and are instances, so often prominent, of Asiatic families entering Austro-Malaya, but not crossing the seas which bound Australia on the north.

Timeliidæ.- Following the Thrushes in the order of the classification adopted for present purposes come the Timeliidæ, a widely distributed and comprehensive family of decidedly artificial construction, which contains the specialised Australian and Austro-Malayan sub-family of Bowerbirds, as well as a number of short- and round-winged small birds of Australian and Austro-Malayan type, and some of Indian genera represented in Australia. Of these may be mentioned *Amytis*, *Acanthiza*, *Calamanthus*, *Cinclorhamphus*, *Ephthianura*, *Sphenura*, and others as Australian; *Cinclosoma* and *Sericornis* as Australian and Austro-Malayan; and *Pomatorhinus* as Indian.

This family, called "Babbling Thrushes" a name derived from the habits of its more typical Asiatic members contains among the ranks of its smaller representatives as many peculiar Australian genera as any group of birds in our region. Not a few of the above-mentioned forms, as well as others to be noticed, are of small size, and are denizens of forests, undergrowth, and dense herbage, which necessitates their being restricted to Australia; a noticeable exception being the large genus of little Grass-warblers *Cisticola*, which, located in Europe, Africa, and the Oriental Region, has found its way through Malaya and Australia as far as King Island, in Bass Straits. Other interesting points in connection with our introductory glance at the distribution of the family in our region are the existence of an isolated typical genus *Turnagra* in New Zealand, and also the fact of your having a representative of the African Grass-bird *Sphenœacus* in the species *S. punctatus*, your so-called Fern-bird. Had this form been South American there would not have been so much cause for surprise.

Passing now this somewhat heterogeneous family under review, we find that one large sub-family, *Brachypodiinæ* (Bulbuls), birds very characteristic of the Indian Sub-region, are nearly unrepresented in Austro-Malaya, and do not at all extend to Australasia or Papuasia. The genera *Chloropsis*, *Ægithina*, *Hypsipites*, *Iole*, *Criniger*, *Pycnonotus*, and *Irena* extend into Indo-Malaya, being found in Borneo, Sumatra, Java, and the Philippines; but only one genus (*Criniger*) reaches Austro-Malaya, being found in the Moluccas, Batchian, Ceram, and Bouru.

The Wrens (*Troglodytinæ*), consisting chiefly of American genera, but slightly represented in Asia, do not approach nearer than Java, where one species of the Indian genus *Pnoëpyga* (Hill-wrens) is located. It is not till we come to the sub-family *Ptilonorhynchinæ* (Bower-birds) that we meet with Australian representation in the *Timeliidæ*. The genera of these remarkable birds namely, *Ptilonorhynchus*, *Ælurædus*, *Chlamydodera*, *Sericulus*, and *Prionodura* are all Australian, the second and third being also found in Papuasia; while another, *Amblyornis*, is exclusively Papuan, and contains a single species in north-west New Guinea. The "Cat-birds" (*Ælurœdus*) have two species in Australia, and one, *Æ. buccoides*, common to New Guinea and its western islands; whilst *Æ. stonii* is confined to the mainland in Papua Of the spotted Bower-bird we have in Australia five species, one of which *Chlamydodera cirviniventris*, is also found in New Guinea. This bird and a single species of *Amblyornis* being the only Bower-birds found in Austro-Malaya, the sub-family may be looked upon as almost exclusively Australian

The next section of this family to be dealt with is the *Timeliinæ*, the so-called "Babblers" an absolutely conventional title. Among them are the small members of the family comprising the numerous Australian genera above alluded to. In the systematic arrangement of the British

Museum Catalogue the most thrush-like groups are placed first, representatives of which are almost absent from our region; *Turnagra*, your thick-billed Thrushes, two species of which exist in New Zealand, and *Lamprolia*, another remarkably isolated genus in the Fijis, being the exceptions. The two beautiful species of the latter, *L. victoriæ* and *L. minor*, ranking among the most remarkable birds in that group of islands. Other genera of interest in India, such as *Thaumobia*, *Copsychus*, *Cittocincla*, and *Brachypteryx*, though extending over Indo-Malaya, do not cross into our region, though one, *Copyschus*, reaches its border in the Island of Bali.

In the group of grass-loving *Timeliinæ* we in Australia have an interesting series of genera, as follows: *Stipiturus* (Emu-Wren), *Sphenura*, *Amytis* (Grass-wren), *Megalurus*, *Origma* (Rock-warblers), *Cisticola*, and *Chthonicola;* and you in New Zealand have your remarkable *Sphenœacus*, already mentioned; three species of this South African form existing here, one of which, *S. rufescens*, inhabits that isolated locality the Chatham Islands. Of the aforementioned genera all are typical Australian forms except *Megalurus* and *Cisticola*, in which we have relationship with Austro-Malaya and the Oriental Region. *Megalurus* must be looked upon as Austro-Malayan, with two straggling species in the Philippines and India; and *Cisticola* has been already mentioned as a roving form with wide distribution, but it is noteworthy that out of twenty-eight species *Cisticola exilis* is the only one that extends into the Austro-Malayan Region. Other oriental genera, such as *Orthotomus*, *Prinia*, *Graminicola*, do not extend beyond the Indo-Malayan Sub-region. So many of the following genera are exclusively Australian that through them we have no relations with Austro-Malaya or Polynesia, which latter sub-region, it may be mentioned, is almost totally without timeline forms. Thus in the possession of the genera *Acanthiza* (Tree-tits), *Orthonyx*, *Hylacola*, *Pycnoptilus*, *Psophodes*, *Cincloramphus*, *Calamanthus*, and *Ephthianura* we stand alone in Australia; but in *Sericornis*, *Cinclosoma*, *Drymaœdes*, and *Pomatorhinus* we share with our neighbouring sub-region, Austro-Malaya. A single species of the three latter is found in New Guinea, and two of the first-named *Sericornis*—in New Guinea and the Aru Islands respectively. The New Guinea species of *Pomatorhinus*, *P. isidori*, is the only representative in Austro-Malaya, this typical Babbler having chiefly an Indian and Indo-Chinese habitat, though we, nevertheless, have four species confined to Australia. In Papua there is an endemic genus, *Eupetes*, with six species, and the only representative of this group of timeline birds in Polynesia is the interesting

New Caledonian form *Megalurulus*, a Grass-warbler of conspicuous plumage for its family, with one species, *M. mariei*. New Caledonia stands out frequently as the terminal point of the range of members of Austro-Malayan and Australian groups, and the starting-point of other genera, which extend eastwards through Polynesia.

Ephthianura deserves passing notice. These little Chats form one of the typical groups of smaller birds highly characteristic of Australia. They have been placed alone with *Accentor* in the final group, *Accentores*, of the *Timeliidæ*, but have no affinity in habits or mode of life with that genus. They live on the ground, and are insectivorous. Four species are known—three inhabiting the south and east of the continent, and the fourth, *E. crocea*, the far north-west.

The facts worthy of notice in our review of the *Timeliidæ* is their absence in Austro-Malaya, and Polynesia more especially, and the number of genera in the family confined to Australia. It is likewise noticeable that fewer genera of the family inhabiting the Oriental Region extend into the Austro-Malayan division of our Region than in most other families.

Paridæ.—The Titmice are an interesting family of the cichlomorphine group of *Passeres*, and, though consisting of more than eighty species distributed over most of the world except the Neotropical Region and Polynesia, are poorly represented in our Region; notwithstanding that, they are noteworthy in having a genus, *Certhiparus*, peculiar to New Zealand. The typical genus *Parus*, containing many species, a good number of which are located in the Oriental Region and China, extends to the Philippines, but not to our region. The Indo-Malayan division of the Oriental Region contains a diminutive, remarkably short-billed form, *Psaltria*, from Java. In Austro-Malaya there are no representatives of the family, but in Australia two genera exist, *Xerophila* and *Sphenostoma*, confined to the continent. The "White-faces" (*Xerophila*) number four species, and are distributed over most of Australia except the north, and a new species has recently been described in the "Emu" from West Australia. *Sphenostoma* contains but a single species, the so-called "Wedge-bill." Lastly, the peculiar form, *Certhiparus*, with its three species, closes the list of *Paridæ* in the Australian Region, and distantly allies Maoriland with other regions than ours.

Following on the Titmice come the Crow-Shrikes (*Laniidæ*), which are allied to the so-called "Butcher-birds" (*Lanius*) of the Palæarctic and Oriental Regions, but are larger birds, with one important genus, *Gymnorhina*, of absolutely different habits and general mode of life from the true Shrikes. One remarkably plumaged genus, *Pityriasis*, is confined to the Indo-Malayan Sub-region. *Gymnorhina* ("Magpie") is exclusively Australian, and contains five species, distributed over the continent, except in the north.

The second genus found in our region is *Cracticus* ("Butcher-birds" of Australia); also an Austro-Malayan form. Nine species are recognised, two of which, *C. quoyi* and *C. cassicus*, are found in Papuasia, the latter being confined to New Guinea. A third genus of this sub-family (*Gymnorhinæ*) is *Xenopirostris*, a Madagascan form, which, according to Dr. Gadow (Catalogue of Birds, British Museum, Vol. viii., p. 109), is identical with *Clytorhynchus* of Elliott, from New Caledonia. If this decision be correct, we have surprising evidence of an African form appearing in that island. There is probably some mistake in Dr. Gadow's diagnosis, as Edward Layard identifies the bird as a *Myolestes*, and gives its habits as quite those of this genus in his article in the "Ibis," 1882, on New Caledonian birds. The remaining genera of the sub-family *Malaconotinæ*, to which the last genus belongs, are well represented in Africa in *Dryoscopus* and *Laniarius*.

We now pass on to the sub-family *Pachycephalinæ* (Thick-head Shrikes), which is the typical group of the Australian Region in this family. *Falcunculus* (Shrike-Tits) and *Oreoica* (Bell-birds) are confined to the continent, but the next succeeding genus, *Eopsaltria*, a representative Australian form termed "Shrike-Robins," and of which we have five species, extends into Polynesia, where there are two species, *E. flavigaster* and *E. caledonica*, confined to New Caledonia, and a third, *E. cucullata*, peculiar to the New Hebrides. The genus also touches Austro-Malaya, as our north Australian bird *E. pulverulenta* is also found in New Guinea and the Aru Islands, and consequently allies us with two of the adjacent sub-regions. *Pachycephala*, one of the most widely extended and representative genera in the Australian Region, is also one of the typical Australian forms. Spread through Australia, Papuasia, and Polynesia, it is a genus which prominently links these sub-regions together, and those who are interested in geographical distribution cannot but regret that it is not also found in New Zealand. Out of a total of more than fifty species, twenty-one are found in and confined to Austro-Malaya, nineteen are found in Polynesia, and twelve in Australia. Of the latter, one species, *P. gutturalis*, is, singularly enough, found in Lord Howe Island, being one of the few links between this part of the New Zealand Sub-region and Australia; another, *P. melanura*, is found also in Papuasia, including New Guinea, which latter island has nine species peculiar to it, and one, *P. griseiceps*, common to it and the western Papuasian islands. Two species are peculiar to Timor—namely, *P. calliope* and *P. orpheus*. Other islands, including Flores, also have their endemic species. In Polynesia its range is fairly wide, though not extending north or eastwards of the Samoan Group, to which *P. icteroides* is confined. Four species are confined to New Caledonia, and one, *P. littayei*, to the adjoining Loyalty Islands. More interesting, however, is the existence of a species, *P. xanthoprocta*, in Norfolk Island, a second instance of entry into the New Zealand Sub-region. Finally, we have to notice that three species have wandered out of the Australian Region—namely, *P. philippensis* to the Philippines, *P. bruneicauda* to Sumatra, and *P. grisola* to Sumatra and Borneo; and, lastly, one beyond the Indo-Malayan Division into the Indian Region—namely, *P. cyanea*, found in Tenasserim.

The genus *Lanius*, comprising the typical Butcher-birds of Europe, Asia, Africa, and part of America, extends in the case of one species through Indo-Malaya by way of the Sunda Chain to Lombok and Timor, where *Lanius bentet* is found.

We now come to the Tree-creepers and Nuthatches. *Certhiinæ* and *Sittinæ*, subdivisions of the family *Certhiidæ*. In these sub-families we have instances of typical Palæarctic and Nearctic genera, *Certhia* and *Sitta* being replaced in our region by representative and closely allied forms in the genera *Climacteris* and *Sittella*. This division between the European and Australian forms is not, however, perfectly defined, for one species of Nuthatch, *Sitta azurea*, has wandered into Austro-Malaya, and stopped in that usual halting-place, Timor. *Certhia* the typical Creeper does not approach nearer our region than North India. There then follows in its lead *Salpornis*, which reaches to central India; after which we have our Australian Creeper, *Climacteris*, of which we have seven species confined to Australia, and extending with two species, *C. melanonota* and *C. melanura*, to the extreme north. In New Guinea there is an endemic species, *C. placens*, while another, *C. rufa*, has wandered north to the Philippines.

It is to be noted that Norfolk Island is given by Dr. Gadow in the British Museum Catalogue as the habitat of one of the Australian species, *C. scandens;* if this be correct it contributes an interesting link between this island and the continent. Two species, *C. pyrrhonota* and the last-named, are recorded in the British Museum Catalogue from Tasmania, but no specimens have been obtained of late years, although a *Climacteris* has been recently seen, but not procured, in that island.

As regards the Nuthatches, in addition to *Sitta azurea*, already mentioned as located in Java and Timor, two others have their habitat in Indo-Malaya, where they are found in the Philippines. These are offshoots from India, where this form is well represented. The Australian representative genus *Sittella* (Tree-runners) consists of eight species, seven of which are confined to the continent, and the eighth, *S. papuensis*, to New Guinea, being there found at the farthest point (north-west coast) from Australia. Doubtless it, or allied species, will be eventually recorded from the south coast of Papua, as two of the continental species, *S. leucoptera* and *S. striata*, are found on the extreme north coast.

The Sun-birds (*Nectariniidæ*) now engage our attention, and, though the continent of Australia possesses but one species of this beautiful tropical form, the genus *Cinnyris*, to which it belongs, is fairly well represented in Austro-Malaya. This family therefore deserves a short notice. It does not extend into Polynesia, which may be taken as fair proof that the Sun-birds spread southwards to our region from the Oriental, passing through the Sunda Chain from India, this sub-region having, as in other genera, affinity with Africa. The genus *Æthopyga*, which is Indian and Malayan, has nine species in Indo-Malaya, chiefly located in the Sunda Chain and the Philippines, while one, *Æ. flavirostris*, comes into our region and is located in Celebes. Another Malayan form, *Chalcostetha*, with a single species, *C. insignis*, also reaches Celebes. We then come to *Cinnyris*, so strongly located in Africa, even to the west coast, and fairly represented in India. Several species inhabit Indo-Malaya, four being located in the Philippines, including our bird *C. frenata*. In Austro-Malaya there are seven: two are found in Celebes, one, *C. grayi*, being confined to the island; two are likewise found in the Kei Islands, one of these, *C. theresæ*, being peculiar to that group; another, *C. solaris*, is found in Flores and Lombok. In New Guinea proper but one species is located, *C. aspasiæ*, which is likewise found in most of the Papuan islands; and, finally, there is the aforementioned *C. frenata*, which extends from the Philippines through the Moluccas and Papuan islands to north Australia. In *Arachnothera* also we have a Malayan genus, which extends into our region, and in which three species are located in New Guinea, without an extension of range to Australia. Finally, there remains the genus *Anthothreptes*, strongly located in Africa, and also in Indo-Malaya, from which one species, *A. malaccensis*, extends to Flores and Celebes in our Region, but does not reach New Guinea or Australia.

Meliphagidæ.—Following the Sun-birds, a honey-loving family, come in natural sequence the *Meliphagidæ* (Honey-eaters), the greatest of Australian families, and one which allies Australia with the surrounding divisions of our Region perhaps more than any other.

The sub-family *Myzomelinæ*, the members of which have somewhat lengthened and curved bills, forms a link with the Sun-birds, and stands next in order, therefore, to the *Nectarinidæ.* It is mainly an Austro-Malayan group, with branches in Polynesia and Australia, in which latter the small genus *Acanthorhynchus* (Spine-bills) is located, the two species of which inhabit the east, south, and west of the continent; the remaining one, *Myzomela*, has its stronghold in Papuasia, its species extending into Polynesia and Australia, where we have five, mainly located in the north, from which two extend into New Guinea. The sixteen species in Austro-Malaya are located chiefly in Papuasia, one, *M. vulnerata*, extending to Timor, and another, *M. simplex*, to the Moluccas. In New Guinea three species are endemic, and several others common to it and the western islands: two are confined to New Britain, one to the Solomons, and one to the Tenimber Islands, the nearest point to Australia except New Guinea. Eastwards, in the Pacific, *Myzomela* ranges to the Samoan Islands, and northwards to the Carolines and Pelews. Fiji, the Loyalty Islands, and New Caledonia have each their representative species, *M. caledonica* from the latter island being the most southern species of the genus in the Pacific.

Next in order is the sub-family *Zosteropinæ*, which contains the genus *Zosterops*,* the most comprehensive in the world as regards number of species.

Two Australian forms, *Melithreptus* and *Plectrorhynchus*, complete the sub-family. In *Zosterops* exists an assemblage of about eighty-six species, ranging over the best part of the Old World and Polynesia, and so well distributed over the Australian Region that it forms a bond of affinity between the several sub-regions of it. An interesting feature in the history of these little "White-eyes," as they are called in Australia, is the manner in which so many distinct species are confined to islands, even though they be of small area. Sixteen inhabit Austro-Malaya, of which three are confined to New Guinea, and an additional four to it and its western isles. The Kei Islands, Tenimbers, Flores, Timor, Batchian, Gilolo, Celebes, and the Louisiade Isles have each their endemic *Zosterops.* Six inhabit Australia, one of which, *Z. cærulescens*, is found in New Zealand and the Chatham Islands, and another, *Z. erythrocephalus*, in New Guinea and the Aru Isles. Polynesia contains fifteen species, located as follows: Two in the New Hebrides, Loyaltys, and the Mackenzie Group, and one

* In the opinion of some systematists, *Zosterops*, on account of the structure of its tongue—and one might also say its frugivorous and insectivorous habits—should not be included in the *Meliphagidæ*. In this case the genus would have to form a family of its own, more particularly as it is subdivided at present into groups.

in each of the following -Ponapé (Carolines), Pelew Islands and Ladrones, Fiji, New Caledonia, Solomons, Mayotte, and Kushai.

In the New Zealand Sub-region there are two peculiar to Norfolk Island and two to Lord Howe Island, the latter being *Z. strenua* and *Z. westernensis*.* In New Zealand the sole species is *Z. cœrulescens*, which some writers think was originally indigenous to the South Island, migrating north in the "fifties," while others hold that it migrated from Australia about the same time. In any case it has extended east to the Chathams. The genus extends west through Indo-Malaya to India, a number of species being found in these sub-regions, and it also occurs in China and Japan; while in Africa it is very strongly represented from the equator southwards, also extending to the Indian Ocean, in which the Islands of Bourbon, Seychelles, Mauritius, and Madagascar have their endemic species. The Australian genus *Melithreptus* consists of nine species, one of which, *M. albigularis*, crosses Torres Strait to New Guinea. *Plectrorhynchus*, containing one species, is exclusively Australian.

We now pass to the typical Honey-eaters, *Meliphaginæ*, through which the zoogeographical relations of Australia and Austro-Malaya are brought very close, for the genera of this class are mainly confined to those sub-regions. In Polynesia but two peculiar genera exist, which are *Leptornis* and *Moho;* and in New Zealand you have three, *Anthornis*, *Pogonornis*, and *Prosthemadera;* Norfolk Island and Lord Howe Island, however, both being without any representatives of the subfamily. Australasia contains six genera confined to it, five of which are found in Tasmania, while three others, *Glycyphila*, *Ptilotis*, and *Philemon*, are common to it and Austro-Malaya the two former ranging also into Polynesia, and the first to Tasmania. Besides the three above-mentioned forms, there are in Austro-Malaya six genera peculiar to it, five of which are notably confined to New Guinea, the sixth, *Melitograis*, being peculiar to the Moluccas.

The distribution of the three above-mentioned genera, which are rich in species, is as follows:

Of *Glycyphila* there are seven species in Australia, six in Austro-Malaya, and three in Polynesia. One of the Australian species is found in the Aru Islands. Four occur in New Guinea, including two of the Australian species. A closely allied form (*G. chloris*) to the Australian *G. ocularis* occurs in Timor and Lombok. Two species are peculiar to the Moluccas and Waigiou respectively. In Polynesia *Glycyphila* is distributed from the New Hebrides through the Loyalty

fthis be distinct from the Australian *Z. cœrulescens*.

Islands to New Caledonia, a single species being peculiar to each of the two latter localities—viz., *G. undulata* and *G. poliotis* respectively.

Ptilotis, the most comprehensive genus in the sub-family, is mainly located in Australia and Austro-Malaya, only two species occurring in Polynesia, these being found in the Samoan Islands and Fiji. In Australia no less than twenty-five species occur, only two of which, *P. analoga* and *P. flavescens*, inhabit New Guinea, the remainder being peculiar to the former area, in which they total more than any other genus of the family. In Austro-Malaya seventeen species occur altogether; twelve of these are found in New Guinea, of which eight are confined to the island, the remainder being also common to the western Papuan Islands. Two are peculiar to Timor—namely, *P. maculata* and *P. reticulata*; another occurs in the Lombok Chain and Timor, and one is confined to Lombok alone. From this it is seen that this genus is located in Malaya in those islands nearest to Australia.

Philemon, the members of which are called in the vernacular "Friar-birds," has five species in New Guinea, of which one, *P. meyeri*, is endemic; other species are located in Timor (three), Bouru, Ceram, the Moluccas, Solomons, New Britain, and the Admiralty Islands. Only one species occurs in Polynesia, which is *P. lessoni* of New Caledonia and the Loyalty Islands.

The two interesting genera aforementioned are peculiar to the following localities in Polynesia: viz., *Moho*, with two species in the Sandwich Islands, and *Leptornis*, with three species occurring in Samoa, Fiji, and New Caledonia respectively.

Returning to Australia, our peculiar genera *Meliphaga*, *Meliornis*, *Entomyza*, *Manorhina* (Minahs), and *Acanthochæra* (Wattle-birds) must be noticed, these being well-known and typical forms. In addition to these, the handsome Honey-eaters (*Entomophila*), four species of which exist, are almost purely Australian, only one, *E. albigularis*, being common to New Guinea as well as the continent. In New Guinea five noteworthy genera occur, which are peculiar to it namely, *Melidectes*, *Euthyrhynchus*, *Melirrhophetes*, *Pycnopygius*, and *Œdistoma*, of the second of which five species exist. Finally, there are the three aforementioned noteworthy New Zealand forms, *Pogonornis* (Stitch-bird), *Prosthemadera* (Tui or Parson Bird), and *Anthornis* (Bell-bird), which latter also occurs in the Chatham Islands. Like most of your restricted New Zealand forms, these are all thoroughly typical, in plumage and in habits, of the interesting ornis which characterizes this favoured land.

Dicæidæ.—Having reviewed the most numerous of the typical families of Australia, we now come to a family of interesting little birds in this great order *Passeriformes*—namely, the *Dicæidæ*, or Flower-peckers. As regards genera, numerically, this family has its headquarters in our region, although not a few species of two genera—*Dicæum* and *Prionochilus*—are located in the Oriental Region and are well represented in Indo-Malaya. In New Guinea and Polynesia a number of genera occur, some of which contain but a single species. In the Sandwich Islands there are eight genera confined to the Group, and only three have more than one representative species, the maximum number of species being three in *Hemignathus* and *Loxops*. In New Guinea there are three endemic genera, which contain only one species; and one genus common to it and the western Papuan Islands, with four species. The genus *Dicæum* allies Australia very slightly to Austro-Malaya, for in the latter it abounds in species extending from Flores through the Papuan Islands to the Solomons, which is the eastern limit of the genus; whereas we in Australia have but one representative, *D. hirundinaceum.* In the next form, *Pardalotus* (Diamond-birds), Australia has no affinity with the neighbouring areas, as it is confined to the continent and Tasmania, and musters nine species. The only other genus to notice is the Indian and Indo-Malayan Flower-pecker, *Prionochilus*, two only out of fifteen species of which cross the boundary into Austro-Malaya, and are found there in Celebes, Timor, and Flores.

Hirundinidæ.—The Swallows are a family but sparsely represented in the Australian Region. As a cosmopolitan family mostly of migratory habit, some members would naturally range from the Oriental Region towards Australia, either as winter migrants or as resident genera, when these latter are of wide permanent habitat. Likewise, as a temperate and sub-tropical continent, it is to be expected that Australia would possess both resident and internal migratory forms of this family; and this we find to be the case to a limited extent. Austro-Malaya is the winter residence of one of the "races" of the common European Swallow, and of an Asiatic form, *Hirundo gutturalis*, which passes down from northern regions to Celebes, the Moluccas, and the north coast of Australia as a straggler, and in all probability occurs in Timor. This is our only distant migrant in the family, for the other occasional visitor, the Eastern Swallow (*H. javanica*), which ranges through Indo-Malaya, is evidently a resident in some parts of Austro-Malaya, and occurs occasionally in the north of Australia. A third migrant from Japan, *H. japonica*, migrates as far as Flores, but does not include north Australia in its flight. Polynesia possesses an endemic species in *H. tahitica*, occurring in the region between the Solomon Islands and the Friendly Islands. In Australia we have another indigenous species, *H. neoxena*, an internal migrant from north to south, including Tasmania, in the summer; also the peculiar genus *Cheramœca*, the single species of which is *C. leucosternum*, an interesting form that is stationary in parts of the continent and nests in holes in the ground.

In *Petrochelidon* (Tree-swallows) exists a genus which slightly unites Austro-Malaya and Australia, but not Polynesia, though one species, *P. nigricans*, appears to wander occasionally to New Zealand. This species is found throughout Australia, migrating to the north in winter and ranging as far as Papuasia and the Aru Islands. A resident species of Australia is *P. ariel*, which moves north and south with the seasons, and has occurred in Tasmania. At Timor a subspecies of *P. nigricans*—namely, *P. timorensis*—occurs as a form restricted to the island.

The Wagtails (*Motacillidæ*) are one of the families of the Old World which are conspicuous by their absence in Australia and Polynesia, though some species of the genus *Motacilla* migrate from Asia into Austro-Malaya, in which area *M. flava* and *M. melanope* occur in Celebes, Gilolo, Flores, and the Moluccan Islands. No further representation of the genus occurs, though outside our limits one or two other species extend from the Oriental Region to Indo-Malaya.

In the widely spread genus *Anthus* (Pipits, or Meadow-larks) we have likewise only a slight representation in our region, as this form is entirely absent from Papua and Polynesia, although found elsewhere over most of the world. Common as the Pipits are in the Oriental Region, but three species *A. rufulus, A. richardi,* and *A. gustavi* migrate as far as Austro-Malaya in the winter, and are there found in Timor, Lombok, Celebes, and the Moluccas; and, though *A. richardi* is found in Mysol, it does not occur in the neighbouring Papuan Islands. The climates of Australia and New Zealand are suitable to the habits of the Pipits, consequently there is a resident species in both countries. *A. australis* is one of the most universally distributed of our species over the whole continent, being found in all the islands as well; while *A. novæ-zealandiæ*, the New Zealand species, is equally truly located in that country, and occurs, like our *Anthus*, in the islands—namely, the Auckland and Chathams.

Artamidæ. The Wood-swallows, one of the most puzzling of the bird-forms of this region as regards systematic position, are placed by Dr. Bowdler Sharpe, in the British Museum Catalogue, in a distinct family with a singular African genus, *Pseudochelidon*, with somewhat of the habits of the *Dicruridæ*, and some external characteristics of the Starlings. *Artamus* will always be a genus of interest to the systematist. It is almost wholly "Australian," two species only having ranged outwards to Indo-Malaya and the Indian and Indo-Chinese Sub-regions. The one gap in the connecting-chain as regards our region is its absence from New Zealand. In Australia there are eight species, *A. sordidus* ranging south to Tasmania, but none of these extend northward into Austro-Malaya, where there are four species confined to the sub-region, and peculiar respectively to New Guinea, Timor, Celebes, and New Britain - New Ireland. A fifth, *A. leucogaster*, occurs in New Guinea, the Moluccas, Timor, Lombok, and Celebes, and ranges through Indo-Malaya to the Andamans. In Polynesia a species occurs in New Caledonia, the Loyalty Islands, and New Hebrides, and a second in Fiji, while a third, *A. pelewensis*, is found in the Pelew Islands.

Sturnidæ.—The Starlings come next in order, and, though so many genera are peculiar to the islands of Austro-Malaya. Australia is almost out of the pale of their distribution, a sole species of the Indo-Malayan and Papuasian genus *Calornis* being the only representative on the continent. This is the so-called "Shining Starling" (*C. metallica*), confined to the northern and north-eastern districts. The genus is freely distributed, too, in Austro-Malaya, and is accompanied by an allied form, *Aplonis*, having a still more liberal distribution in Polynesia, species there occurring respectively in New Caledonia, Loyalty Islands, Tonga, Samoa, Fortuna, Rarotonga, Society, Caroline, and Norfolk Islands, this latter species, *A. fuscus*, being also found in Lord Howe Island. In spite of this range, besides its distribution in Papuasia no species of this representative Polynesian form occurs in Australia. Different species of *Calornis* occur in New Guinea, Mysol, Admiralty Islands, Timor and Lombok, Moluccas, and in the Solomons (two).

Three species of Oriental genera range into Austro-Malaya viz., *Sturnia violacea*, *Acridotheres cinereus*, and *Eulabes veneratus*, which occur in the Moluccas, Celebes, and Flores respectively. The following genera, peculiar to the localities named, occur in Austro-Malaya: *Mino*, *Melanopyrrhus*, and *Macruropsar* in New Guinea; *Streptocitta* in Celebes: *Charitornis* in the Moluccas; *Enodes*, *Basileornis*, and *Scissirostrum* in Celebes, the second occurring in Ceram. We see from the above particulars that in the *Sturnidæ* the relationship between Australasia and Austro-Malaya is through *Calornis*, and the connection between Austro-Malaya and Polynesia through *Aplonis*, which, in fact, is the only genus found in the last-named area.

Ploceidæ.—The Australian Finches, among which are some of the most charmingly plumaged birds of that sub-region, have been separated since the days of Gould from the true Finches (*Fringillidæ*) by Wallace; in fact, removed altogether from the *Fringilliformes* and placed with the *Sturniformes*, or starling-like birds. Our pretty little Finches are accordingly located in the family *Ploceidæ* (weavers), and are all contained in the section or sub-family *Viduinæ*, in which the first primary is very short.

Of the eleven genera found in Australia all are peculiar to the sub-region but three, two of which are of fairly extensive distribution—viz., *Munia* ranging to India, and *Aidemosyne* extending as far as Africa, even though the genus contains but three species; the third, *Tæniopygia*, has one species in Timor and Flores. It is noteworthy that no species of any Australian endemic genus is found beyond the limits of the continent and Tasmania. It is also to be noted that but one genus, *Erythrura*, occurs in all Polynesia, it being also common to Austro-Malaya. It is therefore seen that Polynesia is isolated from Australia so far as individual genera are concerned, though it shares with it the distribution of the sub-family.

There are no species of *Ploceidæ* in New Zealand. Three species of *Munia* are found in Australia, and twelve in Austro-Malaya, chiefly distributed as follows: Three in New Guinea; two in New Britain, New Ireland, Lombok, and Timor respectively; and one in Celebes, ranging to Borneo. The remaining genera restricted to Australia are *Staganopleura*, *Zonæginthus*, *Stictoptera*, *Neochmia*, *Œgintha*, *Bathilda*, and *Poephila*, the last containing seven species, mostly of beautiful plumage and elegant form.

Alaudidæ.—The Larks, with their finch-like bill, follow on the last family. These well-known birds have hardly any representation in our region. Strong as they are in Africa, Europe, and Western Asia, they range sparingly to India, and westward of that extend but little. *Alauda*, the typical genus, ranges into India from Europe, but no further south. Several genera, such as *Alaudula*, *Calandrella*, *Otocorys*, and *Melanocorypha*, which penetrate into the Oriental Region, are mostly restricted to northern India, and do not reach Malaya at all. It is only in the genus *Mirafra* (Bush-larks) that the Australian Region is reached by this family. These stout little Larks, denizens of scrub and desert land, have their stronghold in Africa, like some other genera of the family, but have an outpost, as it were, in India and the Burmese countries, from whence the genus extends sparingly towards the Australian Region, in which it is the only representative of the *Alaudidæ*. It reappears in Java and South Borneo, where the species *M. javanica* occurs. From there it extends to Austro-Malaya, where *M. parva* is located in Flores. Further westward in Papuasia it is entirely absent, but appears again in Australia, where, until recently, only two species, *M. horsfieldi* and *M. secunda*, were known, being closely allied to the Javan bird; but a third, *M. woodwardi*, has since been discovered in north-west Australia.

The *Alaudidæ*, as far as Australia is concerned, close the first subdivision (*Passeres Normales*) of the *Passeriformes* or Perching-birds, and we now come to two remarkable families of the next subdivision, *Passeres Abnormales*—namely, *Atrichidæ* ("Scrub-birds," so called) and *Menuridæ* (the well-known Lyre-birds), both specialised Australian forms. Two species only of the first family, and belonging to the genus *Atrichia*, are known. These are *A. clamosa* and *A. rufescens*, located respectively in the west and east of the continent.

Three species of the genus *Menura* are known– *M. superba*, *M. victoriæ*, and *M. alberti*. These splendid and typical Australian birds are confined to the forest districts of the Australian Cordillera, and are consequently only found from Victoria northwards up the east coast to Queensland. In the possession of both these families Australia stands isolated from her adjacent sub-regions, and, though of much interest to the systematist and naturalist, they reveal no affinity with adjacent areas.

Pittidæ.—We close the notice of the distribution of the *Passeriformes* in the Australian Region with the *Pittas*, one of the most striking groups in this vast order. As handsomely one might even say gorgeously—plumaged and at the same time harmoniously coloured birds, the *Pittas* stand perhaps at the head of the Old-World families of *Passeres*. The genus *Pitta* has its focus in the Malayan Region—Indo-Malaya and Austro-Malaya—ranging from the Sunda Chain and Moluccan Group westward to north India, northward to the Philippines and China, and southwards to New South Wales, its eastern limit being New Britain. It thus establishes affinity between Australia and Austro-Malaya, and is one of the many genera, already noticed, which also ally the Australian and Oriental Regions.

It is somewhat singular that *Pitta* does not extend into western Polynesia, though one is not surprised at a forest-loving, weak-flying form being absent from New Zealand, where, however, it is well replaced by another family restricted to that area. In Austro-Malaya *Pitta* numbers about seventeen species, two of which include Australian species—namely, *P. mackloti* and *P. simillima;* four are found in New Guinea, and include the two last named; three in Celebes and the Sanghir Islands respectively; three in the Moluccan Group; and one in Timor, Bouru, the Banda

Islands, and Lombok respectively. In Australia we have a species—*P. iris*—restricted to the west, and the most beautifully coloured perhaps in the whole genus. The other endemic one is *P. strepitans*. It may be mentioned in dealing with its distribution that the genus has eight species occurring in Borneo and four in the Philippines, while some half-dozen others inhabit the Indian Sub-region and Malacca, and still further north one occurs in China. It is noteworthy, likewise, that one species, *P. angolensis*, has wandered into Africa, which is a remarkable case of aberrant distribution. New Guinea possesses, as is so often the case, a genus peculiar to itself — namely, *Coracopitta* — one species of which, *C. lugubris*, inhabits the Arfak Mountains. Further species no doubt await discovery at the hands of some intrepid naturalist who may still further penetrate the almost untrodden forests of the interior. A further genus, *Eucichla*, exists in the Indo-Malayan and Indo-Chinese areas, extending from Tenasserim to Borneo.

In New Zealand, as above stated, the *Pittidæ* are replaced by the small family *Xenicidæ* (dwarf *Pittas*, locally styled "Wrens"). This is a truly characteristic instance of the wonderful individuality of the New Zealand ornis, even as regards the *Passeriformes*. These strange little birds have a totally different nidification from the *Pittas*, as they lay white eggs in holes in trees. Two small genera comprise the family—*Acanthidositta* and *Xenicus*. The first contains but one species, *A. chloris;* and the second two, *X. longipes* and *X. gilviventris*. Those of you who are familiar with Buller's splendid work are perhaps acquainted with the beautiful plate which contains all the members of this singular little family.

Picariæ.—The interesting order *Picariæ* (picarian birds), mainly founded on the structure of the foot, and in which the sternum is different from that of the *Passeres*, though fairly well represented in Papuasia and Australia, does not muster very strongly in these regions. Being a smaller order than the latter, and having one of its great divisions or sub-orders—the Humming-birds—located in the New World, besides containing the sub-order Woodpecker (*Scansores*), which are so notably absent from Australia, accounts at once for the comparative paucity of picarian birds in the Australasian and Papuan Regions, and likewise in the Polynesian.

Following on the intention given above to comment shortly on groups of birds present in the Indo-Burmese and Malayan Sub-regions and absent in Australia, the Hoopoes (*Upupæ*) will first be noticed. The Hoopoes, though mainly an African group—one family being restricted to that continent—contain two widely distributed species of the typical genus *Upupa*, which, though ranging through the Indian and Indo-

Burmese Regions, singularly do not come into Malaya, the nearest point to Australia reached being north Borneo Being an open-country genus, and not an inhabitant of typical tropical forests, one would not have looked for its members in some of the Malayan islands; but, topographically speaking, Timor and north Australia are well suited to the habits of the Hoopoe, so that it is noteworthy that the range of one of the species in question in India has not extended to Australia.

All the families but one of the sub-order *Coraciæ* are represented in Australia and the Malayan and Papuan Regions. The first in order to be noticed are the Swifts.

The *Cypselidæ* are a family of great interest, owing to their wonderful powers of flight, their absolutely aerial life, the migratory power of some species, and the remarkable breeding habits of others (the genus *Collocalia*), which construct edible nests. The typical Swifts (*Cypselinæ*) have two migratory representatives of wide range in Australia, which pass through the tropics from northern breeding-grounds to pursue their insect food in our hemisphere. The first, *Micropus pacificus*, which follows the eastern Asian littoral districts down to Australia *viâ* Cape York, does not appear to have been noticed in the Papuan Region, though it must lodge there temporarily on migration. The second is the magnificent Spine-tailed Swift (*Chætura caudacuta*), which, with one or two of its larger congeners, is the swiftest bird in existence, and comes to our regions, like the last, from north-eastern Asia and Japan as a summer visitant. It extends down the eastern coast to Tasmania, but does not appear to diverge on its southern course through Malaya to western Australia, but in the former sub-region its place is taken by a splendid resident species, *Ch. gigantea*. It is noteworthy that the Philippines, Celebes, and New Guinea have each their peculiar species of Spine-tail, but the genus does not extend beyond Papua into Polynesia. *Micropus pacificus* has occurred in New Zealand, and there seems no reason why our Spine-tail, with its gigantic powers of flight, should not some day visit that colony.

The fine Crested Swifts (*Macropteryx*) are located in the adjacent sub-regions, but not in Australia. This genus is Malayo-Papuan, one species inhabiting New Guinea, another Celebes, and a third Java, but no representative occurs in Polynesia.

Lastly, we notice the little Swiftlets (*Collocalia*), some of which are extremely local in their habitat, while others are migratory or wandering. Two species occur in north-eastern Australia, and range into the Papuan and Polynesian Regions namely, *C. francica*, which also ranges east and west to Fiji and the Mauritius respectively, and *C. esculenta*, which extends only to Celebes. Some species are local, such as *C. neglecta* in Timor, *C. leucophæa* in Tahiti, and *C. troglodytes* in the Philippines.

Following on the Swifts, we notice their crepuscular and nocturnal allies, the Nightjars and "Frog-mouths." In connection with the first family, *Caprimulgidæ*, we are allied in a small degree with the Papuan and Malayan Regions. We have but one species of the typical and world-distributed genus *Caprimulgus*, which, though well represented in south-eastern Asia, does not range nearer our shores than Celebes, if we except the aforementioned bird *C. macrurus*. To the north of that island the genus spreads to the Philippines, and thence to the Pelew Islands, which possess a local species. Our species has a wide range in Australia, and passes through the Papuan Region, the Malayan Archipelago, and thence to Burmah. In the fine genus *Eurostopus* (Nightjars with undeveloped rictal bristles) we possess a strictly Australian and Papuan form, New Guinea and Australia having two species, *E. albigularis* and *E. argus*, in common, while there exists a third in the Solomon Islands. In the more distinctly nocturnal family *Podargidæ*, Australia is allied to the Malayan and Papuan Regions. The distribution of the "Frog-mouths" is interesting, for, whereas the genus *Batrachostomus* is a strictly Indo-Malayan form, with a south-eastern limit in Java, its ally *Podargus* (the so-called "More-pork") is essentially Australasian. Out of the five species and sub-species now recognised, only one, *P. ocellatus*, is found beyond the confines of our continent, in New Guinea and its islands.

Finally, in this interesting family we have the group of Owlet Nightjars, which are almost entirely a Papuan form. The genus *Ægotheles*, which consists of eleven species, ranges from Tasmania through Australia to New Guinea and the Moluccas the great Papuan island being its headquarters and spreads eastward to New Caledonia, where the species *Æ. savesi* was discovered by my old friend and colleague Edgar Layard. The single Australian species, *Æ. novæ-hollandiæ*, has a wide distribution on the continent, but is not found in New Guinea, which, however, possesses six endemic species, mostly found in the mountains. Lastly, one species, *Æ. crinifrons*, is found in the Moluccas, this being the northern limit of the genus.

The absence of any number of these nocturnal forms from New Zealand is typical of the endemic nature of its avifauna.

In Australia we have one representative of the handsome family of Rollers, belonging to this order *Picariæ*, which contains so many beautiful and interesting birds. Our continent is, in several instances, singular in being, as it were, the outside limit of the range of certain passerine and picarian birds belonging to families which have a wide distribution both in Africa and Asia. We thus find species of certain genera of these orders ranging in our direction as far as the Malayan and even the Papuan Regions in fair numbers, whereas the continent of Australia, with its vast area—and climate at the north somewhat similar—is inhabited only by a single species, as if it were quite outside the pale of their distribution. The topographical features of north Australia and the absence of damp and luxuriant forest is the explanation. It may be mentioned incidentally that the *Coraciæ* are located in a remarkable manner in the comparatively small region of Madagascar, two sub-families being found on it.

The two genera *Coracias* and *Eurystomus*, of the *Coraciinæ*, or typical Rollers, have a wide range. The former is largely spread through Africa, being represented there by some seven or eight species, among which is the familiar English migrant *Coracias garrulus*. Other species are found in southern Asia, including Ceylon, and it is noteworthy that Celebes also has a species peculiar to it viz., *C. temmincki*. The second genus, *Eurystomus*, though fairly represented also in Africa and Asia, has a more extensive range towards Australia, being well represented in the Moluccas and Papuasia. One species, *E. crassirostris*, is found in New Guinea and eastwards to New Ireland; another, *E. azureus*, in the Moluccas: and finally there is our species, *E. australis*, which extends from Celebes to Australia, and even occasionally wanders to New Zealand.

Those beautifully plumaged and elegant birds, the Bee-eaters, are poorly represented in the Austro-Malayan Region, if we exclude two peculiar genera, *Meropogon* and *Nyctiornis*, found in Celebes and Borneo respectively. It may be mentioned in passing that the chief home of this family is in Africa, where one important genus with square tails is entirely located, with the exception of two remarkable outliers—*Merops swinhoei*, ranging from India through Burmah to the Malay Peninsula, and *M. leschenaultii*, confined to Java. Our only representative is a species of the widely distributed genus *Merops*, which has a better representation in southern Asia and Malaya than the last, though it is also largely present in Africa. This bird, *M. ornatus*, is distributed through Papuasia and the Moluccas, and is a summer visitant down to the southern parts of our continent, being doubtless to some extent resident in north Australia. It does not extend into Polynesia and has not been known to visit New Zealand.

Halcyones. The Laughing-jackasses (*Dacelo*), three species of which exist, are the typical Australian Kingfishers, though one sub-species, *D. intermedia*, is found in New Guinea. In the Papuan Region few more beautiful and interesting groups of birds exist than the Kingfishers (*Halcyones*), and, though the above showy genera inhabit Australia, their presence being always conspicuous wherever met with in the bush, we cannot claim to be very well represented as regards this sub-order Only one family, *Alcedinidæ*, inhabits the Australian, Papuan, and Polynesian Regions; and of one sub-family, or division of it viz., *Alcedininæ* we in Australia have but three species, of the genus *Alcyone;* while of the other sub-family, *Daceloninæ*, the genera of which are so well to the front throughout the Papuan, Malayan, and Polynesian Regions, we have but nine species, comprising four genera. As regards the first sub-family, *Alcedininæ*, the three Australian species of the genus *Alcyone* are fairly well distributed over the continent: *A. azurea* in the north-east, east, and south; *A. pulchra* and *A. pusilla* in the south, the latter being also found in New Guinea and the Moluccas. A fourth, *A. affinis*, is confined to the latter group, while a fifth, *A. richardsi*, inhabits the Solomon Islands; and, lastly, a beautiful species, *A. lessoni*, is peculiar to New Guinea and the adjacent isles. The typical and widely distributed genus *Alcedo*, to which the well-known European bird belongs, does not range farther south from the Indo-Malayan Region than Celebes and Lombok, being represented in Australia by the last-named form. The lovely little three-toed genus, *Ceyx*, with its eighteen species, ranging as far north as India, is a thoroughly Malayan and Papuan form, but, one regrets to say, does not find its way to Australia, though represented in New Guinea, its adjacent islands, and the Moluccas.

The remaining sub-family, *Daceloninæ*, which is more numerous than the last in Australia, and contains the above-mentioned Austro-Papuan genus *Dacelo* (Laughing-jackass), is abundant in the Malayan, Papuan, and Polynesian Regions. Of these typical Australian Kingfishers, a southern form, *D. gigas*, and a northern one, *D. leachi*, are recognised, the latter with two sub-species, one of which, *D. intermedia*, is found in New Guinea. The extraordinary notes of these birds are well known to all frequenters of the Australian bush. An allied and smaller genus, *Sauromarptis*, is found in New Guinea and the adjacent isles. The widely extended Asiatic and African genus, *Halcyon*, is, singularly enough, the best-represented genus in Australia. Of the four species inhabiting the continent, one, *H. sanctus*, is well known to all who ramble in the bush in the southern and eastern States, and ranges together with two others, *H. macleayi* and *H.*

sordidus, into New Guinea. In the Papuan and Polynesian Sub-regions there are no less than twenty-five or twenty-six species restricted to them, besides others whose range extends thither from Malaya. No Australian form is more widely found in Polynesia, several islands having their restricted species.

Outside the immediate sphere of my investigation we have four species restricted to the Philippines, and others in the Malayan Islands. In New Zealand the only Kingfisher existent there, *Halcyon vagans*, belongs to this genus, and it is noteworthy that it, as in the case of some other birds, ranges to Lord Howe and Norfolk Islands.

In the beautiful Long-tailed Kingfisher, *Tanysiptera*, Australia claims also affinity with the Papuan and Moluccan areas, having one species out of the two only found there, which inhabits north Australia. No genus among the gaily plumaged Kingfishers can lay claim to greater beauty, combined with elegance of form, than these *Tanysipteræ*, and they find a fitting home in that land of lovely birds, New Guinea and its adjacent islands.

Following on the last group are three sub-orders, which are more or less distributed in the Indo-Malayan Region, and extend sparingly towards Australasia and Papuasia. These are *Bucerotes* (Hornbills), *Trogones* (Trogons), and *Scansores* (Woodpeckers and Barbets). The first are perhaps the most remarkable members of the *Picariæ;* they range from Africa through India to the Malayan Region, and thence sparingly through the Papuan Sub-region to the Solomon Islands, but no member is found so far south as northern Australia. The genus which approaches nearest to us is *Rhytidoceros*, extending from Tenasserim through the Malay Islands to the Solomons. *R. plicatus*, the Moluccan species, is found in New Guinea, and has been recorded from Port Moresby, also from the Solomons. It does not appear to extend into the Aru Islands, and were it found there it would probably be also located in north Australia. The Hornbills are fruit loving birds, and, doubtless, absence of luxuriant forest and fruit-bearing trees causes their absence from our shores.

The Trogons next deserve a passing notice. These beautiful forest birds, characteristic of the verdant forests of Central and South America, have their representative genus also in Africa, one member of which is found in the forests of the great mountain, Kilimanjaro. The group is present in south-east Asia in the form of the beautiful genus *Harpactes*, which extends to the Malay Archipelago, but not to the Austro-Malayan Region; Java and Borneo being the nearest parts to Australia in which any species is found.

Lastly, among the groups of this order which are present in the Indo-Malayan Region and are unrepresented in the Austro-Papuan and Australian Sub-regions are the *Scansores* (Climbers). The two families which come under the above category are the *Picidæ* (Woodpecker) and *Capitonidæ* (Barbets). The former vast family is distributed over the whole of the temperate and tropical areas of the Old and New Worlds, but is entirely absent in Polynesia and Australia, which is a feature of our avifauna always noticed by naturalists from Europe visiting Australia.

The range of these birds of weak flight, except in one instance, does not extend eastward of the Straits of Lombok and Macassar, for they are found in Java and Borneo, and extend by way of Palawan and the Sooloo Islands to the Philippine Archipelago. Numerous genera, which are located in India, Burmah, and Ceylon, such as *Gecinus*, *Chrysocolaptes*, *Chrysophlegma*, *Micropternus*, *Dendropicus*, *Iyngipicus*, &c., are found in the Malay Archipelago within the limit above mentioned, some extending to the Philippines, among which is the latter genus of "Pigmy" Woodpeckers, which is the only one which crosses the Straits of Macassar to Celebes and also the Lombok Straits to Flores. We have, then, this interesting fact: that the Woodpecker found nearest to our limits belongs to one of the smallest genera known. It must be mentioned, however, that these little Woodpeckers have a wider distribution than some of the above-mentioned, as they are found from India, through the areas alluded to, to China and Formosa.

It is difficult to say whether or not food-supply in connection with the paucity of insects affecting our trees, and the nature of the wood and bark to be operated on, has had any effect on preventing the distribution of this family to Australia. But one cannot escape the fact that ants form a large portion of their diet, and that some of the green Woodpeckers, *Chrysophlegma* for example, feed much on the ground, thus making two conditions favourable to their presence here.

Lastly, a few words as to the *Capitonidæ*, another picarian family absent from Papua and Australia. These peculiar fruit-eating birds, which frequent Africa, India, and the Indo-Chinese Region, extend, as do the Woodpeckers, much in the same direction through a portion of the Malay Archipelago. Three genera only, *Xantholæma*, *Cyanops*, and *Chotorhea*, range through eastern Asia and Borneo, the first-named only extending to the Philippines.

The Cuckoos (*Cuculidæ*) are in all countries birds of interest, either as migrants and harbingers of spring, or on account of their singular parasitic breeding-habits.

In Australia this family unites in a marked degree our avifauna with that of contiguous sub-regions. The Cuckoos of the Indo- and Austro-Malayan and the Papuan Regions are well represented in our continent, whether it be as migrants from Asia, as in the genus *Cuculus* (typical Cuckoos), or as wanderers from the Malay Archipelago, Papuasia, or the Moluccas; or, finally, as local representatives of a typical Indo-Malayan genus, such as *Centropus*.

The European Cuckoo does not reach us, but ranges as near to us as Timor, whilst its Asiatic prototype, *C. intermedius*, visits the northern parts of Australia. In the genus *Cacomantis* (the short-winged typical Cuckoos), a Malayan and Papuan form, extending on the one hand to India and on the other to Fiji, we have a representation of three species: one, the well-known Fan-tailed Cuckoo (*C. flabelliformis*), peculiar to the continent, migrating from the north to the south in summer; a second, *C. variolosus*, from Timor to New Guinea: and the third, *C. castaneiventris*, from New Guinea and adjacent islands, which visits north Australia only.

Next comes the little square-tailed genus, *Misocalius*, from the western Papuan Islands, which is found in north Australia, and wanders to the south of the continent. The pretty little Bronze Cuckoos (*Chalcococcyx*), which follow the above in order, are the most numerous in Australia, being represented by five species, which likewise inhabit Papuasia and Malaya, whence they no doubt migrate to us. The focus of distribution of this genus is New Guinea, which has five species peculiar to it, and four common to it and the surrounding islands, with Australia. The range of the genus extends eastward to the Solomons, and southward (as a migrant through Norfolk Island) to New Zealand, where *C. lucidus* is found; also westward to India.

The Koels (*Eudynamis*) have only one representative in Australia, a migrant from New Guinea and Timor, *E. cyanocephala*. These singular black-plumaged Cuckoos are also parasitic, and are a typical Malayan and Papuan form, ranging to India and the Philippines.*

The remarkable Channel-billed Cuckoo (*Scythrops*), whose habitat is Papuasia, is a migrant to the extreme south of Australia, and apparently resident in the extreme north.

We finally come to the large Coucals (*Centropus*), a non-parasitic genus, whose headquarters are the Papuan and Malayan Islands, whence the genus ranges to China, India, and thence westward to Africa. There are no less than

* In this group a remarkable instance of isolation exists in the sub-genus *Urodynamis*, of the Society Islands, the sole species of which migrates to New Zealand through the Kermadec Group, and breeds in Maoriland. The coloration in this form is different from *Eudynamis*, and is rufous in character.

thirteen species located in New Guinea and the surrounding islands, and Australia has its peculiar species, *C. phasianus*, which comes as far south as New South Wales.

Psittaci. As already said, the Parrots are one of the most typical orders of birds in Australia. Although not so numerous on the continent for its large size as in the Malayan and Papuan Regions, they are largely represented there; and in all districts where food and climatic conditions foster their life these interesting birds are strongly in evidence.

General beauty of plumage, elegance of form in many genera, the showy presence of others (as in the cockatoos), the singular notes of so many species, and the remarkable vocal powers of some are features which place the Parrots in the front rank of birds, and make them noticeable all the world over. One would therefore not be surprised to find the traveller and naturalist, after a visit to Australia, giving the palm, among the many interesting bird-forms which would have come under his notice, to the Parrots. The *Psittaci* are a large order, the number of species noted by Count Salvadori in the volume of the British Museum Catalogue devoted to it being no less than five hundred. In the tropical and sub-tropical areas of the world, where abundance of food causes their numbers to be great, it is rather as species than as individuals that the *Psittaci* are numerous. Breeding in holes of trees, as a rule, their eggs and young are protected from molestation, and so are immune from the dangers which many birds are exposed to. In the Neotropical Region, where the genera *Conurus* and *Chrysotis* are so largely represented, their breeding-habits protect them from destruction by monkeys; and the same may be said, no doubt, of the African species, which, however, are not nearly so numerous as their American relations.

In dealing with the *Psittaci* of Australasia and their affinities with their congeners in the surrounding sub-regions, we are led firstly to notice that the focus of distribution is in the Malayan and Papuan Regions, more particularly in Papua and the west Papuan Islands. Here species belonging to the genera of the smaller members of the order, such as *Trichoglossus, Lorius, Glossopsittacus, Chalcopsittacus, Eos, Hypocharmosyna*, of the family *Loriidæ* (Lories and small Parrakeets), are abundant. These small and elegant arboreal species find a congenial home in luxuriant tropical forests, among flowering growth and fruit-bearing trees, and thus are only moderately represented in sub-tropical Australia. We also have certain genera of the *Psittacidæ* (Parrakeets), such as *Nasiterna, Geoffroyus, Psittacula, Psittacella* (peculiar to the mountains of New Guinea), and *Aprosmictus*, which are all typical of the Malayan and Papuan Region, but only one of which—*Aprosmictus* is found in Australia. From this centre of distribution, then, the Parrakeets may be said to radiate northward to the Philippines, southward to Australia, and eastward into Oceania, and thence to New Zealand. To the westward typical Papuan forms are replaced in Malaya by such genera as the widely distributed *Palæornis*, which contains the well-known fine Parrakeets of the Indian Region, with their elegant forms and lengthened tails. This last genus does not reach Papua, and is represented in Australia by *Polytelis*, which, however, is absent from New Guinea. Neither is the well-known group of honey-loving little Lorikeets (*Loriculus*) present either in New Guinea or Australia, in both of which regions one would have looked for their presence. Finally, among this same sub-family, *Palæornithinæ*, of the *Psittacidæ*, is the genus *Pyrrhulopsis*, which is confined to the Fijian area, and is not found in either subdivision of the Papuan Region.

In the above category the fruit- and honey-loving Parrakeets and Lorikeets have been principally dealt with, with the result that little affinity can be shown between Australia and the adjacent sub-regions.

We may next notice the Broad-tailed Parrakeets, which are thoroughly typical of Australia, and comprise some of the most beautiful and tastily plumaged birds in the world. The principal genera, *Platycercus*, *Barnardius*, *Psephotus*, contain the bulk of our Australian Parrakeets, and none are found in the Papuan Region. The same applies to the lovely Grass Parrakeets, so well known on the grassy lands of Australasia, the genus *Neophema* being restricted to Australia, the topographical features of which favour their existence in it. Following on the last genus, we have also several typical Australian forms, which still further emphasize the marked continental individuality of the *Psittaci* of this region. These are: *Nanodes*, an elegant swift-flying Parrakeet; *Melopsittacus*, the well-known "Bitcherryah" of the bird-fanciers; *Pezoporus*, the curious game-like Ground Parrakeet; and *Geopsittacus*, the Night Parrakeet mentioned below. In this sub-family we have an important genus, *Cyanorhamphus*, inhabiting New Zealand and the surrounding islands as far southwards as the Antipodes and Aucklands, and, which is interesting to note, spreading north in a line through the Kermadecs, Norfolk Island, and Lord Howe Island to New Caledonia and the Society Islands. Five species are located in New Zealand and the islands. It may perhaps be true that, as this genus is found in Polynesia, it extended southwards to New Zealand from there, and then spread outwards to the islands from the mainland of that country.

Mention must now be made of the *Loriidæ*, or Lories, several genera of which family have been already referred to. Having their headquarters in the Papuan Region, the Lories extend into Polynesia as far as the Friendly Islands, in which the New Guinea genus, *Hypocharmosyna*, recurs. In Australia this family has a weaker representation than the *Psittacidæ*. Four genera are present in the continent, one of which, *Trichoglossus*, contains two species *T. novæ-hollandiæ* and *T. rubritorques* and another, *Glossopsittacus*, three species, including *G. pusillus*, one of our smallest members of the Parrot family.

As regards the family *Cyclopsittacidæ* (Lorilets), which have affinity with the Lories, it is a small group containing two genera confined to the Austro-Papuan Sub-region viz., *Geopsittacus* and *Cyclopsittacus*. The former is restricted to New Guinea and Timor, the latter island containing two out of three species. The second, which has a larger membership – fourteen species being recognised is a typical Papuan form, two species only, *C. coxeni* and *C. maccoyi*, being found in north-east Australia; the remainder are restricted to New Guinea and its western islands, Mysol and Waigiou, with the Aru and other isles. We have in the habitat of this genus one of the many instances in which north and north-eastern Australia share, only to a small extent, with New Guinea in the distribution of a genus which is characteristic of that great island, twelve species being found fairly evenly distributed round its entire littoral area.

In the *Nestorida* we have a brush-tongued family of large Parrots now confined to New Zealand. Its representative is a single genus, *Nestor*, which contains three species as now recognised in the British Museum Catalogue. Two of these are those remarkable birds the Kea (*Nestor notabilis*), so well known as the sheep-killing parrot of the Middle Island, and *N. meridionalis* (the Kaka). This genus formerly extended to Norfolk and Philip Islands, where two species formerly existed, but now unfortunately are extinct owing probably to the restricted area of their habitat.

New Zealand possesses another interesting family restricted to its area the *Stringopidæ*, a sole genus and species being its representative. This is the curious Owl-Parrot (*Stringops habroptilus*), a nocturnal bird found in both Islands, and which, one may rightly say, is the most remarkable form in the whole order *Psittaci*. There is a remote affinity through this bird between the *Stringopidæ* and the last family, *Psittacidæ*, which contains the singular genus *Geopsittacus*, or Night Parrot of south and west Australia.

These two last-mentioned isolated forms *Stringops* and *Nestor*—as noticed above, are noteworthy instances of the singular and specialised character of the avifauna of New Zealand, the land of the extinct Moa and the curious existing genus *Apteryx*.

The Cockatoos now remain to be noticed, and are worthy representatives of the great order *Psittaci*. This family has its headquarters in Australasia and the adjacent Papuan Islands, though in the case of one genus, *Cacatua* (typical Cockatoos), it extends to the Philippines and Solomon Islands. South of the latter groups, in the Pacific, the *Cacatuidæ* do not extend.

The genera *Callocephalon*, *Licmetis*, and *Calyptorhynchus* are exclusively Australian, and none of the Australian species of *Cacatua* extend beyond the confines of the continent, although the New Guinea species, *C. triton*, is very close to our common and widely distributed *C. galerita*. *Licmetis*, the Long-billed Cockatoo, extends through the continent to the extreme north, where *L. nasica* is found in the Cape York district, but does not extend to New Guinea. On the other hand, *Microglossus*, the Great Black Cockatoo, a New Guinea form, ranges into Australia, but not farther south than the Gulf districts.

The former existence of the extinct genus *Lophopsittacus* in Mauritius points to the belief that originally the Cockatoos had a wider distribution in the Old World to the westward.

Columbæ. Food-conditions apparently account for the comparative paucity of Pigeons in Australia, and, on the other hand, cause their plentiful location and great distribution throughout the Malayan, Papuan, and Polynesian Regions.

The *Columbæ*, which, as a whole, may be looked upon as one of the most beautiful orders of birds, alike attractive for their plumage, elegance of form, grace of bearing, and interesting habits, are plentifully distributed over the whole temperate and tropical areas of the globe; though they do not muster as strongly in the Ethiopian Region as elsewhere.

In the Region under consideration the *Treronidæ* (Fruit Pigeons) and *Peristeridæ* (Ground Doves and Pigeons) are the most abundant. The typical Pigeons (*Columbidæ*), which are the most widely spread over the globe, are also well represented in the Austro-Malayan Sub-region, particularly as regards one sub-family, *Macropygiinæ*. These important families are, however, very poorly represented in Australia, except in the case of the *Peristeridæ*, which combine to make up more than half our list of pigeons. A fourth family, the gigantic Crowned Pigeons (*Gouridæ*), is peculiar to the land of wonderful birds, New Guinea, we in Australia not sharing, as in some other instances, in their distribution. The *Didunculidæ* are peculiar to Polynesia, but this family comprises but one genus with its sole species, that extraordinary bird styled in Gould's work the "Gnathodon."

Dealing with the families in detail, and commencing with the true Fruit Pigeons (*Treronidæ*), it is noticeable that the well-known Indian genus *Osmotreron* extends through the Malay Archipelago and stops at Timor, where a single species, *O. psittacea*, occurs. This form is then replaced by the more numerous and widely ranging Papuan and Polynesian genus, *Ptilopus*, which overlaps it to the westward, starting at the Malay Peninsula, and passing through the Malay Archipelago, diverging in the north to the Philippines and Pelew Islands, as also the Carolines, and so arriving at its focus of concentration in Papuasia. Thence it extends through Polynesia, taking in New Caledonia, to the far-distant groups of the Marquesas, Low Archipelago, and Austral Islands, having the most eastern range of any Pigeon in Polynesia, except one species of the *Peristeridæ*. In New Guinea and the islands of its bays and gulfs there are no less than twenty-two species of this beautiful genus, and no greater proof of the paucity of this group of Fruit Pigeons in Australia is afforded than by the existence of only five species of *Ptilopodinæ* on the continent. Of these, *P. swainsoni* is found in New Guinea additionally to the above-mentioned number, while another, *P. superbus*, extends to the Moluccas. The remaining three, *P. ewingi*, *Megaloprepia magnifica*, and *M. assimilis*, are peculiar to the continent. Two species, *P. cinctus* and *P. flavicollis*, occur in Timor, one in Timor Laut, one in Flores, one (*P. greyi*) in New Caledonia, and others in Samoa, Tahiti, and in the eastern Papuan Islands.

Quite as marked is the absence of the splendid Fruit Pigeons of the genus *Carpophaga* in Australasia. This form is spread throughout Papuasia, ranging thither from India and extending to Fiji. In New Guinea and the western Papuan Islands occur twelve or thirteen species, three of which are peculiar to the great island. In Timor there is an endemic species, *C. cineracea*, and in the eastern Papuan Islands, including the Solomons, there are four representatives of the genus. In Australia *Carpophaga* is entirely absent, its place being taken by the allied genus *Myristicivora* of Indo-Malayan distribution, one species, our "Nutmeg Pigeon" (*M. spilorrhæa*), a migrant to New Guinea, being its only representative. In New Zealand the genus in question, *Carpophaga*, is replaced by an endemic, closely allied form, *Hemiphaga*, differing in the number of its tail-feathers. This form, the only pigeon in Maoriland, consists of three species—one (*H. novæ-zealandiæ*) occurring also in the Auckland Islands, another (*H. spadicea*) in Norfolk Island, and

H. chathamensis in the Chatham Islands. Other genera exist in the Papuan and Polynesian Regions, that which is most worthy of note being the genus *Chrysœnas*, peculiar to the Fijis, of which three lovely species are known.

The typical Pigeons (*Columbidæ*) are well represented in Malaya and Oceania, but not so abundant as the family just noticed, though their distribution from India to Fiji is considerable. The genus *Columba*, which ranges over the Old and New Worlds, is sparingly but tolerably evenly distributed in the sub-region beyond Australia. Five species occur in Papuasia: one (*C. metallica*) is peculiar to Timor, one (*C. leucomela*) to Australia, while another is found in New Caledonia; other species are also found in Fiji and the Samoan Islands. The true Pigeons are, however, better located in Austro-Malaya in the person of another genus, *Macropygia*, which takes the place of *Columba* there, and comprises a number of species. Seven are found in Papuasia, while Timor and Timor Laut have each a species peculiar to their area. In Australia we have but one species, *M. phasianella*, a bad representation of such a numerous and plentifully distributed Papuan form. This bird ranges to south Australia. The large genus *Rheinwardtœnas*, resident in the Moluccas and Papua, might, one would think, have extended to tropical Australia, but such is not the case.

Of the twenty-four species of Pigeon recorded in Australia, fifteen belong to the family of Doves and Ground Pigeons, which come next under notice, and which ally our continent more satisfactorily with its adjacent sub-regions.

That familiar genus *Turtur* (Turtle Doves proper), ranging over the continents of Europe, Africa, and Asia, does not extend through the Malay Archipelago nearer to us than Timor, where one species, *T. tigrinus*, occurs. The *Peristeridæ* are, however, represented by the allied form *Geopelia*, with more rounded wings, longer tail, and no metallic lustre in the plumage. It is a somewhat limited genus, containing only five species, of which three are found in Australia, two being peculiar to it, and one (*G. humeralis*) common to it and New Guinea. Genera of this sub-family *Geopelinæ* are also found in America, to which also the entire sub-family *Peristerinæ* is restricted.

In the next sub-family to be noticed, *Phabinæ*, we in Australia are better represented than in any other group of Pigeons, our well-known Bronze-wing and Partridge-Pigeons belonging to it. Seven genera of the sub-family exist in Australia: *Chalcophaps*, *Phaps*, *Histriophaps*, *Petrophassa*, *Geophaps*, *Lophophaps*, and *Ocyphaps*, six of which are peculiar to it, making our continent the headquarters of the group. The first, *Chalcophaps*, is an Indo-Malayan form of half a dozen species, one of which, *C. chrysochlora*, has a singular distribution, commencing at Timor and passing through the adjacent islands to the east of it, to New Guinea, and north Australia; thence to the eastern Papuan Islands (New Hebrides), to New Caledonia, and Lord Howe Island. *C. indica*, the Indo-Ceylonese form, is widely distributed through the Malay Archipelago, Philippine Islands, Formosa, and terminates its range in north-western New Guinea. *Phaps*, one of the peculiar Australian genera, comprises our two well-known Bronze-wings, *P. chalcoptera* and *P. elegans*. North and north-west Australia are the chief home of two of the above-named endemic genera, *Geophaps* and *Lophophaps*, though one species of the first-named genus ranges to the south of the continent. In the latter genus are the three beautiful Plumed Pigeons, *L. plumifera*, *L. ferruginea*, and *L. leucogaster*.

The three remaining genera, *Petrophassa*, *Histriophaps*, and *Ocyphaps*, contain each but one species, and, with the exception of the latter, are confined to northern and north-western Australia. The fine genus *Henicophaps*, containing one species, is confined to New Guinea and the western Papuan Islands.

We now come to the interesting sub-family of Long-legged Ground Pigeons (*Geotrygoninæ*), which contains genera well located in Africa and America, the typical genus (*Geotrygon*) of the latter region, containing seventeen species, ranging from Mexico to Paraguay. In the Malay Archipelago and Polynesia *Geotrygon* is replaced by a more singular form, *Phlogœnas*, of wide distribution through Malaya and Papuasia, and across the Pacific to the Low Archipelago, ranging likewise northwards to the Philippines, Pelew, and Ladrone Islands.

Notwithstanding that there are four species of *Phlogœnas* found in New Guinea and one in Timor (Wetter Island), no representative occurs in the adjacent area of north Australia. Two species occur in the Low Archipelago, and in common with one species of *Ptilopus*, alluded to above, are the only Pigeons in those far-east groups. The genus in question, it may be mentioned, is characterized by a singular coloration, in which the mantle and wing-coverts have a marked contrast to the head and neck. In Australia we have but one representative of this group, a single species of the Australian genus *Leucosarcia*, *L. picata*, the "Wongawonga" Pigeon. Two additional genera of this sub-family are peculiar to New Guinea—viz., *Eutrygon* and *Otidiphaps;* the latter a specialised form, resembling in outward appearance the *Gallinæ*, with the legs even farther forward than in *Phlogœnas*, and the plumage black of various hues, with chestnut wings and back. Finally to be mentioned in this section as not occurring in Australia is the beautiful Indo-Malayan genus *Calœnas*, which ranges as far south as New Guinea, but is absent from our continent.

Two distinct families of Papuasian and Polynesian Pigeons close the list of members of the order *Columbæ*, both testifying to the remarkable and specialised forms existing in these portions of the Old World. The first is the *Gouridæ*, Crowned Pigeons of New Guinea, the giants of the order, and probably the most singular of the many endemic forms of that wonderful bird country. Six species are known, two of which, *Goura sclateri* and *G. albertisii*, inhabit the south and south east coasts, but do not, unfortunately, affect the opposite coast of north Australia. The second family is *Didunculidæ*, confined to the Samoan Islands, of which the sole member is *Didunculus strigirostris*, the most singular Pigeon in existence, with a hooked bill, toothed under-mandible, and obliquely directed nostrils. This remarkable and aberrant form of Pigeon is found only in three islands of the above-mentioned group—viz., in Upolu, Savai, and Tutuila—its restricted habitat being a singular feature in its history, recalling the similar fact in connection with its extinct ally the Dodo, which had also, it should be noted, oblique nostrils. To those who know Gould's beautiful plates of Australian birds,* the figure of this extraordinary Pigeon, in which the toothed bill is shown, will be familiar.

Gallinæ.—The typical forms of Game Birds inhabiting the Old World are entirely unrepresented in Australia, the widely distributed genus *Coturnix* and the Indo-Chinese form *Excalfactoria* being the only members of the family *Phasianidæ* which are present in our region. The Brown Quails (*Synœcus*) are an Australian and Austro-Malayan type.

The Partridges,† and their Asiatic relations *Perdicula*, *Francolinus*, *Microperdix*, *Arboricola*, and the Malayan genera *Caloperdix* and *Melanoperdix*, have no place even in the Austro-Malayan Sub-region.

The handsome Pheasants (*Phasianus*) and their restricted Asian allies, as well as the Indo-Chinese and Malayan forms *Lophura*, *Acomus*, *Bambusicola*, *Polyplectron*, range no nearer to our continent than Borneo; nor do the Indo-Malayan forms *Gallus* (Jungle-fowl), *Galloperdix* (Spur-fowl), *Argusianus*, and *Pavo* (Peacock), denizens as they are of forests, extend to the Austro-Malayan Sub-region with its similar vegetation.

As aforesaid, the Quails (*Coturnix*), which have a wide Old-World distribution, range into Australia, the mainland species, *C. pectoralis*, inhabiting the whole of the continent as far north as Queensland; while in New Zealand we have the

* Included in this work in error, the locality being unknown to the author.

† No mention need be made of the *Tetraonidæ* (Grouse), nor of the separate order *Pterocletes* (Sand-grouse).

singular occurrence of a species, *C. novæ-zealandiæ*, peculiar to that sub-region. More typical of Australia, however, is the above-mentioned continental and Austro-Malayan form *Synœcus*, which consists, according to some writers, of several closely allied species* in Australia, one of which, *S. cervinus*, extends to New Guinea, while an Austro-Malayan species, *S. raalteni*, ranges westward to Flores, not crossing the deep strait to Lombok.

Lastly, among the Quails we have the handsome little genus *Excalfactoria*, connecting the Australian and Malayan Sub-regions, our species, *E. lineata*, extending as far north as the Philippines, with a Papuan congener, *E. lepida*, inhabiting the New Britain Group.

We now come to a section (sub-order *Peristeropodes*) of the *Gallinæ* which takes the place of the Pheasants and large Game Birds of the Indo-Chinese Region—namely, the *Megapodidæ*, the members of which rank among the most interesting specialised forms in Australia on account of their singular nidification. Three genera exist in our region, two of which are peculiar to Australia, and the third, *Megapodius*, is a Papuan form, with its headquarters in Papuasia and an extended geographical distribution, inasmuch as one species, *M. nicobariensis*, is found in the Nicobar Islands; a second, *M. cumingi*, in the Philippines; a third, *M. laperousii*, in the Pelews; and a fourth, *M. pritchardi*, in Polynesia, in Ninafou. The Australian representative "Mound-raiser," *M. duperryi*, which is found in Australia only in the Northern Territory and north Queensland, extends to New Guinea and as far west as Lombok. The New Hebrides group is inhabited by *M. layardi*, and the remainder of the species are located in New Guinea and islands east and west of it. The genera *Lipoa* and *Catheturus*, peculiar to Australia, have chiefly an eastern and southern distribution in the continent. The Mallee-fowl (*L. ocellata*) ranges from New South Wales round to west Australia, and the "Wattled Turkeys" (*Catheturus lathami* and *C. purpureicollis*) inhabit New South Wales and Queensland, the latter being, as far as is at present known, confined to the Cape York district.

HEMIPODII.—The final group to be dealt with is the order *Hemipodii* (Hemipodes, or "Three-toed Quails"), which can rightly be called a characteristic one of Australia, though the order has a wide Old-World, tropical, and sub-tropical distribution. It contains one very singular form, *Pedionomus*, which in mode of life, general habits, and nidification is a connecting-link between the *Gallinæ* and the Plovers in

* Combined in one, *S. australis*, in the Catalogue of the British Museum; but plumage, habits, and nesting all warrant *S. sordidus* and *S. cervinus* retaining at least sub-specific rank.

the order *Limicolæ*. In the family *Turnicidæ*, which is the only one in the order, the females are the larger of the sexes and the handsomer in plumage. *Turnix*, the single genus in the family—if we except *Pedionomus*—has a wide distribution in the Old World, but the nucleus is in Australia and the Malayan and Austro-Malayan Sub-regions, where eleven out of the twenty-three species are located, the Philippines being the northern limit of this group. In India there are six species, forming another group, two of which, *Turnix taigoor* and *T. blandfordi*, range to the east and north as far as Manchuria and China. Africa has its group of four, one of which, *T. sylvatica*, extends into Europe. In Madagascar there is a species peculiar to the island. One of the six species found in Australia, *T. maculosa*, is found in New Guinea and Celebes, and may probably exist in the intervening Moluccan Islands: the remaining five, *T. melanogaster*, *T. varia*, *T. velox*, *T. castanonota*, and *T. pyrrothorax*, are peculiar to the continent. Timor and New Britain have each a species, and a species closely allied to *T. varia* is said to inhabit New Caledonia.

Our notice of these diminutive and peculiar Game Birds, in which the male incubates the eggs, closes with the above-mentioned perplexing bird *Pedionomus torquatus* (the "Plain-wanderer"), which is an inhabitant of the southern portions and the interior of the continent. This little bird will always be classed by the field naturalist, at any rate, as one of the most remarkable forms in Australia. Its shape is quite unlike that of the Hemipodes, and it possesses a hind toe. Standing erect, with head stretched upwards and with lengthened legs, it moves to and fro on the open plain after the manner of a Dotterel, and flies with outstretched wings and flapping motion. The egg* is entirely limicoline, being a pyramidal oval and pointed quite as much as many plovers' eggs. The absolutely dissimilar habits and limicoline eggs almost warrant this genus being separated from the *Turnicidæ* and placed in a separate family, *Pedionomidæ*.

FULICARIÆ.—The only family of this order, the *Rallidæ*, with which we are concerned is fairly represented in Australia, which is inhabited by twelve genera. It is also distributed widely, though sparingly as regards species, throughout Papuasia and Polynesia and the New Zealand Sub-region. The number of genera confined to single islands throughout Oceania is remarkable, and in the case of those which are in Australia much affinity is exhibited with surrounding sub-regions. The typical genus of Rails, *Rallus*, does not extend from the Indian

* The first notice of the egg of this curious bird was given by the writer in the P.Z.S. for 1869, a female having been shot by him with an egg ready for expulsion, which was unfortunately broken.

Region south of Ceylon, though it reaches to Japan. It is replaced in southern Asia, Malaya, and Australia by its near ally *Hypotænidia*, which is a genus whose species are in one or two cases widely distributed, and in other instances restricted to islands in our regions. Examples of the latter are the species respectively peculiar to the Andamans, Celebes, the Philippines, New Guinea (*H. saturata*), Sula Islands, New Britain, and even the remote Macquarie Island, in which Captain Hutton's sub-species, *H. macquariensis*, closely allied to *H. philippensis*,* is located. This latter bird connects the Malayan Islands, Australia, and New Zealand, as also Polynesia, being found in each sub-region as far east as Samoa. Our Australian species, *H. brachypus*, though reported from the Auckland Islands by Hugel and Sir Walter Buller, does not appear to frequent New Zealand, and how it has intervened geographically as a typical Australian form between *H. philippensis* in New Zealand and its close ally *H. macquariensis* is very remarkable, and a puzzling question in geographical distribution.

In the Short-billed Rails (*Rallina*) we have an Austro-Malayan form ranging on the one hand into India and on the other into north-east Australia, where one species, *R. tricolor*, is found, as well as throughout Papuasia. Celebes and the Philippines likewise have each their endemic species. The Indo-Ceylonese bird, *R. superciliaris*, does not range farther than the Malay Peninsula, but the more eastern form from Burmah, *R. fasciata*, has the widest distribution of any member of the genus, being found in Sumatra and Labuan, Palawan and the Pelew Islands, having been perhaps overlooked in the intermediate southern Philippines: or it perhaps furnishes another instance of erratic distribution on the part of this family. Coming to the Crakes (*Porzana*), we have a genus of small members of the family which has a very wide distribution, being located in the Nearctic and Neotropical Regions, and sparingly throughout the Old World. Out of thirteen species known, we have three, *P. fluminea*, *P. palustris*, and *P. tabuensis*, in Australia, the first two being peculiar to the continent, and the third, a species of Malayan and Polynesian distribution, also found in New Zealand and the Chatham Islands; besides which New Zealand has its peculiar form, *P. affinis*. It may be mentioned, as a further instance of how widely scattered the *Fulicariæ* are, that the Galapagos Islands have their peculiar species, *P. galapagoensis*. Another member of the Crakes is *Poliolimnas*, containing one species of Malayan and Polynesian distribution,

* *H. australis* and *H. assimilis* are combined in this form in the British Museum Catalogue

ranging from the Malay Peninsula to Fiji, and passing through Timor, north Australia, and New Guinea. Additional genera in the Papuan and Polynesian Sub-regions are. *Rallicula* (New Guinea), with three species; *Megacrex* (New Guinea); *Habroptila* (Halmahera); *Tricholimnas* (New Caledonia); *Pennula* (Sandwich Islands); *Porzanula* (Laysan Island); and *Aphanolimnas* (Kushai Island).

We may now notice the cosmopolitan genus *Fulica* (typical Coots). These abound more in America than in the Old World. *Fulica atra*, the well-known European Coot of Palæarctic and Indian distribution, does not range nearer to Australia than the Philippines, being replaced in more southerly latitudes, including Australia, by the closely allied *F. australis*, which is notably absent from Austro-Malaya. Elsewhere *Fulica* appears in the Sandwich Islands, *F. alai* being peculiar to that Group; likewise, in New Zealand, with one species, *F. novæ-zealandiæ.* The Moor-hens (*Gallinula*), in spite of the almost world-wide distribution of the six species known, have their representatives in the Australian and Malayo-Papuan areas, as also in the Sandwich Islands. The Australian *G. tenebrosa* and the Malayan *G. frontata* are both found in New Guinea. In the genus *Porphyrio* we have a conspicuous and handsome form of *Rallidæ*, which may rightly be treated as Malayo-Polynesian, taking in the Australian and New Zealand Sub-regions and spreading sparingly westwards to Asia, Europe, and Africa. Out of the fourteen species recognised, ten range from Sumatra eastward to Fiji. Australia has its western species, *P. bellus* and its eastern form, *P. melanonotus*, taking in also New Zealand, beyond which is the species *P. chathamensis*, peculiar to the Chatham Islands. The Samoans have a species peculiar to them in *P. samoensis;* the Admiralty Islands, *P. ellioti;* while another, *P. samaragdinus*, extends from Celebes through New Guinea. *Amaurornis* is an Indo-Chinese form of Crake, spreading into the Malayan Region with one species, *A. moluccana*, connecting Australia, Papuasia, and the Moluccas. Lastly, there come before us two groups peculiar to Australia and New Zealand respectively. The first consists of our so-called native hens, *Tribonyx* and *Microtribonyx*, which genera contain but one species each. *T. mortieri* is almost wholly Tasmanian, examples having apparently strayed to the mainland. The latter, *M. ventralis*, is a wandering bird, which appears in great flocks in certain localities in south and west Australia; and it is notworthy that an example was procured at sea, between the Auckland Islands and Tasmania. This fact, perhaps, furnishes some little clue to the distribution of members of this family in the remote islands south of New Zealand. The New Zealand group is again characteristic of the specialised forms of that sub-region, and consists of the following genera: *Notornis*, a remarkable form of Coot, with one existing species, *N. hochstetteri*, and one (*N. mantelli*) extinct, as also a third (*N. alba*) extinct in Lord Howe Island; *Ocydromus* (Wood-hen), a Rail of which there are three species; and the curious little *Cabalus* from the Chatham and Lord Howe Islands. There are two species of this diminutive weak-flying Rail, which, let us hope, will not follow the path of so many of this family in small islands and become extinct.

ALECTORIDES (Cranes and Bustards).—The *Gruidæ* are a family of wide distribution in the Old World, and extend into the Nearctic Region, but not to South America, where their place is taken by a family of smaller size, the *Psophiidæ*. The stately and graceful Cranes are well represented in Africa, four endemic genera existing in that continent. *Grus*, the typical Crane, has a northerly distribution in Asia, Africa, and America, and only just penetrates the Oriental Region, one species out of seven reaching northern India. It is noteworthy that one very fine species is located in Mongolia, inhabiting the shores of the great Lake Kokonor. Our genus *Antigone*, which is allied to *Grus*, has an interesting distribution, extending in a wide belt from the Caspian district through India and the Indo-Chinese Sub-region, there ceasing its range and reappearing in an endemic Australian species, *A. australasiana*. As remarked elsewhere, its location in Australia is interesting, and is doubtless due to the topographical features of the continent affording it the extensive plains necessary for its existence; hence its absence from Austro-Malaya and Polynesia. There are two other species: *A. collaris*, being the Indian bird, and *A. antigone*, the Indo-Chinese.

In New Zealand the nature of the country may have been formerly adapted to the habits of the *Gruidæ*; but they were evidently not one of those forms located in the original South Pacific continent of geological times, although it must have been plentiful in Europe and America, from the number of fossil species found in the Eocene, Pliocene, and other deposits.

Otididæ (Bustards): In this family of noble birds we have, as far as Australia is concerned, another instance of a genus of wide distribution and with few species reappearing in Australia and absent in Indo-Malaya and Austro-Malaya. Our genus, *Eupodotis*, contains but four species, two of which are located in north and south Africa respectively, a third in India, and the fourth in Australia. Like the last family, open plains and widely extending areas of semi-desert country are suitable to its habits, and hence the existence of a Bustard in Australia. It is noteworthy that the Australian *E. australis* is closely allied to the Indian *E. edwardsi*.

The stronghold of this family is Africa, where there are six genera restricted to the continent. Next follows India, with plains suitable to the habits of the Bustard, and where there are two endemic genera found; while three others, including *Eupodotis* and the typical genus *Otis*, range from beyond its limits, but do not extend to the extreme south. Our Australian form, therefore, has a very isolated habitat.

As with the last-named family, and for similar topographical reasons and food-conditions, the *Otididæ* do not extend to Polynesia or New Zealand, and we have seen that they have skipped Austro-Malaya.

PLATALEÆ. The Ibises and Spoonbills, together with the Herons, the next order to be noticed, being birds which frequent inland waters as a rule, some being widely distributed, while others are restricted to more or less small areas, constitute groups through which affinity between contiguous sub-regions can be established. They come, therefore, conveniently within the limit of our present investigations. The family *Ibidæ* contain genera which either have a wide distribution, or are stationary in certain areas, and in both these respects are useful to our present purpose in working out the relations between our several sub-regions.

The *Ibidæ* are strong in Africa and America, where not a few restricted genera are located. Certain forms are distributed over the Oriental Region, and furnish us with our residents and visitants. Australia is the limit of their habitat, neither the Polynesian nor New Zealand Sub-regions possessing any representatives. Four species monopolize the genus *Ibis*, one of which is African, another belonging exclusively to Madagascar; the third, *I. melanocephala*, is Oriental, ranging as far as Java, beyond which its place is taken by the Papuan and Australian *I. molucca*, which is found in New Guinea, western Papuasia, and the Moluccas, ranging as far south in summer as Victoria. It is noteworthy that this species does not occur in Timor, its range passing to the eastward; and, being a bird of powerful flight, one would not have expected its wanderings to be so limited.

The next member of the family to be noticed is *Carphibis*, which is almost restricted to Australia, being only found occasionally in New Guinea. One species, *C. spinicollis*, exists, and is one of our characteristic birds of the interior, chiefly owing to its uncertain wanderings in immense flocks when depending on the rainfall for its food-supply. The following member of the Glossy Ibis group, *Plegadis falcinellus*, is cosmopolitan, passing in its range through Austro-Malaya to us, but not to Polynesia. It therefore reveals no affinity with our neighbouring sub-region.

Two additional genera occur in the Oriental Region—

namely, *Inocotis* and *Graptocephalus*—but they are restricted to India and the Indo-Chinese area respectively. The habitat of the Chinese form *Nipponia* is also somewhat restricted, it not being found south of Hainan. It may also be noted that among the numerous African genera *Lophotibis* is restricted to Madagascar.

Among the Spoonbills (*Platalea*) we have one species, *P. regia*, allying Australia to Austro-Malaya, and extending to Borneo. This Spoonbill is referred to, but doubtfully, by Dr. Sharpe as being the same as that found in New Guinea, the Moluccas, Celebes, and Borneo.

Lastly, we have a crestless form, *Platibis flavipes*, peculiar to Australia—the so-called Yellow-legged Spoonbill.

HERODIONES.—In this order we have affinity between the sub-regions or divisions of our region in a marked manner. The *Ardeidæ* (Herons) comprise several genera which ally Australia to Austro-Malaya, such as *Ardea*, *Herodias*, *Ardetta*, *Nycticorax*, and *Butorides*, which are more or less cosmopolitan, and *Demiegretta*, *Mesophoyx*, *Notophoyx*, *Garzetta*, and *Dupetor*, which are Oriental and "Australian." Of these, *Notophoyx*, *Ardetta*, *Nycticorax*, *Butorides*, *Demiegretta*, with the addition of *Botaurus*, extend to Polynesia also, the latter being likewise found in Australia. Finally, to New Zealand, *Nycticorax*, *Botaurus*, *Ardetta*, *Ardea*, *Herodias*, *Demiegretta*, and *Notophoyx* likewise range. Our region is therefore strong in numbers of this family; and, besides the above-enumerated forms, two Oriental, European, and African genera, *Ardeola* and *Bubulcus*, range into the Austro-Malayan division through their species *Ardeola speciosa* and *Bubulcus coromandus*, both of which range to Celebes, and the latter to Timor as well. Then we have *Phoyx* of equally wide distribution, which ranges, in the species *P. manillensis*, through Indo-Malaya to Celebes. Further, there is the Chinese form *Nannocnus*, which passes down the Asiatic coast and reaches Borneo and Celebes; and, finally, we have the interesting Polynesian and Austro-Malayan genus *Erythrophoyx*, of which two species exist—*E. woodfordi* in the Solomons, and *E. prætermissa* in the Moluccas. These are Bitterns with highly developed neck-plumes, and are quite a specialised form to the Pacific area.

Dealing now more particularly with the distribution of individual genera, we find as above that one species of *Phoyx*, which is Oriental, comes no farther than Celebes, whereas two Grey Herons, *Ardea cinerea* and *A. sumatrana*, extend to Australia, the former being cosmopolitan in the Old World, and likewise ranging to New Zealand. We have one species of *Mesophoyx*, *M. plumifera*, common to Australia, New Guinea, Celebes, and the Moluccan Group. Then follows

Herodias, which is the largest White Egret form, the representative of which, *H. timoriensis*, ranges from the Chinese area through Austro-Malaya and Australia, and passes also into New Zealand. Coming to *Notophoyx*, a strictly local genus, we have the common Heron of the Australian landscape, *N. novæ-hollandiæ*, extending to Timor, New Guinea, and the Moluccas, and passing into Oceania to New Caledonia, whereas its congeners, *N. picata* and *N. pacifica*, are confined to Australia; while, on the other hand, the Aru Islands Heron, *N. aruensis*, comes into the Northern Territory of Australia.

In *Garzetta* (the White Egrets with the long crest or nuchal plumes) we have *G. nigripes*, an Australian species extending to the Moluccas and Celebes, and thence to Java. The Reef Heron (*Demiegretta sacra*) is found around the Australian coasts and in all the islands of Austro-Malaya; in addition to which it has the widest range in the Pacific of any Heron, and inhabits New Zealand as well. From the Solomon Islands and New Hebrides it passes through New Caledonia to Fiji, the Friendly and Society Islands (Tahiti), and other groups, but is not recorded from the Sandwich Islands. Its range further extends through the Philippines up the east coast of Asia, and also westward to the Bay of Bengal and Burmah. In the Night Herons (*Nycticorax*) we have a world-wide genus, the common species of which ranges from Europe, through Asia and Malaya, to Celebes only, just penetrating our region, in which it is replaced by *N. caledonicus*, extending to the Pelew Islands, New Caledonia, and New Zealand, and located all over Australia and Tasmania.

Of the cosmopolitan form *Butorides* (Little Green Bitterns) we have in our region two species *B. javanica*, which extends from India through Malaya to Celebes, and *B. stagnatilis*, ranging through Australia, Austro-Malaya, and Polynesia, in which latter it is recorded from the area lying between the Solomons, with New Caledonia, and the Society and Friendly Islands.

The Cattle Herons (*Ardeola*) only range from the Oriental Region as far as Celebes, with the species *A. speciosa*. In the cosmopolitan genus *Ardetta* (Little Bitterns) we claim two species one, *A. sinensis*, an Oriental form which passes through Austro-Malaya (Celebes and New Guinea) to Australia and northwards from the Moluccas to the Pelews, Carolines, and Mariannes; the other, *A. pusilla*, an Australian member of the genus, which occurs in New Zealand too. In *Dupetor* we have what is more an "Australian" genus than an Oriental one. Two species are found in Austro-Malaya (New Britain and Moluccas); the third, *D. gouldi*, is restricted to Australia; and the fourth, *D. flavicollis*, is widely distributed through the Oriental Region, including Malaya and China, and ranges towards us as near as Celebes.

Ciconiidæ.—The order *Herodiones* closes with the Storks. These giants of the order, so far as the Old World is concerned, are chiefly located in the Oriental and Indo-Chinese Regions, the exception being *Ciconia*, the genus of typical Storks, some of which winter in Africa and migrate to Europe to breed. None of the species of *Ciconia* come nearer to the Australian Region than north India. Two of the Oriental genera *Xenorhynchus*, *Dissura*, and *Leptoptilus* extend in our direction, whilst *Anastomus*, also found in Africa, ranges eastwards to China, but does not even reach Indo-Malaya. *X. asiaticus*, our large Black Stork, has a singular distribution, for it ranges from India into Burmah and does not touch Indo-Malaya, but yet is found in New Guinea, and, reaching north Australia, is our only member of the family. *Dissura*, the large Stork known in India as the "Parson-bird," extends into Indo-Malaya, and, penetrating Indo-Malaya, is, as is so often the case, monopolized by Celebes, getting no farther. *Leptoptilus*, also an African form, ranges into Indo-Malaya, but does not reach our region.

To sum up, no Storks reach Polynesia; two range into Austro-Malaya, and but one reaches Australia.

Sub-class RATITÆ (Orders CASUARII and APTERYGES).—In our notice of the distribution of the genera in the Australian Region, we have now arrived at the *Dromæidæ*, *Casuariidæ*, and *Apterygidæ*, with which this paper closes. These are highly specialised groups, and, one might say, ultra-typical of our region, as the Rheas and Ostriches respectively are of the Neotropical and Ethiopian areas. The first family of the *Casuarii*, the *Dromæidæ*, is restricted to the continent, and consists of two species, *Dromæus novæ-hollandiæ* and *D. irroratus*, ranging from the north, down the east coast to the southern States. A small dark-coloured Emu existed formerly in Kangaroo Island, to which it was restricted, but it, unfortunately, was exterminated by the early settlers. Luckily for science, a specimen and skeleton have been preserved in the Paris Museum, leaving an invaluable record of its past existence. It is not at all remarkable that this species should have been confined to so small an area, as we see a like characteristic at the present time in the singular manner in which the Cassowaries are restricted to small islands in Papuasia, and to very limited portions of the coast-area in the north-west of Papua. *Casuarius* is a typical Papuasian form, the only species well outside the limits being our Australian bird, restricted to the Cape York Peninsula and as far south as Rockingham Bay. Out of the ten species in Papuasia (a remarkable number of such a form for so comparatively small an area) six are confined to New Guinea and the Islands of Jobi and Salwatti, at the north-west end of the mainland. The Jobi species, *C. occipitalis,* is, moreover, restricted to this island, which lies in the great Gulf of Geelvinck. The Salwatti bird, *C. uniappendiculatis,* is also found on the coast of New Guinea opposite Salwatti, which lies in a curious depression of the west coast, and is divided from the mainland by a narrow strait dotted with small islands. No doubt in recent geological times Salwatti formed part of New Guinea, hence the presence of the species in the latter, where it has the same restricted habitat as *C. papuanus*, *C. salvadorii*, and *C. tricarunculatus*. These three Cassowaries are confined to the small littoral tracts on the south and north-west sides of Geelvinck Bay. Another species is common to the mainland of Papua and the Aru Islands. On these islands, moreover, there singularly is an endemic species, *C. bicarunculatus,* as well. The same is true of the Island of Ceram, which really belongs to the Moluccan Group, and which contains *C. galeatus*. On the south-eastern Papuan coast *C. picticollis* is found, and is probably restricted to no very extensive coast-line. That there should be three species on the south and west coasts of the Geelvinck Gulf and one in the Island of Jobi, which lies in the vast expense of its waters, is most remarkable when we consider the size and habits of the bird we are dealing with. The last and only remaining species to be noticed is the New Britain Cassowary *C. bennetti* from that island. This island forms the eastern range-limit of these large struthious birds.

Lastly we come to the interesting little struthious family so typical of the New Zealand specialised forms, *Apterygidæ*. These small members of the *Ratitæ*, the various species of *Apteryx*, for which your fair land is so noted, are the only remaining and aberrant links of your once gigantic birds the Moas. Small as you know they are, they are nevertheless interesting representatives of the extinct giants of your forests and plains. Out of the six species recognised, one, *Apteryx lawryi*, is endemic to Steward Island; two, *A. australis* and *A. oweni*, are located in the South Island; and one, *A. mantelli*, in the North Island; while *A. haasti* and *A. occidentalis* are found in both North and South Islands.

The foregoing notice of the geographical distribution of genera throughout the sub-regions of the "Australian" Region leads to the following conclusions respecting the ornithological relationship between these areas:—

1. Australia and Austro-Malaya are the most closely allied sub-regions. The typical families showing this alliance are *Meliphagidæ*, *Muscicapidæ*, *Campophagidæ*, *Laniidæ*, *Pittidæ*, *Loriidæ*, *Megopodidæ*, *Ardeidæ*.

2. The relations between Australia and Polynesia are mainly through *Meliphagidæ, Muscicapidæ, Laniidæ.*

3. Between Austro-Malaya and Polynesia we find affinity through the *Meliphagidæ, Muscicapidæ, Loriidæ, Peristeridæ, Treronidæ.*

4. Between Polynesia and New Zealand through the genera *Rhipidura, Cyanoramphus, Urodynamis, Notophoyx.*

5. Between New Zealand and Australia through the genera *Rhipidura, Pseudogerygone, Zosterops* (doubtful).

In the foregoing I have not included certain genera of wide range, species of which are found throughout the various subdivisions of the Australian Region.

No. 1.—ON THE INTRODUCTION AND BEHAVIOUR OF EXOTIC TREES ON THE CANTERBURY PLAIN.

By T. W. Adams.

Having during the last twenty-five years planted many species of trees and shrubs, an opportunity has been afforded me of testing their suitability to withstand the extremes of the winter cold and the heat and drought of summer characteristic of the Canterbury Plain.

Greendale, where most of the planting has been done, is situated in the forks of the Selwyn River, is about 400 ft. above sea-level, and about ten miles from the western foothills. The average rainfall is about 26 in. per annum; but during the years 1897 and 1898 not more than half that quantity per annum was registered.

On the Canterbury Plain there is no marked difference as to rainfall in any part of the year, and rain may fall in any month. In the dry year of 1897 February was the wettest month, with less than 3 in. of rain for the month. In the next year, which was also very dry, the most rain fell in the month of May, about 3½ in. On the Canterbury Plain the summers are very hot, the thermometer in the shade sometimes registering nearly 100 degrees Fahr. On the other hand, the winters are occasionally very severe, 24 degrees of frost having been registered on more than one occasion. Such extremes limit considerably the number of species of trees that can be successfully grown; but, as the country is everywhere intersected with water-races, it is possible to grow to a limited extent many trees that would not otherwise live through the seasons of drought. But for trees that will not bear the winter frosts there is no remedy. Speaking generally, western-American trees have succeeded best, although there are trees from many other parts of the world that are equally successful.

Australian trees are generally capable of bearing the dry summers pretty well, but the number that are able to withstand our winters is very limited indeed. Trees from Japan seem quite incapable, unless assisted by an artificial water-supply, of living through our dry summer, but they withstand our winters admirably.

As a rule, one would expect that trees growing in any country of about the same latitude as any particular part of New Zealand would probably succeed in that district, but in practice one finds many exceptions. Altitude, soil, amount of rainfall, and, above all, number of rainy days have to be taken into account before any satisfactory conclusions can be drawn as to the probability of success or failure of certain trees, and even after this many puzzling exceptions will be met with, some trees growing quite readily at a much lower latitude than their native habitat. The Kauri (*Agathis australis*) is a notable illustration of this, being only found growing in the north of New Zealand, yet I believe it can be grown quite successfully as far south as Dunedin. Of exotic trees we have a striking example in the Brazilian Monkey-puzzle (*Araucaria brasiliensis*). This tree, although a native of the country north of Rio de Janeiro, and within the tropics, has proved hardy in Canterbury, and grows much faster than the Chilian Monkey-puzzle (*Araucaria imbricata*). On the other hand, a good deal of disappointment has been met with through planting trees from northern Europe, such as the Larch (*Larix europea*), the Spruce (*Abies excelsa*), and Scotch Pine (*Pinus sylvestris*). Judging from English text-books, these ought to have been just the trees for our thin soils, as one of the best authorities says of the Scotch Pine, "No tree can be reckoned upon with so much certainly to succeed in poor soils of diverse quality and texture, ranging from loose sand to stony formations." Also of the Larch he says, "An alluvial gravelly soil is what the Larch requires." Here on the Canterbury Plain we have the exact soil that these trees are said to require, and yet these trees have proved sad failures except in a few favoured positions.

As the Canterbury Plain when first settled was almost destitute of trees, and at the same time subject in summer to very violent gales from the north-west of a very hot and parching character, and in the winter to frequent snow-storms with strong winds from the south, the first settlers very naturally began to inquire for suitable trees for shelter. From their Home experience they planted many thousands of Larch, Scotch Pine, and Norway Spruce, and these at first throve so well that they were raised in large numbers by the nurserymen: but after a few years' experience they were found quite unsuited for the drier atmosphere of the Canterbury Plain. The same may be said of nearly the whole of the species of trees introduced from Japan Other trees that failed badly in our years of drought besides those already mentioned were the following: *Wellingtonia gigantea* (I am following the English nomenclature all through the paper), *Sequoia sempervirens*, *Abies alba*, *Abies nigra*, *Thuja gigantea*, *Abies menziesii*, *A. canadensis*, *Cupressus lawsoniana*, and, in a less degree, *Abies douglasii*. Of the trees that escaped with the least injury, that close relation of the Scotch Pine, the Austrian Pine (*Pinus austriaca*), was very noticeable, the deep green of its leaves being in strong contrast to the foliage of the Scotch Pine. Other pines that proved capable of withstanding the dry seasons were *Pinus ponderosa*, *Pinus coulterii*, *Pinus jeffreyii*, *Pinus laricio*, *Pinus rigida*, *Pinus sabiniana*, *Pinus fremontiana*, *Pinus benthamiana*, *Pinus tuberculata*, *Pinus muricata*, and *Pinus insignis*. Professor Lemmon, of California, speaking of *Pinus insignis* and *Pinus muricata* in a letter to me, expresses surprise that they should stand drought, as they are, he says, "both lovers of low moist coasts." In the droughts both of 1886 and 1897 and 1898 a few trees of each of these perished when in unfavourable positions, but on the whole they stood the test very well, although not as well as the Austrian Pine, or *P. coulterii*, *P. sabiniana*, and one or two others. The cypresses, several species, were not much injured by the drought. *Cupressus nutkaensis* seems capable of bearing a long drought better than many others. Of the deciduous trees few, if any, stood the test better than the English Oak, although in the long drought of 1897 and 1898 this tree lost all its leaves, and in some cases died back to the extent of two or three years' growth. On the return of better seasons the oaks quickly recovered. In the shorter but more intense drought of 1886 the oaks were little damaged, whilst the spruces and larches were killed by thousands; but in the longer drought the oaks suffered equally with the spruces. The various willows were an interesting study during the dry seasons, showing that there exists a wide difference between the various species as to their power of doing without water. The broad-leaved or sallow willows last out much longer than the others, the most sensitive being the Huntingdon Willow (*Salix alba*), which soon died after it lost the support of water. The Upright Poplar is very drought-resistant, and the Grey Poplar (*Populus canescens*) stood it well, but the Canadian Poplar (*Populus balsamifera*) was soon killed. Of the maples, *Acer campestre* went through very successfully, and *Acer negundo* was not much damaged, but most of the others in a large collection suffered severely. The English Ash (*Fraxinus excelsior*) is quite a failure except in the better land of the plains. The most promising of this latter family are *Fraxinus oregana* and *Fraxinus viridis*. The species of elms are generally more at home than the species of ash, and not much difference was observed between the trees of any one species of elm. *Catalpa speciosa*, of which so much has been recently written, is of no value whatever on the Canterbury Plains. Of walnuts, the Black Walnut (*Juglans nigra*) gives the most promise of success. They all escaped damage from frost except the Californian Walnut, which had all its previous year's growth killed. The eucalypts, as was to be expected, passed through the dry seasons better than most of the other families of trees, although some trees of *E. amygdalina* in unfavourable positions were killed, and trees of *E. coriacea* became almost leafless. The winter frosts are the chief hindrances to the successful growing of the various gum-trees in Canterbury, and out of a large number of species tried the only ones to live through a succession of our winters are *E. coriacea*, *E urnigera*, *E. gunnii*, *E. stuartiana*, *E. regnans*, *E. amygdalina*, *E. mulleriana*, and *E. globulus*. In the exceptionally cold winter of 1899 trees of the Blue-gum (*E. globulus*) 70 ft. high and nearly 3 ft. in diameter were killed; these had been growing for more than thirty years. In the same season wattle-trees of equal age, of the species *Acacia dealbata*, were killed. Younger trees of *A. melanoxylon* were also killed. No other species of wattles have stood the frosts of more than two or three winters, although many species have been tried. Of the thirty or forty species of oaks planted here none were much damaged by the frost. Two of the Californian evergreen oaks (*Quercus dumosa* and *Q. agrifolia*) only had their leaves browned, but were not otherwise hurt. The beautiful evergreen species from Japan, *Quercus acuta*, *Q. cuspidata*, *Q. glauca*, *Q. lævigata*, and *Q. phyllioides*, came through unhurt. The cypresses all proved hardy enough to stand the winter, except the Guatemala Cyprus (*C. excelsa*), which was a little damaged. As showing the severity of the winter of 1899, I may mention that the native trees almost without exception were greatly damaged, such species as Manuka (*Leptospermum scoparium*), Cabbage-trees (*Cordyline australis*), and other plants indigenous to the plain being killed in great numbers.

So far I have dealt mainly with the effects of the two extremes of our climate on the various species of trees and shrubs. But in other cases causes have been at work to change the habit of a tree from its behaviour in its natural state, changes that are not so easily explained. Writing to a gentleman in California of the way *Pinus tuberculata* and *P. murrayana* grew here, he was so surprised that he hinted that he thought I should have to change my labels; but on sending him specimens he admitted my trees were correctly named. Here *Pinus tuberculata* and *P. murrayana* both grow rapidly and make good shelter-trees, with a wide spread of branches, on which it is not unusual to find still unopened cones for each year for twenty-five years. Although I have hundreds of trees of *Pinus tuberculata* with cones on from twenty to thirty years old, I do not remember to have seen one opened by the sun. Another remarkable fact about the cones of *Pinus tuberculata* is that, being pointed at the base, it is not an uncommon thing for the cones to become quite imbedded in the tree, and it is said that such cones when taken out of the tree and opened have yielded seeds still retaining their vitality. I cannot vouch for this, but cones fifteen years old and remaining on the tree unopened contain fertile seeds, as I have proved. These trees, I am told, as found in their natural state are growing in thick clumps of small poles without any side branches, and as unlike their habit here as possible. The reason for this remarkable change in habit may be found, I think, by considering the fact that these trees never release their seeds until a fire passes through them. The cones then open, liberating thousands of seeds which fall on a prepared soil, and spring up like grass, each one struggling for existence. The seedlings, pressing upwards to the light, are thus drawn up into their poles without any side branches.

Obviously the planting of exotic trees must be of an experimental character, and only those who have been engaged in the work of introducing new plants can appreciate the difficulties met with; but if we all gave to the world our experiences and changed notes now and then, there would soon accumulate sufficient knowledge to enable us to work on a systematic plan, and avoid the frequent errors of the present rule-of-thumb methods.

No. 2.—ON THE IMPORTANCE OF NEW ZEALAND AS A FIELD FOR BOTANICAL STUDY AND RESEARCH.

By L. Cockayne, Ph.D.

It is not by a superabundance of species that the importance of a flora is to be estimated for purposes of study, but rather by its richness in material of various kinds suitable for investigations in all branches of botany. An area containing this variety, but at the same time sufficiently limited in extent to be of value to an individual student, must be distinguished by such special climatic, edaphic, and topographical conditions as give rise to many most diverse plant-formations. Although these occur abundantly in either of the two main Islands of New Zealand, they are present in a still more striking manner in the New Zealand biological region considered as a whole, extending from the Kermadec Islands (latitude, 79 deg. 16 min.) in the north to Macquarie Island (latitude, 55 deg. 44 min.) in the south, and embracing the Chatham Islands, lying some 450 miles to the east of Banks Peninsula.

Without going into special details regarding the various formations the following may be noted:—

There are numerous forests consisting of many species of trees and shrubs, varying in their constituents in different localities and some floristically distinct from others, but all having this in common: that they are œcologically tropical-rain forests,* and this in a temperate climate. The very extensive coast-line, its beautiful sounds in certain places extending far inland, offers many different plant-stations, with the result that sea-weeds abound, a mangrove formation occurs in the north, coastal-shrub formations of various kinds are frequent, sand-dunes occupy large areas, and there are different rock and strand formations, salt meadows and marshes. The high ranges of mountains contain an abundant alpine and subalpine flora, the members of which form various plant-formations, such as meadow, bog, rock, and subalpine scrub. These ranges, too, play a most important *rôle* in leading to a heavy rainfall on their seaward slopes and to a comparatively dry climate inland, so much so, indeed, that there are tracts where, if there is not an actual desert climate, plants of the most marked xerophytic character flourish. Such a variety of most varied plant-formations, it need hardly be pointed out, furnish an abundance of material

* For characteristics of such forests see Schimper, A. F. W., "Pflanzengeographie," pp. 326–65. Jena, 1898.

for anatomical, biological, and floristic study of very distinct types. Thus, in the rain-forests is a wealth of liver-worts, mosses, lichens, and filmy ferns, while many interesting genera are present, such as *Cyathophorum*, *Dawsonia*, *Lindsaya*, *Gleichenia*, *Agathis*, *Podocarpus*, *Dacrydium*, *Phyllocladus*, *Pseudopanax*, *Elatostemma*, &c. Tree-ferns are abundant, while lianes, epiphytes (including orchids with aerial roots), and parasites occur amongst both the spermaphytes and the lower plants. Such forests are in many places quite near the larger centres of population, a most important factor in enabling their components to be studied while alive and *in situ*. Besides the rain-forests proper, there are others in which certain species of *Nothofagus* predominate. These, although much poorer in species than the above-mentioned forests, contain a good deal of important material, and are especially interesting as œcologically related to the forests of Fuegia.

To come now to the vegetation of the coast, the sea-weeds first claim attention. The majority of these require detailed investigation as to their anatomy, biology, and distribution. Some of them are of much greater size than any in the Northern Hemisphere, *Macrocystis dubenii* being, of course, the best-known example. As for the dune vegetation, *Scirpus frondosus* affords a most instructive example of a sand-binding plant. There are various halophytes in the salt meadows and marshes, one of which (*Selliera radicans**) is specially adapted for cross-fertilisation. Certain endemic coastal plants are of peculiar interest, such as *Myosotidium nobile*, of the Chatham Islands, now almost extinct in the wild state; *Colobanthus muscoides*, of the southern islands, which forms dense, hard cushions; *Celmisia lindsayi*, growing on cliffs in the south-east of Otago; *Sicyos angulatus*, *Lomaria dura*, and *Olearia operina*, which, in conjunction with *Senecio rotundifolius*, forms dense thickets on the shores of the West Coast sounds.

It is, perhaps, the alpine and subalpine regions which offer on the whole the greatest attraction to the student. As constituents of the subalpine scrub are species of well-known northern genera or natural orders, but strikingly different in habit to those of the north—*e.g.*, shrubby *Compositæ* and various species of *Veronica*. Some of these arborescent plants attain considerable dimensions, becoming truly forest trees, of which *Senecio huntii* and *Veronica gigantea*, of the Chatham Islands,† or *Olearia lyallii*, of the southern islands, are perhaps the most striking examples. Alpine and subalpine meadows contain a wealth of interesting species, many of which have life-forms resembling those of other alpine regions,

* Cheeseman, T. F., Trans. N.Z. Inst., Vol. ix., p. 452.
† Cockayne, L., Trans. N.Z. Inst., Vol. xxxiv., p. 298 and p. 319.

notably of the Andes, though belonging to different genera or even natural orders. Here, too, is the wonderful Vegetable Sheep of New Zealand, a somewhat misleading term, since it is applied to plants of two different genera *Raoulia* and *Haastia*. These plants grow on rock in process of disintegration, which is usually so much buried by stony *débris* that the plants appear as if growing out of this latter. The strong, woody roots penetrate far into the rock, and serve especially as holdfasts. The shoots are pressed so closely together as to form a dense, more or less convex mass, sometimes several yards in length. In the interior of the plant the leaves are quite decayed and usually sopping with water, into which peaty mass the ultimate branchlets send many adventitious roots in search of water and other food-materials. Probably large plants are of great age, but no measurements of growth have yet been taken.

To enumerate the mountain plants requiring detailed study would far exceed the limits of this paper; here a few examples need only be given. Amongst genera containing many variable species, *Celmisia* and *Veronica* offer an interesting field for investigation, since the forms of the different species are manifold, and apparently are beautifully in harmony with their environment. The species of *Veronica*, for instance, vary from a tree 40 ft. in height, with leaves like those of the willow, to small xerophytic shrubs with much reduced scale-like leaves pressed closely against the shoot-axis.

Sphagnum bogs offer much material for study; in such are curious *Restiaceæ*, various cushion plants, *Utricularia*, *Drosera*, and the pigmy pine *Dacrydium laxifolium*. Such bogs are also remarkable for containing a large proportion of the Fuegian element of the New Zealand flora.

Perhaps the most remarkable plants of the mountains, if we except the Vegetable Sheep, are those of the great masses of the stony *débris*, so common in the eastern half of the Southern Alps, known as "shingle slips."* These plants have frequently leaves more or less the colour of the shingle; they are exposed to no struggle for existence with one another, but they have peculiar forms and structure evoked by their remarkable environment, of which the instability of the shingle, the extremes of temperature, the strong insolation and the scanty water-supply are important factors. One of the shingle-slip plants, *Cotula atrata*, is worthy of special mention on account of the flower-head being almost jet-black.

Turning next to the vegetation occupying the dry regions of the North and South Islands, as before mentioned a most remarkable class of plants occurs, whose structure, as was first pointed out by Diels,† is apparently out of all keeping

* Cockayne, L., Trans. N.Z. Inst., Vol. xxxii., pp. 129, 130. 1900.
† "Pflanzen biologie von Neuseeland," Engler, Bot. Jahr. B. 22. 1896.

with the present climatic conditions. Such are certain xerophytic mosses and spermaphytes, of which, amongst others, the almost endemic genus *Carmichaelia* furnishes an instructive gradation of forms.

At the present time one of the most important branches of botanical research is experimental morphology, regarding which Professor Bower states,* "Morphology has lately passed to a third stage, that of experiment. . . . It has become a general view that the facts of morphology are but the stereotyped facts of physiology, form being determined by function, but under the check of heredity. This experimental phase of the study of plant-form is directed, as it were, to the very setting of the types before the stereotype plate is cast. We watch nature's compositor at work, but we also ascertain that the plate itself after it is cast is much more plastic than some of us had thought." The extraordinary plasticity of many New Zealand plants fits them to no small degree for studies of this kind. Take, for instance, the effect of moist air in conjunction with more or less feeble light upon the New Zealand Whipcord Veronicas,† or upon the almost leafless *Discaria toumatou*. In the former case adult plants having scale-like leaves pressed close against their stems in a few weeks' time undergo a complete change, new shoots furnished with hygrophytic pinnate leaves being produced, while the new portions of the old xerophytic shoots are furnished with similar leaves, and so long as moist-air culture is carried on only these hygrophytic shoots are produced; or if a seedling plant of the same species is given moist-air culture it never assumes the adult form, but continues to grow with seedling pinnatifid, thin leaves such as those evoked in the adult by moist-air culture. The case of *Discaria toumatou* is still more striking. This plant in the adult stage is provided with assimilating spines, and for the greater part of the year it is almost leafless. The seedling, however, is quite leafy at an early stage and has no spines. After a time spines make their appearance. Such a plant I placed in a "moist-chamber," and although it has been thus treated for more than two years no more spines have been produced; all the shoots are of indefinite growth and are abundantly furnished with leaves.

The heterophylly, so common in many New Zealand plants, and which is in some cases so striking, fits them especially for experimental morphology. Certain plants have a distinct juvenile form which persists for a number of years before the adult form is assumed, or such juvenile form may reappear at a late period in the life of the plant as a "reversion-shoot."‡

* Opening Address, Brit. Assoc. Bot.: *Nature*, Vol. lix., pp. 66, 67.
† Cockayne, Trans. N.Z. Inst., Vol. xxxiii., p. 290. 1901.
‡ Regarding such shoots, see Goebel, K., "Organography of Plants" (Eng. trans.), pp. 171, 174. 1900.

Certain species of *Dracophyllum*, for instance, have on their upper branches both the ordinary narrow-leaved adult shoots and the much broader-leaved juvenile shoots at the same time.* *Sophora microphylla* is an interesting example of heterophylly. This tree for a number of years is of a shrubby habit, its branches interlacing and forming a dense mass resembling a shrub which had been exposed to constant fierce winds. Later on it changes this habit altogether and grows upright like an ordinary tree, the shrubby part still persisting below. But the early shrubby juvenile form is very similar to the species known as *S. prostrata*, which never assumes any other habit, while the adult form corresponds to *S. grandiflora*, which, on the contrary, does not pass through the *S. prostrata* (the shrubby) stage. As to how this has come about does not concern us here.

Liver-worts, of which, as stated before, New Zealand possesses a large share, are cultivated with comparative ease, and, owing to their simplicity of structure and their richness in form, are of great importance for experimental morphology.

A region consisting of islands varying much in size, lying isolated far from large masses of land, affords for obvious reasons most excellent opportunities for studying the principles of œcological phytogeography, especially since, as I have shown above, there are so many very different plant-formations. This study becomes complicated, but at the same time more instructive through the admission into the flora of very many foreign species. Thus the primitive and modified or artificial formations can be compared, and the changes can be estimated which have been brought about by the advent of herbivorous mammals and other agencies in the vegetation which had been evolved without their presence. At the present time Campbell Island offers a most striking example of the effect of sheep upon an absolutely virgin vegetation. Seven years ago sheep were brought there for the first time, and during those years they have increased, and more have been brought until there are now more than four thousand pastured on the mountains slopes and valleys. The effect of these animals on the subalpine tussock-meadow of Campbell Island, in some places aided by fire, is thus summed up in a paper of mine now in the press: "Here, then, a distinctly changed formation is in process of evolution in which the two most striking plants, which stamp the physiogony of the original formation, will be altogether absent, while some of the smaller plants kept in check by these dominant larger ones will increase considerably in numbers."

Some of the very small islands off the New Zealand coast

* Cockayne, L., *l.c.*, p. 318.

afford interesting phytogeographical studies. Dog Island, about three-quarters of a mile in length, situated near the entrance to Bluff Harbour, in Foveaux Strait, has been changed by man, fires, and domestic animals from a plant-formation of certain shrubs to a meadow of *Carex appressa* tussock, except near the sea-shore, where the halophytic "coastal turf" holds its own against introduced animals and plants, though here at the junction of meadow and coastal turf *Bellis perennis* (the common Daisy) is becoming dominant.

In striking contrast to the above are the Open Bay islands, off the coast of south Westland. Here there has been no settlement; all is in its virgin state. Yet here great changes must have taken place in the plant covering at a comparatively recent date, geologically speaking. The islands are only some four miles from the Westland shore, to which they must have been joined at one time, as evidenced by the geological history of New Zealand and the presence on the mainland of what is probably an ancient river-terrace. Leaving out of consideration the smaller plants, the two islands are now occupied by a dense growth of lianes; on the larger island *Freycinetia banksii*, and on the smaller *Mühlenbeckia adpressa*. Now, when the islands formed a portion of the mainland they would be covered with ordinary Westland rain-forest, but as their area diminished by degrees so would the forest be exposed more and more to the inimical wind charged with sea-spray, until finally the forest trees and shrubs would be all destroyed, the lianes alone remaining, they being better adapted for severe conditions of existence in their possession of certain xerophytic adaptations,* which they had acquired together with and in consequence of their climbing-habit.

Railway-cuttings, landslips, river-beds, &c., give excellent opportunities for observing the sequence of plants before an apparently permanent formation is formed. But the opportunities for phytogeographical research are so many that here one can only touch lightly on the subject.

Where plants from far-distant lands are brought into a country and settle down under conditions both climatic and edaphic other than those to which they are accustomed, it is to be expected that changes, both morphological and physiological, might take place. Possibly, too, such changes if they took place might be hereditary. To examine accurately into such matters is a work of great importance, but one which would require many years' patient study to be of much moment. Many thousands of species of plants have been introduced into New Zealand, both purposely and accidentally, and of these some hundreds are now naturalised over the

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* Warming, Eng., "Lehrbuch der öologischen Pflanzengeographie," Zweite Aufl., p. 110. Berlin, 1902.

length and breadth of the land, living side by side with their indigenous companions, or having quite usurped the place of these latter—indeed, in many places exotic plants are more common than the indigenous ones. I should hardly think any biologist questions the fact of evolution, but as to how that has taken place is quite as much a debated question as ever. Two most important theories, those of mutation and the heredity of acquired characters, can be tested by experiment, and the introduction of all these foreign species into the New Zealand flora is an unpremeditated experiment of high importance. Here I can give only one example of what may be a case of mutation. The common Broom (*Sarothamnus scoparius*) does not vary in Europe, so far as I have been able to ascertain, except quite recently in one direction, when the variety now so well known in gardens as *andreanus* was found in France. But in New Zealand, on the contrary, on the sand-dunes near New Brighton, Canterbury, where the broom is extremely abundant, forming, indeed, with gorse an artificial plant-formation, it varies to a very considerable extent, and this in three directions—viz., in colour of flower, the colour varying by different gradations of yellow from the ordinary yellow to almost pure white; in shape and size of flower and of its parts; and in time of flowering, which latter might be called a physiological variation. How far such varieties come "true" from seed I am not in a position to state. Professor Hugo de Vries, to whom I sent an account of this fact, has thought it worthy of mention in his great work.*

Not only are the introduced plants of great interest from this standpoint, but those indigenous to New Zealand are hardly of less moment, "varying" to as great an extent as do many of the so-called "species." Of such variable species different forms require selecting, seeds sowing from one individual, and results tabulating. My own investigations of seedling-forms have shown incidentally that many so-called varieties and even unnamed forms of certain species come "true" from seed, or, in other words, such forms are distinct entities or "little species." On this matter, however, I hope before long to make some definite statements. Of all New Zealand genera, *Epilobium* is perhaps most suitable for this work, since the plants arrive quickly at maturity.

Speaking generally, there still remains a great deal to do before New Zealand as a whole can be considered even fairly well botanically explored. There are wide tracts of country on which no botanist has as yet set foot, while even the better-known regions constantly yield new forms. Lists of species from all parts of the Islands are wanted before any really

* "Die Mutationstheorie," Band 2, Lief. 3, p. 664. Leipzig, 1903.

accurate account can be given of the range of the plants. Moreover, varieties and forms, even the most trivial, require looking for and recording; hitherto such have been usually disregarded.

There is much work, therefore, not only for the botanist who wishes to dive deeply into the why and wherefore of plant life, but for him also who is content merely with collecting and recording--a work in a new country of the highest scientific importance.

No. 3.—ON HYBRIDIZATION IN THE GENUS *EUCALYPTUS*.

By J. H. Maiden, Government Botanist, and Director Botanic Gardens, Sydney.

The amount of variation in the genus *Eucalyptus* is especially great,* and thoughtful men will ponder over the explanations accounting for the same. Here we have a genus which practically occurs all over the vast continent of Australia, species being found along the coast, on the tops of the highest mountains, and in the deserts of the interior; flourishing where the rainfall is bountiful and where it is almost absent, where there is almost perpetual snow, and where hot winds prevail. Again, some revel in rich soil, while others grow in country which seems to be as sterile as possible. Here we have room for variation—it would surprise us if it did not exist; but the explanation of the variation is doubtless complex.

That there is a certain amount of variation amongst individuals is known by every person who has raised a box of *Eucalyptus* seedlings. The greater our experience the more we find that variation occurs, and there must be some finality in the naming of forms. I desire to invite attention in a preliminary way to the part that hybridization plays in variation in the genus. Time was when I believed that this phenomenon did not occur in *Eucalyptus*, or was so rare as to be negligible; but, as the result of extensive field-work and examination of herbarium specimens, I have arrived at the conclusion that hybridization is a factor that may not be neglected. At the same time care must be taken not to unduly attribute to hybridization variation which may be the result of other causes.

To a very large extent, as regards natural forms, we have only circumstantial evidence of hybridization. As regards cultivated forms, the evidence (in some cases quite satisfactory, as I shall show) is circumstantial also. I do not know

* See "Is *Eucalyptus* variable?" Journ. Roy. Soc. N.S.W., Vol. xxxvi., p. 315. 1902.

any cases in which direct experiments of the transfer of the pollen from the anthers of one tree to the stigmas of another have taken place, and the seedling produced as the result of the cross further examined after flowering. It would take a number of years for the experiments to produce results even under the most favourable circumstances, and further difficulties arise owing to the irregular flowering-periods of most of the species.

The study of hybridism is a phase of the study of eucalyptology the importance of which to the systematist it would be difficult to overrate, while its value to the physiologist goes without saying.

The first scientific man to refer to possible hybridism in the genus was the zoologist, W. Sharp Macleay, early in the last century. He remarked* "that parrots and other birds occasionally bite off the flower-buds, and may accidentally uncover a stigma and remove the anthers; and, again, insects may then finish off their work and carry pollen across from another species."

The late Rev. Dr. Woolls refers to the subject: "Even in the Grey Gum or Hybrid Box (*E. tereticornis*), which appears more subject to variation than any Gum in New South Wales, there is sufficient uniformity in the seed-vessel to mark the species. The leaves are subject to great diversity. . . . It is in this Gum that workmen speak so much of hybridization, as they imagine that the flowers of the Grey Gum are sometimes inoculated by the pollen of the Box, so that an intermediate variety springs up. . . . My own impression is that the varieties of the Grey Gum, to whatever causes they may be due, are not transmissible from generation to generation, and that they do not extend beyond the individuals so circumstanced: whilst I regard one of the kinds at least which workmen consider hybrid as a true species, for it has a uniform seed-vessel of its own, and prevails to too great an extent to admit of the supposition that it is the result of fortuitous impregnation."† The above remarks were published in 1867, and as the author died in 1893 it is obviously unfair to quote him as a non-believer in hybridization in *Eucalyptus* I do not, however, know any published statement of his in which he expressed different views, and at least up to within a few years of his death he leaned to his views of 1867.

One must not attach too much importance to the expression "bastard" as applied to trees and timber by timber-getters and timber-workers. As a very general rule the term is applied to conceal ignorance. A man does not know what

* Woolls, "A Contribution to the Flora of Australia," p. 219.
† *Op. cit.*, pp. 219 20.

a tree or a timber is, and so he says it is a bastard this or bastard that. For example, he uses the term "Bastard Mahogany" as an equivalent for *E. botryoides*, which is a good species, in the usual acceptation of the term.

Mueller always seemed to fight shy of the question, both in conversation and in his writings. Here follow two observations from his pen: "Also in the particular series of *Eucalyptus* species to which *E. fœlschiana* belongs some forms occur, the original of which may possibly be traceable to hybridism, notwithstanding that in this genus the contact of the anthers with the stigma commences already, while stamens and pistils are still covered by the lid," &c.* Again, "On the summit of Mount Wellington I collected a state of *E. urnigera*, with all leaves nearly oval and with simply truncate-ovate fruits. Hybridism does not seem to explain the origin of these aberrant forms in a genus, where cross-fertilisation is guarded against by a calycine lid, though, as pointed out by Mr. W. Sh. Macleay, the possibility of such a process is thereby not absolutely excluded, as parrots," &c.† (see preceding page).

The late M. Charles Naudin, of Antibes, southern France, distinguished both for his researches on hybridization in plants and for work on the cultivated forms of *Eucalyptus*, was a correspondent of Mueller, and he distinctly states‡ that the latter does not believe in hybridization in *Eucalyptus*: "M. le baron Müller ne croit pas à l'hybridation dans les *Eucalyptus*, cependant il existe des formes si parfaitement intermédiares entre des espèces acceptées par tous les botanistes, qu'on ne peut guère douter qu'il ne s'y forme des hybrides, comme dans tant d'autres genres, les Saules et les Rosiers par exemple."

Naudin§ pointed out that the flowering of *Eucalyptus* begins with the throwing-off of the operculum, after which the stamens arrange themselves in a circle around the ovary and style. It is an open question whether fecundation takes place before the fall of the operculum or solely after. The observation does not appear yet to have been made, "mais il semble probable à priori qu'elle est postérieure a cette chate, et que c'est au mélange de beaucoup de pollen étranger à l'individu fleurissant, apporté sans doute par des insectes, qu'il faut attribuer la grande variabilité de certaines espèces. Evidemment les croisements ne seraient pas possibles si la fécondation s'opérait a huisclos sous l'opercule, mais par

* "Eucalyptographia," under "*E. fœlschiana*."
† "Eucalyptographia," under "*E. cordata*."
‡ "Memoire sur les *Eucalyptus* introduits dans la Region Mediterraneene." Ann. des Sciences Naturelles, 6e serie, Bot., t. xxv., 337 430 (1883), p. 355. Quoted by me as "1st Mem."
§ 1st Mem., 354

cela même que les fleurs restent longtemps ouvertes, on peut conjecturer avec quelque vraisemblance qu'elles réçoivent du pollen d'autres arbres de même espèce ou d'espèces voisines." Here we have M. Naudin's own opinion, which is in favour of the great probability of hybridization in the genus.

So far as I know, direct and conclusive experiments defining whether fecundation takes place before or after the lifting of the operculum have not even yet been made, and it would be a research well worthy the attention of a careful botanist living in the vicinity of *Eucalyptus* trees. The experiments should be undertaken, although collateral evidence that fertilisation may take place after the removal of the operculum seems abundantly available.

Later on M. Naudin formulated his belief in these words: "Le croisement entre espèces d' *Eucalyptus* est rigoureusement possible."*

Hybridization amongst Eucalypts is, of course, only possible between species that flower at the same time, and the tendency of the genus seems to be in the direction of irregular flowering-periods. Our dry and erratic seasons accentuate, even if they do not cause, this irregular flowering. This irregularity has in Australia passed into a byword, and in Europe amongst cultivated trees something of the same tendency appears to obtain. For example, Naudin† points out that the irregularity applies not only to different species, but also to individual trees. In Australia it is very difficult to predict when a species will bloom; if one desires the flowers of a certain species, one may have to wait two years and more for them. If a species flowered during a certain month in one year it is highly improbable that it will flower during the same month in the following year. The buds often take months before they throw off the operculum. They may appear plump and ready to open, and in that stage they often appear to be stationary. Watching for them is tedious, and often perplexes those who are unaware of the peculiarity of the genus in this respect.

Dr. Trabut, of Algiers, leaves no doubt as to his views on the question of hybridization in the genus. In his "Les *Eucalyptus* hybrides dans la Région Mediterranéene,"‡ he states that there is no difficulty at the present day in admitting that every factor of variability can contribute to the genesis of new species, and hybridization is, without doubt, in many cases the starting-point of new forms which in process of time become fixed species, having a place either in

* "Description et emploi des *Eucalyptus* introduits en Europe," &c. (Antibes, 1891), p. 30. Quoted by me as "2nd Mem."

† 1st Mem., 362.

‡ *Bulletin Horticole de l'Algerie et de la Tunisie*, 15 Juillet, 1901; *Revue Horticole de l'Algérie*, Aout, 1901.

nature or amongst cultivated forms. He adds that the genus *Eucalyptus* furnishes in the Mediterranean region a very evident demonstration of this principle. One hundred species have been acclimatised in north Africa for thirty years. He gives an instance of the seedlings produced from trees of *E. botryoides*, Sm. He found that the descendants were of two kinds—(*a*) "*Eucalyptus botryoides* légitimes"; (*b*) "*Eucalyptus* tres différents, evidemment hybrides." The only species existing in the immediate neighbourhood of the parent *botryoides* was *E. rostrata*. He assumes that some of the descendants are hybrids of these two species. He reproduces figures of the fruits of one supposed hybrid, and describes the new "species," which he calls *E. rameliana*. It seems to me that he has proved without reasonable doubt that *E. rameliana*, Trabut, is a hybrid.

Dr. Trabut follows the subject up in a recent paper,* in which he again gives an account of *E. rameliana*, and figures and describes two other hybrids viz., *E. gomphocornuta*, a hybrid between *E. gomphocephala* and *E. cornuta*; and *E. bourlieri*, a form which he states is evidently a hybrid of *E. globulus*, but it does not appear to be possible to indicate the male parent.

Dr. Trabut states that he has other hybrids of *E. robusta*, *rudis*, *tereticornis*, and *rostrata*. The announcement adds terrors to the botanist who is asked to name the protean cultivated forms of *Eucalyptus*. I think that it is indisputably proved that the forms observed by Dr. Trabut (and his colleague Dr. Bourlier) are hybrids. They did not actually apply pollen to stigmas; their plants are the result of cultivating seedlings from *Eucalytpus* plantations. The evidence is only circumstantial as to the parentage of the supposed hybrids, but the evidence that hybridism does account for these forms is to me quite conclusive. And if *Eucalyptus* trees in a plantation naturally hybridize, it is difficult to suppose that it is impossible for species spontaneously growing to hybridize also. In nature it would appear that in the course of time the forms have acquired a degree of stability which is unknown in *Eucalyptus* plantations, which even yet in Algeria, southern France, and California are scarcely forty years old.

Now that this fortuitous hybridization of *Eucalyptus* in plantations has been ascertained, there is no doubt that many forms desired to be indicated by names will be brought to light. In this connection I recommend: (1.) That the name should indicate in some way that it is a hybrid. The nomenclature of hybridized Orchids may be taken as a pattern.

* "Quelques *Eucalyptus* hybrides dans la Région Mediterranéene" (*Revue Horticole*, 16th July, 1903, pp. 325-28).

(2.) That the description of a form include a description of the habit of the tree, nature of bark, description of sucker and mature foliage, buds, flowers, and fruits. The suckers are especially important in this connection as indicating atavistic relations.

I do not propose on this occasion to do more than briefly indicate a few spontaneous Australian forms in regard to which hybridization may be reasonably inferred. Doubtless other observers will give the matter attention, and later on it may be convenient to separately indicate other forms deemed to be hybrids.

Mueller, in "Eucalyptographia," under both "*E. resinifera*" and "*E. robusta*," refers to a tree which partakes of the characters of both, and for which he proposes the provisional name of *E. kirtoniana*. There are reasons for supposing that this tree is a hybrid, one of whose parents being probably *E. rostrata*.

The same botanist* published without comment a statement that Mr. W. Bauerlen had sent from near the Clyde, New South Wales, "specimens of an Eucalypt which he considers a hybrid between *E. corymbosa* and *E. maculata*, in which case the characteristics of the former are prevailing." He then goes on to describe some of the points in which the specimens in question partake of the character of the two species referred to. Mr. Bauerlen was then, as now, Collector for the Technological Museum at Sydney, the botanical collections of which were founded by me. It is only proper to say that Mr. Bauerlen was, during the period that he served under me, a consistent advocate for recognition of the principle of hybridism in *Eucalyptus*. In taking up the position I do now, of freely recognizing the principle, I bear testimony to the fact that Mr. Bauerlen, in correspondence with me, confidently asserted it at a time when I felt myself unable to definitely commit myself to an opinion without further evidence than I then possessed.

Mr. Deane and I have already tentatively drawn attention to the matter of hybridization in the genus.† We have pointed out that in supposed cases an Ironbark has hitherto been generally looked upon as one of the parents. The papers in question (and also that of Mr. Cambage, *infra*) show that the Boxes also play an important part in the cases of supposed hybridism which have hitherto been brought under notice. In fact, we have a number of trees, found in different parts of this State, which, partaking as they do of the characters of Ironbark and of Box, are intermediate in character, and are

* *Victorian Naturalist*, October, 1890.

† "On Apparent Hybridization between *E. sideroxylon*, Benth., and *E. hemiphloia*, F. v. M.," Proc. Linn. Soc. N.S.W., 1900, p. 111; also "Further Notes on Supposed Hybridization amongst Eucalypts," *Ib.* 1901, p. 339.

fitly termed Ironbark Box. (I have drawn further attention to the subject in a paper on *E. odorata*, read before the Royal Society of South Australia, and which is now passing through the Press.) Speaking generally, I may say that I have now many specimens in which Ironbarks and Boxes may be reasonably assumed to be concerned, from the point of view of hybridization, and have, indeed, so much evidence that it appears desirable to review the whole of the aberrant forms in which these two groups of plants may be deemed to be concerned. *E. affinis*, Deane and Maiden Proc. Linn. Soc. N.S.W., xxv., p. 104 (1900) would pass in review in this connection.

The question of hybridization is discussed by Mr. R. H. Cambage* in regard to supposed hybrids between *E. sideroxylon*, A. Cunn., and *E. woollsiana*, R. T. Baker. After relating certain facts as to the occurrence of intermediate forms in the vicinity of these two species, he says, "There are points of circumstantial evidence which suggest hybridization."

I exhibited (November, 1903) before the Linnean Society of New South Wales specimens of *E. longifolia*, Link and Otto, from near Gosford, New South Wales, having seven flowers in the head (the normal number being three). The shape of these fruits shows a slight resemblance to those of *E. robusta*, and there are some trees of this species in the vicinity. It may be that this abnormality was the result of hybridization in which *E. robusta* was concerned. Only one tree was found which lends colour to the supposition that its parentage is exceptional.

I am of opinion that hybridization between *E. viminalis* and *E. gunnii* may in part account for some at least of the forms which appear to be intermediate in character between these species.

I have already quoted Mueller's opinion that hybridization may account for some of the forms to which *E. fœlschiana* belongs.

Abbot Kinney† says, "Mr. L. Stengel, an experienced and careful nurseryman, is of opinion that *Eucalyptus* has a strong tendency to hybridize." He then refers to certain seedlings obtained from a sowing of reputed *E. robusta* seed: "The vast majority were true to the parent tree. . . . One specimen was identical with *globulus*, several were like *amygdalina*, var. *regnans*—in fact, about fifteen distinct species apparently came from these *robusta* seed." This is not evidence of hybridization, but of mixed seed; at the same time I have seen Californian specimens which, in my opinion, indicate hybridization.

* Proc. Linn. Soc. N.S.W., xxv., p. 716.
† "Eucalyptus" (Los Angeles, Cal.), p. 23. 1895.

No. 4.—NEW ZEALAND BIRD LIFE.

By Edgar Stead.

No. 5.—NOTES ON THE SUBTERRANEAN *CRUSTACEA* OF NEW ZEALAND.

By Professor Chilton, M.A., D.Sc., F.L.S.

[*Abstract.*]

In this paper it was explained that small, blind, colourless crustaceans had been discovered in the underground waters of the Canterbury Plains more than twenty years ago, and were known to be widely distributed, and in some cases pretty abundant. They are commonly known as "well-shrimps," and are usually brought to the surface by ordinary pumps. Similar well-shrimps are known to occur in Europe and in North America. The paper contained notes on some facts with regard to these creatures that have been observed since 1894, when the author published a paper dealing with the whole question in the Linnean Society's publications. The main new points are as follows: Previously no well-shrimps were ever obtained from the artesian water of Christchurch, though they occur in wells at Eyreton, Lincoln, and other places in the neighbourhood. Within the last two years, however, specimens of two different species have been obtained from an artesian at St. Albans, a suburb of Christchurch. One of the well-shrimps is a very peculiar Isopod, for which a new genus, *Phreatoicus*, was established in 1883, and this genus differed so much from other Isopods that it had to be placed in a special tribe by itself. Since then various representatives of this family have been discovered in Australia, some of them living underground like the New Zealand species, and others inhabiting the surface waters. The New Zealand underground species must, no doubt, have been originally derived from some form living in the surface fresh waters of these Islands, but no such form was known to occur in New Zealand till rather more than a year ago, when Professor Kirk found one living in a fresh-water lagoon in Ruapuke Island, in Foveaux Strait. The family appears to be a very ancient one, and was probably widely spread in past ages, and it is quite possible that other representatives of it may yet be found in other places in New Zealand. Quite recently Dr. Cockayne found in surface streams at Castle Hill specimens of another of the subterranean well-shrimps—*i.e.*, the Amphipod *Paraleptamphopus subterraneus*. It is blind and colourless, and,

though now living in surface streams, is quite identical with those obtained from the underground waters of the plains. This little Amphipod has since been found to be abundant in several streams in the neighbourhood of Castle Hill, which is at a height of more than 2,000 ft. above the sea. In all probability it exists as an underground species further up the hills, and has come to the surface by means of the springs arising from the various river-terraces at Castle Hill, and has then been able to maintain itself in these surface streams; but its existence there, so far removed from the underground waters of the plains, is a point of considerable interest.

No. 6. THE *PHREATOICIDÆ*, A PECULIAR FAMILY OF AUSTRALASIAN FRESH-WATER *ISOPODA*.

By Dr. Chilton.

[*Abstract.*]

The *Phreatoicidæ* are the family to which one of the well-shrimps mentioned in the preceding article belongs. For some years only the one underground species was known, but later on others belonging to the original genus, *Phreatoicus*, and other closely allied genera were found in Australia, some of them being underground species, but others living in surface waters. The family is a very peculiar one, and evidently an ancient one, as it possesses characters common to several of the other families of *Isopoda*.

No. 7. SOME *ISOPODA* FROM THE SOUTHERN ISLANDS OF NEW ZEALAND.

By Dr. Chilton.

[*Abstract.*]

This paper describes some land Isopods recently obtained by Dr. Cockayne from the Auckland and Campbell Islands Some of them belong to species already known from New Zealand, but one proves to be a new species, and another large species *i.e.*, *Scyphax(?) aucklandiæ* is confined to these islands, and is of considerable interest to the systematic zoologist.

No. 8.—THE STRUCTURE OF THE EYE AND ASSOCIATED PARTS IN *NOTORYCTES TYPHLOPS.*

By Miss G. Sweet, M.Sc.

POSITION.

The eye of the Australian marsupial Mole *Notoryctes typhlops* is not visible from the exterior, nor on simply removing the skin from the head, but is to be found close against the skull-wall about half-way between the end of the snout and the auditory opening, covered over by the temporal muscle, and often, in addition, by a mass of connective tissue. Nor does it harmonize with the typical mammalian eye in structure any more than in position.

STRUCTURE.

In *Notoryctes* the eye, with its glands and ducts, its muscle, nerve, and blood-vessels, are all enclosed within a long and funnel-shaped tough, fibrous capsule, which is closed in front, and is attached by its posterior small end to the bony wall of the skull, alongside which it lies. The hinder part of this conical capsule is occupied by the four or five bands of unstriped muscle fibres, one or two of which are attached anteriorly to the capsule itself, the remainder ending among the connective tissue within it. The larger anterior portion contains the eye itself, and surrounding it on almost every hand is a remarkable development of glandular material, evidently serous in character, which may sometimes be so great in quantity as to extend also outside, around, and even posteriorly to the capsule, which in these cases is more or less irregular in its hinder portion. In every case, however, the ducts of the gland, some four to six in number, whether inside or outside, empty their contents into an irregularly shaped but very definite space or sac in the extreme front of the conical capsule, which is lined by columnar epithelium and surrounded by unstriped muscle fibres. From its anterior border two ducts emerge, the shorter outer one of which runs for a varying distance obliquely outwards and forwards, being lined by cubical epithelium, and ends blindly in the connective tissue of the dermis beneath the outer skin, with which it is not connected. The longer and inner of these two ducts runs upward, forward, and inward, and, passing through the skull-wall by the lachrymal notch, descends towards the middle line (grooving and then passing through a canal in the upper maxillary bone), into the internal meatus of the nose, and finally comes to lie in the lateral wall of the nasal furrow, into which it opens anteriorly.

Returning to the capsule, we have still to consider the eye itself. This consists of a pear-shaped hollow ball of pigment, its wall being thicker in front, above and below, and on its outer side, and thinning off elsewhere to the posterior bluntly pointed end, where it is thinnest. This ball of pigment is enclosed within a fibrous capsule of its own, which anteriorly is partly continuous with fibres passing round the gland-space above mentioned, this space having its hinder wall closely apposed to the anterior wall of the eye. Within the hollow ball is to be found a mass of cells with rounded nuclei, which in the majority of eyes examined shows no differentiation. In one instance, however (the least degenerate), there was to be found in just two consecutive sections a double-layered arrangement of cells. (Immediately within the pigment is a layer, some five to seven cells deep, of much-crowded cells having small darkly staining nuclei. This layer thins out anteriorly, and is reflected in the median line longitudinally as a single or two rows of nuclei, which posteriorly become connected with each other, and each with the outer thick layer of similar cells.) Between the two thin median longitudinal lines of cells is a fibrous appearance arising anteriorly from a spreading base, and running back piercing the posterior pigment-wall, outside which these fibres become lost among those of the pear-shaped fibrous capsule, which here passes posteriorly to its attachment to the outer fibrous wall. The remainder of the eye contains a somewhat fibrous-looking matrix, in which are imbedded irregularly scattered cells, containing large, lightly staining nuclei.

The blood-vessels of this region are similar in origin to those of other mammalian forms, but are abnormally large in proportion to its size.

No nerves can be detected in connection with the eye itself, whether by dissecting lens or by sections (longitudinal or transverse of the eye, brain, or of the whole head), other than the fibrous appearance noted above, which I have no doubt represents the last remaining fibres of the optic nerve. Also, in one section across the whole head there was to be found a slight swelling, which may represent the vestige of the root of the abduceus, or sixth nerve. Otherwise no trace could be found of the motor oculi trochlear, or abduceus.

The gland, and probably the muscles also. are supplied by a large branch from the ophthalmic nerve.

SUMMARY AND CONCLUSIONS.

We are now in a position to very briefly review these structures and trace their homologies with the typical mammalian eye, and so to determine the extent to which degeneration has taken place.

1. The eye itself: Here the nervous retina of the normal eye is reduced in most cases to a simple undifferentiated mass of cells, with the exception of the one case, that of the least degenerate, found among the eyes examined. The vitreous humour is represented apparently by the central matrix. The choroid is thickened in its degeneration by the greater formation of pigment in place of lens, iris, &c. The sclerotic and cornea are represented by the pear-shaped fibrous capsule enclosing the ball of pigment.

2. Nerves of the eyeball and of its muscles: These are virtually absent except for the vestige in the eye shown, and possible fibres from the branch of ophthalmic muscles.

3. Accessory and external parts of eye: Eyelids are, of course, as such, quite absent. Muscles: These are reduced to four or five simple bands, which no longer retain their connection with the eyeball. Lachrymal gland, ducts, and conjunctival sac: These are in bulk, and probably in functional importance far and away the most highly developed part of the eye. The huge mass of glandular material surrounding the eye, from its position, the course of its ducts, and its innervation, has, without doubt, arisen from the lachrymal gland of the typical eye. The space in front of the pigment-ball into which the gland-ducts open can only have been derived by the complete closing-over of the eyelids. The space so included (*i.e.*, the conjunctival sac) for a time retained its connection with the exterior by a duct. The secretion of the gland poured into the conjunctival sac by the four or five lachrymal ducts, and expelled thence by the contraction of the surrounding muscle-layer, as well as indirectly by the contraction of the two muscle-bands attached to the outer capsule, would thus at first have the option of two courses—either directly to the exterior, which was evidently not of much use to it: or indirectly by the nasal duct into the nose, which has become now the sole escape for the secretion of the gland. It has apparently acquired considerable functional value, since with the loss of the direct passage to the exterior the gland has increased in size. Presumably the present function of the secretion is to prevent particles of sand from entering or accumulating in the nasal cavity when burrowing in the fine surface sand in which *Notoryctes* hides itself.

I have not been able to find any record of any mammalian eye so degenerate as this. Of the moles of Europe, America, or South Africa we merely read that the eye is minute, hidden within the fur, and more or less rudimentary, though in some cases they are said to be functional, which we certainly cannot claim for that of *Notoryctes*.

In his abstract of his work on the blind fish of Cuba, Eigenmann states that, though "in the old a connection between the eye and brain cannot be traced," still in *Amblyopsis* the "eye is perfectly outlined and the lens is developed," while "the cones are (merely) uncertain in their development": while in *Typhlotriton*, though the "eye is normal in the young, the eyelids are already closing over, more marked degenerative changes following the metamorphosis."

The greater degeneration of the eye of *Notoryctes* over that of the English Mole is to be explained by the difference in environment, since, as already pointed out by Professor Spencer in his report on mammals of Horn Expedition, although *Notoryctes* is much more a surface animal than *Talpa*, yet the irritation caused by the fine sand on the eye, were it present, would quite outweigh disadvantages it now suffers in having no eye to use when above ground.

No. 9. THE LONG-TAILED CUCKOO (*URODYNAMIS TAITENSIS*, KOEKOEA, OR KOHOPEROA):

An Account of its Habits, Exhibition of a Nest containing its (supposed) Egg, and some Suggestions as to how the Habit of Parasitism in Birds has arisen.

By Robert Fulton, M.B., C.M., Edin.

Dr. Fulton, M.B., C.M., read a paper on the habits of the Long-tailed Cuckoo (*Urodynamis taitensis*), of which the following is a summary:

On exhibiting a nest of the Tomtit (*Myiomoira macrocephala*), which contains the egg of a Long-tailed Cuckoo (*Urodynamis taitensis*), Dr. Fulton referred to the very general opinion that the Grey Warbler (*Gerygone flaviventris*) is the usual "host," from the fact that this little bird is so frequently seen feeding the young of this parasite. A comparison between the size of the Cuckoo and the nest of the Warbler throws doubt on this theory, and so far no one has ever found the young bird in such a nest. There is no doubt that the egg of the Bronze Cuckoo is deposited in the nest of the Warbler, and hatched out by that bird, as numbers of instances are known of the young Cuckoo being found filling the nest up to almost "bursting-point." To attain this end the parent Cuckoo, like Cuckoos all the world over, probably lays the egg on the ground, and carries it in its bill until a nest suitable for the purpose is found, when the egg is gently dropped into it. The fact of Cuckoos carrying their eggs in their bills is now universally admitted, and this has given rise to much of the accusations against them. The Long-tailed Cuckoo invariably chooses an open or cup-shaped, and not a domed or covered-in nest, and the nest of the Tomtit, exhibited, was a fair example of the former class. The commonest host in both South and North Islands is the native Canary (*Orthonyx*), but the Tui, Mocker, Robin, White-eye, and some of the imported birds are also imposed on. Sets of eggs showing "protective mimicry" were exhibited, and differences in size and colouring of Cuckoos' eggs of the same species explained. Those contained in closed-in or domed nests, being in darkness, need no "protection," while those in open nests are spotted in such a way as to resemble the natural occupants of the nests. With regard to the habits of the Cuckoo, Dr. Fulton has received abundance of evidence as to its robbing-propensities, though he is of opinion that this is a comparatively modern "failing," due to the prevalence of the nests of small imported birds in the trees on the edge of the bush, where the Cuckoo usually shelters. No instance has been recorded of a Cuckoo robbing a native bird's nest, and the writer thinks this very unlikely. The evidence as to the migration of the Long-tailed Cuckoo was gone fully into. Native legends and sayings as to the appearance of the bird from the ground where it has "hibernated as a lizard," and the significance of the parasitic habit, from the Maori point of view, were reviewed. A careful summary of the dates on which the birds are first seen on the coast-line, gathered through the courtesy of our lighthouse-keepers and others, forms a chain of evidence as to the spring migration; and the curious habits of flight, ventriloquial cry, movement of wings, and tail, mode of perching lengthwise on a bough, &c., were all gone into in detail. The autumn migration was also fully traced to the departure of the birds in flocks from different localities (105).

The more important part of the paper namely, a suggestion as to the reasons which have led up to this extraordinary habit of Cuckoos of imposing eggs upon other birds was then put forward, as follows:

It may be considered of interest if I digress for a few moments to give some of the suggestions as to how the habit of parasitism in birds has become established.

Newton says, "The reflective naturalist will pause to ask how such a state of things came about, and there is not much to satisfy his inquiry. Certain it is that some birds, whether by mistake or stupidity, do not infrequently lay their eggs in the nests of others. It is within the knowledge of many that Pheasants' eggs and Partridges' are often laid in the same nest, and it is within the knowledge of the writer that Gulls' eggs have been found in the nests of Eider Ducks, and *vice versâ;* that a Redstart and Pied Flycatcher will lay their eggs in the same convenient hole, the forest being rather deficient in such accommodation; that an Owl and a Duck will resort to the same nest-box, set up by a scheming woodsman for his own advantage; and that the Starling, which constantly dispossesses the Green Woodpecker, sometimes discovers that the rightful heir to the domicile has to be brought up by the intruding tenant. In all such cases it is not possible to say which species is so constituted to obtain the mastery; but it is not difficult to conceive that in the course of ages that which was driven from its home might thrive through the fostering of its young by the invader, and thus the abandonment of domestic habits and duties might become a direct gain to the evicted householder. This much granted, all the rest will follow easily; but it must be confessed that this is only a presumption, though a presumption that seems plausible if not likely" (41).

Darwin says, "It is supposed by some naturalists that the more immediate cause of the instinct of the Cuckoo is that she lays her eggs not daily, but at intervals of two or three days, so that if she were to make her own nest, and sit on her own eggs, those first laid would have to be left for some time unincubated, or there would be eggs and young birds of different ages in the same nest. If this were the case, the process of laying and hatching might be inconveniently long, more especially as she migrates at a very early period, and the first-hatched young would have to be fed by the male alone. But the American Cuckoo is in this predicament, for she makes her own nest and has eggs and young successively hatched all at the same time. It has been both asserted and denied that the American Cuckoo occasionally lays her eggs in other birds' nests; but I have lately heard of the discovery of a young Cuckoo, together with a young Jay, in the nest of the Blue Jay, and, as both were nearly feathered, there could be no mistake in their identification. I could also give several instances of various birds which have been known occasionally to lay their eggs in the nests of other birds. Now, let us suppose that the ancient progenitor of our European Cuckoo had the habits of the American Cuckoo, and that she occasionally laid her egg in another bird's nest. If the old bird profited by this occasional habit, through being enabled to migrate earlier or any other cause, or if the young were made more vigorous by advantage being taken of the mistaken instinct of another species than when reared by their own mother, encumbered as she could hardly fail to be by having eggs and young of different ages at the same time, then the old birds or the fostered young thus reared would gain an advantage. Analogy would lead us to believe that the young thus reared would be apt to follow by inheritance the occasional and aberrant habit of their mother, and in their turn would be apt to lay their eggs in other birds' nests, and thus be more successful in rearing their young. By a continued process of this nature I believe," says Darwin, "that the strange instinct of our Cuckoo has been generated. It is undoubted that, though very rare, reversion to the long-lost habit of nidification has occasionally been recorded" (45*a*).

Jerdon says that parasitism in Cuckoos is said to arise from a lack of sufficient intelligence to build a nest, and that this low intelligence is evidenced by the weak sexual organs and the eggs, which are very small in comparison with the eggs of other birds (43).

We know that a reduction in the size of the egg is not necessarily a proof of weak sexual development, but often as much an evidence of protective resemblance as is the colouring and spotting of the surface of the egg. It is notorious that all the world over the parasitic Cuckoo lays an egg absurdly small for the size of the bird, but nearly always deposits it in the nest of a bird which lays eggs smaller than its own. In this way it is easy to see that those Cuckoos would be preserved whose eggs most approximated in size as in colouring to those of the rightful owner of the nest, while those less fortunate in this respect would become extinct by the builders throwing out or deserting the strange-looking eggs. It is probable that this choice of nests containing very small eggs makes it more easy for the young Cuckoo to perform its villainous work of ejection, which would be difficult, if not impossible, with birds hatched from eggs of a larger size.

It is curious that in the New World, where some of the Cuckoos have not yet acquired the habit of parasitism, but are still industrious enough to build nests for themselves, we should find *Crotophaga ani*, a bird which seems to form the link between the parasitic and non-parasitic Cuckoos. In this case several females unite to lay in one nest. Full details of their economy are wanting, but incubation is carried on socially, for any one approaching the nest will disturb half a dozen of its sable proprietors, who with loud cries seek safety in the nearest available covert (42). It certainly seems to me that this bird, which is a true Cuckoo in structure and migratory habits, forms a link in the chain of evidence. The nest in which these birds lay their eggs must be a very large one to accommodate a number of birds sitting side by side, or else one or more of the owners do the hatching for the rest. The incubation may be attended to in turn, or, so to speak, in "watches," and some of the birds, being extra lazy or cunning, may scamp their duty or be driven away, and in this way the habit of intrusting the hatching to the other birds be established.

Is this loss of interest in preparing habitation for the young and the gradual acquisition of parasitism not connected in some way with the migratory instinct, as suggested by many people as far back as the days of Edward Jenner? It is remarkable that with few exceptions all parasitic birds are migratory, and it has always appeared to me that there must be some unexplained link between the two wonderful habits. Against this theory, however, is the fact that there are a number of birds which migrate for breeding purposes, but are not parasitic, and there are some of the parasitic Indian Cuckoos which are not considered migratory, and these facts certainly make the subject the more difficult of explanation.

The only birds other than Cuckoos which are parasitic are the *Molothrus* species or Cowbirds, and *Cassidix oryzivora* or Rice-birds of the New World, which are all allied to the Blackbirds and Orioles, belonging to the *Icteridæ*. The *Molothrus* is migratory, some coming from southern Mexico, and spreading up through the United States to south Canada, their range extending over several thousand miles. The different species exhibit almost every gradation between true nest-building and parasitism, and, like the *Crotophaga*, they are polyandrous, and breed promiscuously (45*a*). *Cassidix oryzivora*, which has recently been found to be parasitic by Dr. Goeldi, of Para, belongs to a different genus, but to the same family of *Icteridæ*. I can obtain no details of its economy beyond the fact that this bird deposits its eggs consistently in the hanging nests of the different species of *Cassicus*. It has an extensive range from northern to southern Brazil, is partially graminivorous, and chooses as its hosts birds of about the same size as itself *Cassicus persicus*, *Ostinops decumanus*, and *Ostinops cristatus*, all of which are gregarious; it is a near relative of *Molothrus*, and hanging their purse-like nests in beautiful symmetrical rows from the tips of the fronds of the Cabbage-palm. *Cassidix* belongs to the sub-family of *Quiscalinæ* or Grackles, many of which are gregarious, it is a near relative of *Molothrus*, and we shall await with great interest details of its economy, in order to clear up this question of mixed breeding or polyandry (88). It is remarkable that the very birds upon whom *Cassidix* foists its eggs are themselves generally seen in small flocks of seven or eight males, and the males, according to Mr. Goodfellow, always seem to outnumber the females (88). These birds are near relatives to the parasite, and one species, *Cassicus persicus*, was observed by the writer occasionally to have young of various ages in the nest, a point to which I shall refer later. It is quite possible that we shall yet hear of parasitism in several of the *Cassicus* species (89). There is another family of parasitic birds, the African *Indicatoridæ* or Honey Guides, which for many years were classed as a sub-family of the *Cuculidæ*, but have now been placed near the Barbets and Woodpeckers. They are zygodactylous, insectivorous; often feeding on bees; are extremely fond of honey, which they expect man to obtain for them, for it is undoubted that they will lead him to the locality of the bee-nest for that purpose. So far as I can gather of most of the species, the bird is nearly always seen alone: I can get no details of its pairing, but the various species are known to deposit their eggs in the nests of other birds, among which are *Hirundo*, *Dicrurus*, and *Melanobucco torquatus*, the South African Barbet (89). Some of the *Indicator* species are Bee-eaters; others refrain from touching these insects, but eat honey; some at times build pensile nests, in which they deposit their pure-white eggs; but the members of the family are, as a rule, considered to be pretty generally parasitic. Until further details of the *Cassididæ* and *Indicatoridæ* are to hand we cannot hope to throw much light on the subject of parasitism so far as they are concerned, but our knowledge of the habits of Cuckoos and Cowbirds is such as to warrant our coming to a fair conclusion on the subject without any great stretch of imagination. From what we find of the American Cuckoos, the suggestion put forward by Darwin appears to be the most reasonable step towards an explanation.

Bendire says, "The Yellow-billed Cuckoo is one of the poorest nest-builders known to me, and undoubtedly the slovenly manner in which it builds its nests causes the contents of many to be accidentally destroyed, and this probably accounts to some extent for the apparent irregularities in their nesting-habits. The nests are shallow, frail platforms of twigs and rootlets, through which the eggs can often be seen. The number of eggs varies from two to five, but now and then as many as six or seven, but it is questionable whether they are all the product of one female. Usually an egg is laid daily, and incubation does not begin till the set is completed; but it is well known that the bird may commence incubation when the first egg is laid, and at the same time continue laying at irregular intervals, varying from two to eight days, so that one will occasionally find birds of different ages and eggs of different stages of incubation in the same nest. It is also well known that this species will occasionally deposit an egg or two in the nest of the Black-billed Cuckoo, and the latter returns the compliment, and now and then the egg has been found in the nests of other species, such as the Wood-thrush, Robin, Cat-bird, Black-throated Sparrow, Cardinal, and Mourning Dove. The majority of these cases may well have been due to accident: its own nest having possibly been capsized, necessity compelled the bird to deposit its egg elsewhere. It is indisputable that latent traces of parasitism do exist in our Cuckoos, and especially among the Black-billed species. From personal observation I am inclined to believe that the Black-billed Cuckoo is more irregular in its nesting-habits than the Yellow-billed, and that cases of parasitism are of more frequent occurrence. I also think that their eggs are much oftener found in different stages of incubation than appears to be the case with the former species" (38*a*).

The nests of the Yellow-billed are slightly better built than those of the other species, but nevertheless numbers of cases are known of true parasitism in this bird. The eggs have been found in nests of Wood-pewee, Warbler, Cat-bird, Sparrow, &c., and in the nest of the last-named bird the young Cuckoo, when hatched, proved to be the tyrant which he is elsewhere, for he quickly threw his companions out of the nest.

Burroughs says, "The European Cuckoo builds no nest, but puts its eggs out to be hatched, as does the American Cow Blackbird; and the American Cuckoo is master of only the rudiments of nest-building. No bird in the woods builds so shabby a nest; it is the merest makeshift—a loose scaffolding of twigs through which the eggs can be seen, and which is often destroyed by a rough gale." A large gooseberry-bush standing in the open field not far from his house was occupied by Cuckoos for two seasons in succession, and, after an interval of one year, for two seasons more. This gave him an excellent chance to observe them. He says the mother-bird lays a single egg, and sits upon it a number of days before laying the second, so that he has seen one young bird nearly grown, a second just hatched, and a whole egg all in the nest at once. This is the settled practice, the young leaving the nest one at a time to the number of six or eight. The young have quite the look of the young of the dove in many respects. The mother-bird is unnaturally indifferent when her nest and young are approached; she makes no sound, but sits quietly on a near branch in apparent perfect unconcern. These observations, together with the fact that the egg of the Cuckoo is occasionally found in the nests of other birds, raise the inquiry whether the American bird is slowly relapsing into the habit of the European specimens, which always foists its egg upon other birds. Its irregular manner of laying seems better suited to a parasite like the Cowbird or the European Cuckoo than to a regular nest-builder (38*c*).

Turning to the Cowbird (*Molothrus ater*), Bendire says, "It is a well-known fact that the Cowbird is a parasite, building no nest, but inflicting her eggs usually on smaller birds, leaving them the labour and care of her young. It appears to be entirely devoid of conjugal affection and practises polyandry, there being generally more males than females in the small flocks in which they are found. The laying season begins about the middle of May, and lasts for about two months, during which time from eight to twelve eggs are laid by each female, or the equivalent of two broods, and several days elapse between the laying of the eggs. It is likely, and this is fortunate, that not more than half of those are hatched, as some are occasionally dropped in old or abandoned nests, or, when the female is hard pressed, even on the ground. When she wishes to deposit her egg the female leaves her associates, and begins her search for a suitable nest, usually selecting one of a smaller species than herself. She does not forcibly drive the owner from her nest, but waits for an opportunity to drop her egg in it when it is unguarded. She imposes upon nearly a hundred different kinds of birds, including (38*b*) even the Yellow-billed Cuckoo herself. The young bird grows very quickly, and, seizing all food which comes to the nest, starves its companions in about three or four days." It is asserted that Cowbirds occasionally build their own nests, but Bendire discredits the statement himself. From what we know of the Cuckoo this is quite possible.

Another observer, Mr. Hudson, tells us that *Molothrus badius* sometimes lives promiscuously together in flocks and sometimes pairs; it either builds a nest of its own or seizes one belonging to another bird, throwing out the nestlings; it either lays in this nest or builds one for itself on top of it; it usually hatches and rears its own young, but is often parasitic. Another species, *Molothrus bonariensis*, is more highly developed, and is well on the road to parasitism, though occasionally it tries hard to return to the architectural habits of its ancestors. This bird, so far as is known, invariably lays in the nest of strangers; but it is remarkable that several sometimes commence to build an irregular untidy nest of their own, placed in ridiculous situations, such as on the leaves of a large thistle, and Mr. Hudson observes they never complete or use their nest. They lay from fifteen to twenty eggs in a large foster-nest, peck or make holes in the other eggs in the nest, and often drop their eggs on the ground. The third species, *Molothrus ater* or *pecoris*, I have already alluded to. It has acquired the full habit of parasitism, and never lays more than one egg in a foster-nest, so that its young is securely reared (45*a*).

The habit of parasitism, then, seems to be found chiefly in birds which have this peculiar irregularity of laying, but the cause of this irregularity is hard to determine. It is not the least curious part of the whole business that of all these American birds, including nearly a dozen species of Cuckoos and five or six species of Cowbirds, a large majority of them have the regular or occasional habits of consorting in parties, breeding promiscuously, laying in common nests, and practising polyandry, and if there is any evidence of the same habits pertaining elsewhere we should be nearer a solution of the origin of parasitism. What is the cause of this irregular ovipositing it is as yet hard to say, but that it almost universally obtains among parasites we have already seen.

Is it not possible that the spring migration of the Cuckoos and Cowbirds, which we have seen always results in the males arriving first, may have helped to produce this promiscuous pairing and polyandry? Has this promiscuous pairing and shortage of females not led to breeding and nesting in parties, to laying eggs in "common nests" and to irregular laying, and hatching of eggs of various ages? Having acquired the instinct of getting some of its eggs hatched in a common nest, along with those of others of its own species, is there not a likelihood that to still further lessen the discomfort of a long incubation and a tedious tending of a family, and to be earlier ready for the return migration, the female Cuckoo should deliberately set to work and impose her eggs upon a suffering public? To lay six eggs, and to drop them into six different nests, would be a much better arrangement than to lay and tediously hatch, or assist to hatch, the same eggs, a task that would take nearly twice as long, and might prevent the female from being ready for her migratory flight. The young birds, after being tended by their foster-parents, can follow later, as we know they do, and the female bird is free to lead a roving life, with none of the cares of motherhood; she can continue to lay eggs right on, or, what is more likely, after an interval of a week or two, can start off with a new set of mates, and lay another batch of eggs, which will be similarly boarded out at the expense of others.

As bearing on this question of nesting in common, it is interesting to notice that in all of these parasites probably the first step is the deposition of the egg of any one species in the nest of its own immediate relatives of the same species; then of birds of similar habits as to breeding and nest-building, near relatives; then more distant relatives; and eventually birds of almost any genus, family, or order. The American Cuckoos frequently impose upon each other Cuckoos of the same or of different species; similarly Cowbirds upon other *Molothrus* indviduals—one species consistently upon another *Molothrus*, which builds a nest; all of the *Molothri* upon Blackbirds and Orioles, their immediate "first cousins." *Cassidix oryzivora*, which sometimes builds a purse-like nest, utilises the pensile dwelling of its cassidine connections, and the *Indicator* or Honey Guide often drops her egg into the home of her cousin, the Barbet.

It has been suggested that the irregular laying might be the result of the parasitic habit, acquired by the female through the necessity of having to retain the egg until a suitable nest is found in which to deposit it. This theory can, however, be put on one side by what we know of the American Cuckoos, where we find irregular egg-laying by Cuckoos which are not yet fully parasitic, proving conclusively that this peculiarity of ovipositing precedes parasitism, besides which it is not uncommon in other birds.

May not this peculiarity have been acquired for the very purpose of having birds of various ages in the nest, so that each succeeding egg may get the advantage of the warmth of the body of the previously hatched chicks, while the mother is away foraging on behalf of her offspring? As the male Cuckoo is notorious for the lack of interest which he takes in the nest or its contents, and does not know the joys of domestic happiness, the young birds have to act the "big brother" to each arriving infant. The same thing, according to Mr. Bosworth Smith, is seen in the Barn-owl. He says, "Alone, I believe, among birds, she sometimes lays her eggs not continuously, but at considerable intervals of time. At first, it may be, she lays two eggs, on which she will sit for a week or two; then two more; and then, when she has hatched the first two, perhaps three more; so that you may find fresh eggs, hard-set eggs, and young birds in the same nest. What is the reason of this peculiarity? Is it that by leaving the later eggs to be hatched in part at least by the warmth of the young birds she has more leisure by an all-night absence to satisfy the cravings of her voracious brood? (38*e*). The male Owl, though remaining faithful to his mate, does not assist in the hatching of the eggs, and the female, with so large a number as six or seven chicks to feed, has acquired the advantageous method of keeping her eggs warm in her absence. She not only approaches the Cuckoo in this extraordinary peculiarity, but her nesting-habits are of the most primitive description. No Owl has much building-talent; she may lay her eggs, five or seven in number, in an old Squirrel's drey far out on the bough, sometimes in an old Hawk's or Crow's or Magpie's nest, not caring to do anything to repair, or make them comfortable (38*f*). The Owl is sometimes sociable enough to lay her eggs in the same dovecote with Pigeons, and from the moment that Waterton was able to exclude rats from his dovecote there was no further massacre of young Pigeons, and thenceforward both Barn-owls and Pigeons lived, laid their eggs, and reared their young, as members of one happy family. Pigeons do not mob the Barn-owl, who lives amongst them, because they know him well: other birds do mob him, because, being a bird of night and quite unlike themselves, they hardly know him at all" (38*g*).

Pigeons have the peculiar habit of laying pairs of eggs at intervals, and of having eggs, small chicks, and fairly large ones in or about the nest at the same time. This, no doubt, is partly for the same reason of supplying vicarious warmth while the parents are on the search for food, but also in order to further the production of as many chicks as possible in the one season. Our New Zealand Hawk has this habit also, on occasion, of depositing its eggs at intervals, and here again the same reason comes into play. Hawks have much hunting, soaring, and searching away from the nest before they can get food for their hungry little ones; and this irregular laying no doubt enables the uncovered eggs and young to withstand the effects of the frequently inclement weather. Cuckoos, Cowbirds, Pigeons, and Hawks are all most voracious feeders, and the efforts of both parents and foster-parents are necessary in order to provide sustenance and satisfy their clamorous offspring. Pigeons, Owls, and Hawks strictly pair, and are strictly faithful to their respective mates; and, flimsy and rude as the nests of all of them are, it is undoubted that both sexes take their share in the "burden and heat of the day." Cuckoos do not pair, and parasitism consequently results.

There is another possible reason for the irregular laying of eggs. Young Cuckoos and Cowbirds are so voracious and their natural insect food so unsatisfying that in those cases in which the parasitic egg is hatched the intruder finds it expedient either to throw out, or, by seizing all food, to starve to death in a few days, the rightful tenants of the nest. May not the mother Cowbird or Cuckoo through countless ages have witnessed such a struggle in her own rude nest, and unconsciously finding one youngster alone of a large brood, and that the strongest or oldest, to survive, have gradually come to lay her eggs at intervals, so that at no time would food for a bird at one age be exactly suitable in quantity or quality for a bird at an older or younger stage? Soft grubs and other minute insects for the tiniest chick; moths and butterflies for the next in size; caterpillars and other hairy insects for still larger; beetles and hard-backed cockchafers and crickets for the next; and finally lizards and even small (85) frogs for those about to quit the nest. Does it not seem likely that an advantage would be gained by that mother who had her chicks separated by the widest intervals in ages, so that, having satisfied with some trouble the greedy eldest, she could with more leisure attend to the next in size, and finally, with little trouble, the tiny demands of the infant? In addition to this, the half-fledged bird is not so likely to hustle and throw out a tiny nestling, which hardly interferes in any way with its feeding-arrangements, so that this fact also must be taken into consideration

It is undoubted that the "heaving-out" process takes place before the young parasite is three days old, it having the instinct to practise this barbarity upon any occupant of the nest which it finds it can wriggle under and eject. Is it not significant that the young American Yellow-billed Cuckoo, which will amicably accept its due proportion of food in a nest containing older and younger brothers and sisters, on being hatched in a nest alongside birds of its own age should immediately hustle them from the nest? (38). In his own true domicile, if the eldest bird, he will probably have the nest entirely to himself for a week, and then he may find beside him a smooth round egg, which he will have considerable difficulty in balancing on his back and so disposing of; but, as a matter of fact, his hustling propensities are by this time almost got rid of, and the new object is probably left undisturbed. If the bird is himself a younger brother he will find any attempts at hustling his elders childishly futile; they on their part having neither the wish nor the necessity to displace him. At the same time their very presence in the nest would effectually prevent his hurling out an egg if such were laid beside him. When two Cuckoo's eggs are deposited in the same nest and hatched out at the same time a tremendous struggle takes place for mastery, and after alternate attempts at throwing out each other the strongest or more adroit at length succeeds in attaining its desire and becoming sole tenant of the nest. In this way numbers of Cuckoos and Cowbirds are annually sacrificed to the superior strength of their foster brothers or sisters, two or more of which have been "dumped" into the same nests by their respective parents (84).

This ovipositing at intervals does not seem to be entirely confined to parasitic birds, but that it is almost universal among them is undoubted, and by many is looked upon as the immediate cause of parasitism.

To recapitulate: Male Cuckoos and Cowbirds are always in the majority, especially at the beginning of the breeding season; and for reasons before mentioned this may be partially due to the long flight of migration. Coincident with this preponderance of males, promiscuous breeding and polyandry very generally obtain among parasitic birds. Owing to the absence of domestic habits in the male, the female Cowbird or Cuckoo, being single-handed, has almost lost the faculty of nest-building, and is contented with a few poor sticks, through which the eggs can be seen, and from which eggs and young are often capsized by rough weather. Owing to an insufficiency of nourishment, at all times of a very unsatisfactory nature, the stronger young Cowbirds and Cuckoos, in the struggle for existence, have acquired the habit of either appropriating all food, to the fatal detriment of the weaker, or else of hustling them over the side of their flimsy domicile. Finding that many of her young are sacrificed, and that it is impossible for her to bring them all to maturity if fed at the same age, the mother has acquired the habit of irregular laying. This is a protection in warmth to her eggs and chicks during her absence from their wind-swept tenement, is a preventive against the cruel ejection of the weaker, and, by reducing the need for appropriation of all food by the stronger, is a means of lessening the burden of feeding the young. Owing to the promiscuous breeding, nesting in common nests or laying in a common "foster-nest" or "boardinghouse" is frequently seen in Cowbirds and Cuckoos. Some of the American Cuckoos show irregular laying of eggs, generally make their own nests, but occasionally practise parasitism. The different species of American Cowbirds show irregular laying of eggs, and all the stages between nest-building, laying in common nests, in common "boardinghouses," and true parasitism. Some of the American Cowbirds and Cuckoos, and our own and the Old-World Cuckoos, having probably passed the stages of nesting in common and of depositing their eggs in common "lodginghouses," but still retaining the the habit of irregular ovipositing, find it expedient, in order to be ready for the return autumn migration, to drop their eggs one by one into the nests of other birds. The whole matter may be placed in a nutshell: Owing to the promiscuous breeding, entire neglect of domestic habits, and provision by the male of a home for his doubtful progeny, the unfortunate female, tired of having single-handed to provide dwellinghouse and sustenance, leaves her eggs on the doorsteps of those whom she thinks most likely to take pity on, feed, and bring to maturity her fatherless children.

I have shown that the loss of domesticity in the male is the probable cause of parasitism, and I will now mention an instance which seems to indicate that a return to decent behaviour in this respect is very soon followed by a resumption of the habit of nest-building. The true Indian Cuckoos are strictly parasitic, and *Hierococcyx sparveroides* is considered by most observers to be universally so. The Indian Cuckoos are seldom seen in pairs—generally singly, or in small parties—but this particular species is said by Allan Hume to be more often seen in pairs than any of the other ones. That this is an evidence of a leaning towards domesticity we find in the interesting fact that Mr. R. H. Morgan, of the Madras Forestry Department, avers that on one occasion he watched this species actually build its own nest, and that he then removed the eggs, of which four were laid (86).

It is of great interest that we find in other parts of the world besides America accounts of parasitic birds consorting in parties or flocks, and the same promiscuous breeding and polyandry, as a stepping-stone to true parasitism. Jerdon says that the true Indian Cuckoos do not pair, many males being seen with one female, and mentions this particularly of *Coccystes melanoleucus*, and he says of the Indian Koel (*Eudynamis orientalis*) that, though not generally gregarious, several may often be seen on the same tree (43). Dr. Brehm says of the European Cuckoo (*Cuculus canorus*) that the relationship between the two sexes seems to be peculiar. "During pairing-time the male bird acts like a headstrong passionate idiot. How angry is its cry and what a rage it gets into when another of the same species dares to invade its territory! It is possible that the Cuckoo is content with one mate, yet it is more likely that neither sex is particular in the matter. It seems much more likely that each male should court all hen birds alike, and *vice versâ*, else why this unbounded jealousy?" (12*a*). Mr. Percival reported of *Chalcites smaragdineus* in South Africa that he had seen it in flocks, and found it pugnacious, six or eight males chasing each other, with only one female (96). Out of twenty-five specimens of various species of Cuckoos obtained in East Africa by Mr. F. Jackson, only four were females, and one of these was immature (96). The experience of many other explorers points to the same numerical preponderance of the male Cuckoos over the females in different parts of the world (98). Of the Australian birds Mr. Campbell writes, "While in a forest near Cape Leeuwin in October, 1891, I saw four or five Bronze Cuckoos in shining coats making a great stir in a low tree, chasing each other and making melancholy, tremulous, whistling noises. Anxious to ascertain the cause of the disturbance I approached too close to the little company, which immediately departed to another tree" (38*h*). Mr. Broadbent reports, "I have seen in January flocks of Channel-bill Cuckoos in company with *Streperas* just under the mountains in the Big Scrubs" (38*i*). Gould says of the Pallid Cuckoo, "During the vernal season it is an animated and querulous bird, and may then be seen either singly or two or more males engaged in chasing each other from tree to tree" (38*j*). Mr. Robinson says of the North Queensland *Scythropa novæ-hollandiæ*, "Plentiful, feeding in flocks on very high trees" (88). Latham says of the Channel-bill, "It is chiefly seen in the morning and evening, sometimes in small parties of seven or eight, but more often in pairs." Turning now to our own birds, I am informed on good authority that the Bronze Cuckoo migrating from Australia to the West Coast is seen in large numbers at Totara, an old Maori battlefield, two miles south of Shortland, Thames (38*d*).

There is no doubt in my mind that the ventriloquistic character of the call in both of our Cuckoos has to do with the promiscuity of their relationship, and is probably utilised by the male for the purpose of calling the female, while attempting to deceive the other males as to his whereabouts. It is most interesting to find that in other countries the same ventriloquial character is observed of the call of many of the Cuckoos; for instance, the Plaintive Cuckoo of India

(*Polyphasia nigra*) has a peculiar call of two syllables, to which the bird by pointing his head in different directions, as he sits calling, gives a most ventriloquistic effect, sometimes appearing as if coming from one side, and immediately afterwards from the opposite (61*a*). The same thing is known of the African and American birds. Captain Mair says, "While passing down the Hurukaureo River during the intensely hot weather of February, 1872, I was astonished at the number of Kohoporoa that coursed about overhead. During the three days that we were making the passage we saw some hundreds of them, swarming about in the air like large Dragon-flies, as many as twenty or thirty of them being sometimes associated together. The loud clamour of their notes became at length oppressive. There was much dead timber on the banks of the river, and it appeared to me that the birds were feasting on the large brown Cicada (63). This is the only occasion on which I have observed this species consorting together, as it were, in parties." A correspondent at the Bay of Plenty tells me that he has seen as many as three in one tree apparently busy after Sparrows' nests; another in the same locality that he saw about a dozen in some trees near the post-office on one occasion (38*o*). Mr. Gallien, of Winton, saw a Long-tailed Cuckoo fly on to a tree and scream at intervals, attracting as many as four more -that is, five on one tree at one time (38*p*). Mr. McLay saw four of the same birds in a small gully at Waikouaiti one morning; they were being fiercely attacked by Tuis (38*q*). Mr. Elsdon Best's Maori informant says, "We do not recognise male and female; we do not know that they pair," and, as before mentioned, he saw five or six one day all flying together (38*r*). Mr. Crawford Anderson says, "I do not think our big Cuckoo pairs, as I have seen two males following one female, and she evidently was quite unconcerned which of them gave her attention" (38*s*).

Numbers of my correspondents say that they have never seen a pair of these Cuckoos together, that it is a solitary bird, and that they entirely discredit the statement that it breeds with us: and I may say that during my own observations of the Cuckoo, extending over a period of twenty-five years, I have never seen more than one at a time. Their courtship is evidently of the briefest duration, as is the case in other parts of the world. One gentleman tells me, "When selecting a mate it is rather interesting to listen to them and to watch their movements. The male bird utters a peculiar whistle which the female answers at a considerable distance off. They gradually approach one another and take up positions about a chain apart, and there for the space of about ten minutes utter peculiar calls which they do not give on any other occasions. The female flutters her wings, and seems to do her best to attract the male bird" (104). Mr. McLean, of Te Tua, says, "One day while sitting under a Bokaka tree I noticed a peculiar fluttering in the tops of the branches, and, looking up, saw what I took to be a new bird. It was a large bird, brown in colour, and every feather seemed standing on end; the tail and wing feathers were all spread out fan-shape, making a complete semicircle. The bird was evidently feeding, and fluttered about from twig to twig, sometimes above the branches, sometimes hanging back-downwards beneath the branches, and never a moment at rest; but whether feeding on leaves, berries, or insects I could not discover. I watched it for some time, and when it flew away, to my surprise, I found it was just a common Cuckoo. It was about New-Year time" (99). This was more than likely a female bird, and it is probable that the male bird was in the immediate neighbourhood.

Further careful observation of the habits of our two Cuckoos is necessary to fully clear up this question, but it seems to me probable that, like Cuckoos elsewhere, they will be found to be similarly polyandrous, and that of those migrants which travel for breeding purposes Cuckoos and Cowbirds have lost the habit of nest-building, and have acquired that of inflicting their eggs on others as an indirect result of the migratory habit. In concluding, I should like to say that I do not claim to have given you much that is new or specially original; with the limited number of works on ornithology at my disposal, it is more than likely that I have missed a good deal that is known on the subject of parasitism; but it has been to me a labour of love and a very great satisfaction to have placed on record all that is at present known of that most interesting bird, the Long-tailed Cuckoo of New Zealand.

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No. 10. STARCH IN THE WOOD OF WHITE-PINE, OR KAHIKATEA (*PODOCARPUS DACRYDIOIDES*).

By Professor H. B. Kirk, M A.

[*Abstract.*]

Starch has long been known to be present in the medullary rays and xylem parenchyma of a number of forest trees. It has not yet, so far as the writer is aware, been recorded as occurring in any New Zealand timber, although it occurs in several—noticeably in the White-pine, or Kahikatea. Kahikatea is widely distributed throughout New Zealand, and is specially abundant on low and damp lands. It yields a white timber, easily worked, and much used for cheap furniture, for the making of tallow-casks, and especially of butter-boxes, and often for building. It is capable, as experiments have shown, of yielding excellent paper-pulp. Used as building-material, it frequently lasts long in dry and exposed places, as when it forms the shingles of a roof or the walls of unlined huts. Indoors it is very susceptible to attack by the larva of a small beetle, which riddles it completely, and destroys its value as material for the construction of permanent articles of furniture. Occasionally it is found that the timber lasts well indoors and in positions in which it usually succumbs to attack; and it has long been known that timber that has been rafted by sea after being sawn may prove highly satisfactory. Microscopic examination of timber frequently shows that the cells of the medullary rays and of the xylem parenchyma contain numerous starch-grains, and they are sometimes found packed with them. The grains vary in size, and present an unusual amount of variation in shape; but they are generally round. The writer has examined an enormous number of specimens of worm-eaten Kahikatea, and has found that in every case starch is present. It seems extremely probable that the timber is attacked by the beetle on account of the abundant store of starch that it contains. There is some conflict of evidence as to the action of salt-water upon starch, but it is not unlikely that the rafted timber that has been found to stand well has been felled just after all the starch has been converted into dextrine for the use of the plant in producing its flowers and fruit, and that then the action of water has sufficed to remove the carbo-hydrate. Experiments are being carried out, and will be continued, with a view to determining at what time the trees should be felled, which will probably be found to be just as the fruit is ripening, and as to what treatment subsequent to felling is most suitable.

No. 11.—ANIMAL RIGHTS.

By C. W. Purnell.

SECTION E.

GEOGRAPHY.

PRESIDENTIAL ADDRESS.

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(Delivered Thursday, 7th January, 1904.)

THE SOUTHERN OCEAN AND ITS CLIMATIC CONTROL OVER AUSTRALASIA.*

TECHNICAL EDUCATION AND GEOGRAPHY.

THE great educational controversy of the nineteenth century was whether the study of literature and philosophy was of higher educational value than reasoning that can be checked by experiment and observation. The result of the battle was the admission of science into the old schools of learning and its predominant influence in all the new, a revolution in the method of primary education, and a remarkable revival in classical research. The victory is so complete and the results in one way so unexpected that even in Oxford compulsory Greek at the first examination—that last relic of the claim, that a smattering of Greek is indispensable to culture—cannot last much longer in the seat of learning, where the newer methods of classical work have rediscovered for us the revenue laws of Ptolemy, and have revealed to us further sayings of Christ.

The old controversy is closed. With the new century the centre of educational conflict is changing, and there are signs of a new strife which has some analogies to that of the last century. With the vast growth of the extent of science, no student can keep in touch with it all. Decade after decade the sciences are being further divided and subdivided, and the minor divisions of a subject to-day have a greater literature than the parent science had a century ago. The educational problem that is now pressing upon us is the selection of the subjects which are of the most educational value. There are branches of science that are travelling on blind roads or in useless isolation. There are some which, so far

* An expansion of this address, with fuller details and illustrations, has been published as "The Climate of Australasia in reference to its Control by the Southern Ocean," Whitcombe and Tombs, 1904.

as we can judge, are at present as purely academic as the classics. On the other hand, there are branches of science in which any progress is at once turned to practical account; while there are industries whose work is hampered because important lines of research have been neglected.

Some of the modern advocacy of technical education is no doubt due to impatience with anything that is not immediately useful. To modify our educational system to satisfy that spirit would be disastrous to education, would cramp scientific progress, and ultimately prove injurious to industry. The best feeling in the advocacy of technical science seems to me due to the recognition of the alternative that scientific teaching must inevitably be restricted in its range, or must become so superficial and elementary in its standard that it will lose much of its value as a medium of education.

The advocates of technical education affirm the principle that, in the selection of branches of science that are to be taught, if two subjects are of equal educational value preference should be given to that which is also of economic value. Educationally, the first test of a subject's value is the scientific exercise it gives the mind, and many teachers believe that the principles of science can in most cases be best taught by the study of those branches which are of most practical service to man. To justify that belief the teaching of the technical subjects must be improved, and, at all costs, that teaching must give a thorough training in rigorous scientific method. Most branches of applied science afford excellent educational material, for their results are tested daily by experiment on a scale vastly larger than pure science could afford. Applied science can be so taught as to give an especially powerful stimulus to the imagination, owing to its victories over space and time, its conversion of waste matter into useful products, and those triumphs over disease which have enabled us to dispel the delusion that there is anything in climate to prevent the successful occupation of any part of the world by white races.

The claims of technical education may be resisted on the grounds that, in education, it is better to concentrate attention solely on the methods of work, and not excite impatience by even glimpses of the goal. But the teachers can be trusted to convince students that the goal will never be reached except by thorough and honest work. And surely any student will work all the more cheerfully if he knows that school and college work is useful directly, by arming him with ammunition for subsequent use, as well as indirectly, as an intellectual treadmill.

The fear that academic science will be neglected if technical science is used for educational work seems to me needless. The revival of classics, since the loss of its educational monopoly, is a valuable lesson. Academic science is even less likely to be neglected; it will always have its attractions for intellectual hermits, and it will always have its appeal to the fancy with its true fairy-tales. As applied science must be dependent on theoretical science, the greater the prosperity of applied science the more urgent will be its demands on pure science for further information, and the more generously will the world be prepared to pay for pure scientific research. The victory of science in the last century has not resulted in the predicted overthrow of culture. Instead of the progress of science having been fatal to the study of classics, it has inspired a period of unrivalled brilliancy in classical research. So far from its having destroyed all respect for past history and led to the neglect of books of authority, it has caused the rewriting of history on improved lines, and has brought the various scriptures into the category of popular literature. So far from being fatal to art, it has supplied the means of a modern Renaissance.

I venture to introduce these general educational principles because they have especial application to geography, the teaching of which has, of all familiar subjects, been the last to benefit by recent progress. What passes as commercial or economic geography is too often a mere catalogue of natural products and climatic conditions. British geography has suffered from its inclusion among the arts subjects, and by being pursued by the method of the humanist studies. Geography must be studied as a science, with methods better adapted to its materials and problems, and with a more exact and adaptable terminology. It must also look below the surface and seek deeper into the nature of things. Here in Australia geography provides the most useful educational material that is available to us. Everywhere around us we are surrounded by the unknown, or what, educationally, is perhaps even better, the imperfectly known. Geography gives us the readiest means of exciting that passion for research which is the life-blood of science, and stimulates that habit of independent inquiry which is the essential aim of education. Geography on the Continent of Australia and New Zealand has made excellent progress owing to its practical value, but the surrounding oceans have been almost entirely neglected. What we know of the oceans, except what can be seen from the surface, we owe almost entirely to England and to Germany. And an appeal that Australasia should herself take up the investigation of the adjacent oceans can be fully justified by economic considerations alone.

THE SOUTHERN OCEAN.

When in September, 1513, Balboa and Francisco Pizarro, "silent from a peak in Darien," first looked on the great ocean that divides the western from the eastern world, from the accident of their position, the part they saw lay to the south of them, so they called it the Mar del Zur—the Sea of the South. That inappropriate name was replaced by Magellan's more attractive title of the Pacific Ocean, which was given eight years later; and though the name of the South Seas was used in the seventeenth and eighteenth centuries, and we still hear of the South Sea islands, it was only in modern times that the name of the Southern Ocean was revived for the unbroken belt of sea that encircles the Southern Hemisphere. The title of the Southern Ocean to independent recognition is not yet universally admitted. According to popular British usage the Southern Ocean is divided between the Pacific, Indian, and Atlantic Oceans by arbitrary meridians, while it is cut short to the south by the Antarctic Ocean. Modifications in this simple scheme are necessary. The Antarctic Ocean must be abandoned, for within its assumed limit there is probably far more land than sea. Instead of the antarctic area being occupied by ocean, it appears to consist of a great land-mass, into which two seas—the Weddell Sea and Ross Sea—project southward from the oceans that lie to the north.

Another important change in the popular British classification is calling the great gathering of waters south of the latitude of 40 deg. S. the Southern Ocean. Recent oceanographic work has supported the claim of the Southern Ocean to recognition as an independent geographical unit, but in a somewhat restricted sense. Its northern limit is generally defined as the 40th parallel of south latitude, but this boundary is artificial and is no longer necessary. The northern boundary of the Southern Ocean is better defined by a line passing from Patagonia along a submarine ridge to Cape Colony; thence, approximately, along the parallel of 36 deg. south latitude to the south-western corner of Australia. The Southern Ocean washes the whole southern shore of Australia, and may fairly be extended to include all the Tasman Sea. It runs down the western shores of New Zealand, and thence continues southward to the antarctic continent, near Cape Adair, where the Atlantic-coast type of Wilkes Land joins the Pacific-coast type of Victoria Land. The whole Pacific is one geographical unit. It is bounded entirely by coasts of the Pacific type. If we limit the Southern Ocean to the great ocean-belt that extends from South America and Graham's Land on the west, past South Africa to New Zealand on the east, it also may be regarded as an independent geographical unit, bounded by coasts of the Atlantic type.

The general idea as to the nature of the Southern Ocean at the close of the work of the "Challenger" expedition is well expressed in Wyld's "Thalassa." It was thought that the South Pacific consisted of one vast depression, occupying the area between the South Pacific island-chain and the northern boundary of the shallower water beside the antarctic lands. The Southern Atlantic was represented as two troughs, separated by a ridge down the central line of the Atlantic. South of the Cape there was thought to be another trough from 2,000 to 3,000 fathoms deep, connecting the deep basin of the eastern Atlantic with the main basin of the Indian Ocean. The platform on the southern border of the Atlantic and Indian Oceans was regarded as an extension of the antarctic plateau, while the deep troughs of the Southern Atlantic and Indian Oceans were the channels by which the cold water, which chills the deeper waters of the great oceans, flows slowly north from the Antarctic.

The work of the last five years has changed most of that. The "Valdivia" found deep water in the Antarctic where it expected to find shallow, and it found shallow water in the Indian Ocean where it expected to find deep. The view that the antarctic continent sloped gradually northward was founded on little direct knowledge. The work of the "Valdivia" alone has shown, according to Dr. Mill, that the mean depth of the Southern Ocean is twice as great as the estimate made by Karsten so late as 1894.

The deeps now proved in the Southern Ocean and the transverse ridges found in the Indian Ocean are of great meteorological importance. The deep basins hold the cold waters, formed by the melting of the antarctic ice. The deep cold water is sucked northward by the movement of the surface waters, and this deep-sea horizontal drift is deflected by the ridges into vertical currents, which reduce the temperature of the surface waters.

The climatic effect of an ocean upon an adjacent continent depends upon its temperature, and the little we know of the sub-surface temperatures of the Southern Ocean shows that they are very complex. The "Valdivia," roughly speaking, found water colder than the freezing point of fresh water extending from the surface to below 60 fathoms; then there was a layer of warmer water 7,000 ft. thick, ranging in temperature from 32 deg. to 35 deg.; and, lastly, the bottom zone, 7,500 ft. thick, with water below 32 deg., but not quite so cold as the surface layer.

The currents of the Southern Ocean are simple, so far as our crude knowledge of them goes. Ocean currents are mainly dependent on the winds, and the winds that blow across the Southern Ocean are arranged with diagrammatic simplicity. Between the latitudes of 40 deg. and 50 deg. is the great belt of the variable westerly winds, which blow uninterruptedly round the world. These winds cause a steady drift of water from west to east along the Southern Ocean and across the South Pacific. Where corners of land project southward into this great drift, they cause the water to be heaped up as against a groin, and this accumulation of water is released by currents flowing outward in various directions. It is naturally the south-western corner of each continent which serves as such a groin. Accordingly, in South Africa, Westralia, and South America, in each case a cold current runs northward along the western shore of the land. These currents, travelling northward, are blown westward by the north-eastern trades, and thus gradually lose their nature as direct currents and become the equatorial drifts, traversing the oceans from east to west. These equatorial drifts impinge against the western shores of these oceans, and the waters are again piled up, and again produce definite currents. The surplus water cannot escape across the equator to the north, but is deflected southward, and flows along the eastern side of the three land-masses as a current flowing southward. Thus, in the South Atlantic, Indian, and South Pacific Oceans the typical circulation is a vast eddy, the water flowing in the direction opposite to the movement of the hands of a watch. On the southern side of the oceanic eddy the water moves as a drift from west to east; on the eastern side the water flows northward as a current along the western coast of the continent; on the northern side the water drifts eastward; and then on the western side of each ocean the water completes the circuit by flowing southward as a current down the eastern coast of the continent that bounds it to the west.

From reference to our limited knowledge of the Southern Ocean we may pass to that vaster subject our ignorance of the Southern Ocean. Our knowledge of the other oceans shows that the sea-floors have geographical forms as varied as those of the land. They have their broad, sinuous valleys; their deep, steep walled canyons; their mountain-chains, composed of numerous mountain-ranges, of which the highest peaks project above the sea-surface as islands. They have their broad plateaux and their widespread open basins, both floored by "the great, grey, level plains of ooze." Oceanographic work, in fact, during the last thirty years has revealed to us a new world, vaster than that discovered by Columbus, with a geography as complex, a geology as interesting, and with an economic importance perhaps as high.

What should we know of Australian geography if we knew no more of its contours than we do of an equal area in the Southern Ocean? What idea should we have of the structure of Australia if, after leaving the coast of Victoria, the first known point was near Sydney, and the next near Brisbane; and if, going north-westward, the only available information was the approximate height of four points between Melbourne and Lake Eyre? Our ignorance of the Southern Ocean is colossal and costly.

OCEANIC CONTROL OVER CLIMATE.

Australia is small and New Zealand insignificant in comparison to the great sheets of water by which they are bounded, and by which they are in every way dominated. All the rain that maintains the flow of our rivers, the life of our forests, and the growth of our food is raised by evaporation from the oceans. That screen of moisture which protects us from the intense heat of the midday sun and from the utter cold of outer space at night is oceanic in its origin. The stability of the composition of the air, the fact that it is always fit for our respiration, is also due to the sea; for the carbonic-acid gas with which New Zealand volcanoes and Australian bush-fires are steadily polluting the atmosphere is removed as fast as it is formed by the all-beneficent sea. Should at any time the growth of plants or the weathering of rocks too greatly reduce the supply of carbon dioxide, the sea will at once breathe forth that gas and restore the equilibrium which is necessary to our existence. The sea, in fact, in addition to its many other functions, automatically regulates the composition of our atmosphere.

The possibility of the human occupation of Australia and all that makes that occupation profitable and pleasant we owe to the surrounding seas, and any variation in their condition inevitably affects our national prosperity and welfare. It is incumbent on us, therefore, to study those oceans more closely than we have done hitherto. To quote Newton's famous illustration, we are like children playing with shells upon the shore of a vast unknown ocean; but at present we neglect the chances offered by the retreat of the waves to pick up finer and rarer shells, and are careless of the advance of the larger waves which may sweep away all our collection.

It is unnecessary to consider in detail the effects of an ocean on the climate of land adjacent to it. They are well known and are explained in elementary text-books. The superiority of insular climates, such as those of England and New Zealand, with their moderate annual range of temperature over those less-favoured lands, where the people in winter buy their milk by the pound and in summer buy their butter by the pint, is usually attributed to the proximity of an ocean. We know, too, that coast-lands generally have a heavier rainfall than districts farther from the sea. In Vic toria, for instance, we notice a steady reduction of the rainfall as we go north from the coast.* We are therefore apt to think that the proximity of water necessarily insures a moist climate. But if we consider the barrenness of the coast-lands along which the Sahara meets the Atlantic, or read Eyre's account of the utter desolation on the shores of the Great Australian Bight, or note the contrast between the heavy rainfall of Central Africa and the coast deserts along Damaraland, or between the torrential rains of the upper Amazon and the almost absolute rainlessness of the desert of Atacama and the guano islets of Peru, we shall realise that the proximity of an ocean is not alone sufficient to endow a land with a generous rainfall. Let us then consider the relations of Australasia to the adjacent oceans.

IRREGULARITIES IN OCEANIC CIRCULATION, AND THEIR RESULTS.

The geographical units of the south temperate and tropical zones are six areas of land and water, arranged alternately in a girdle round the Southern Hemisphere. The units are South America, the South Atlantic, South Africa, the Indian Ocean, Australasia, and the Southern Pacific. In consequence of the different effects produced by the sun's heat on land and water, each of these continents in winter is an area of high atmospheric pressure (it is a high-pressure area or anti-cyclone), and the winds will blow spirally out of it to the adjacent oceans, which then are low-pressure areas. Australia, for example, in winter lies under anti-cyclonic conditions. In summer the conditions are reversed; the lands are cyclonic, and the oceans are anti-cyclonic.

The direction and power of the winds is naturally affected by these seasonal changes in atmospheric conditions. And as the winds cause the ocean currents, they in turn vary with the seasons. If the ocean currents do not flow on fixed and permanent courses, like the rivers on the land, as it was once thought they did, we can understand that they must have a varying effect upon the climate of the adjacent lands. And not only is the oceanic circulation different at different times of the year, but what is still more important is the abundant evidence to prove that the oceanic circulation also varies from year to year. The ocean currents and drifts may occupy different positions at the same time in different years; these irregular movements of the sea, there is every reason to believe, are the main cause of the irregular variations of the seasons.

The powerful effect that may be produced by comparatively slight disturbances of the normal oceanic circulation may be illustrated by the following case: The "Valdivia" found the

* Gregory: "The Geography of Victoria," p. 275.

surface temperature of the sea at a station in latitude 14 deg. S. off Western Australia to be 81 deg. Fahr., at the depth of 654 fathoms the water-temperature was 69 deg., and at 1,640 fathoms it was 48 deg. So the upwelling of water from the depth of 650 fathoms would reduce the surface temperature by 12 deg., and from 1,600 fathoms would reduce the temperature 33 deg. Air at a temperature of 81 deg. can carry one-forty-fifth of its own weight of water. At the temperature of 68 deg. it will carry only one-sixtieth of its weight of water; and the rise of water from 1,600 fathoms to the surface would diminish the amount of moisture which could be carried by the air moving across the Indian Ocean in the latitude of 14 deg. S. to less than half. Such upwellings of the cold water are not improbable. The great pools of green water which appear at intervals in the Southern and Indian Oceans may be due to this uprise of the deep antarctic waters. The slow-moving, deep water impinging against the ridges on the floor will be deflected upward; thus the cold, deep water chills the surface of the ocean and lessens the rainfall on the adjacent lands.

IS THERE A WEATHER-CYCLE?

The Grail of meteorology is the key to the succession of good and bad seasons. The highest aim of meteorology is to determine whether there is any regular succession of wet and dry periods, and, if there be, the discovery of the law that regulates them. Belief in ordered, periodic weather-cycles has existed at least since the time when Joseph made the family fortune by predicting the seven lean and seven fat years in Egypt, and turning it to good account by his system of preferential trade. The search for the secret of Joseph's success has engaged the attention of ambitious men from that day to this. The search has been stimulated by many encouragements on the way. Weather-records often show remarkable periodicity, which has led man after man to think that the key was almost within his grasp.

Four chief weather-cycles have been proposed. The first and most famous is a cycle of eleven years and one-ninth, in which the round of weather-changes is said to be due to the influence of sun-spots. There is no doubt that our weather ultimately depends upon the sun. Rain, for instance, is the result of a process of distillation, by which water is raised from the sea by the sun's heat; the moisture thus produced is carried inland by air-currents, which are driven by the sun's power: the moisture is then chilled till it falls as rain. The process is identically the same as in the distillation of water; the steam which is raised in the furnace is chilled in a condenser. Any decrease in the power of the furnace will cause the distillation to go slower. Lessen evaporation on the Indian Ocean and the rainfall in central Australia is necessarily reduced. That connection is inevitable, and it is obvious.

The sun's surface is sometimes clear, bright, and unspotted, and at other times, as notably during October, it is marked with black spots, due to a great change in the outer envelope of the sun. The development of these sun-spots varies in a cycle, the length of which, on an average, is a little over eleven years. It was therefore natural to look for a corresponding variation in our weather. The connection between sun-spots and rainfall was suggested by Sir Norman Lockyer and Meldrum in 1872. Since that time the suggestion has received much support, and has been discussed in a now voluminous literature; but the influence of an eleven-years cycle on rainfall is not yet widely accepted. Incredulity as to the fact is easily understood. For example, a diagram of the rainfall at Melbourne shows a rise and fall in short waves, which are irregular both in height and length. If we mark the year of the highest rainfall in Melbourne, and put other marks eleven years apart from one another, they do not by any means coincide with the highest points in the rainfall-curve. The diagram shows no particular agreement with an eleven-years cycle. The rainfall over a much wider area is similarly irregular; the amount of water collected by the greatest rain-gauge in Australia—the River Murray—varies greatly in different years, and the variations show no agreement with the eleven-years period.

While Lockyer and Meldrum have advocated an eleven-years cycle in connection with the sun-spots, other men have claimed that the weather varies in cycles of longer periods. Dr. Russell, of Sydney, who has done brilliant work in the organization of Australian meteorological research, advocates a weather-cycle of nineteen years, and Brückner one from thirty-four to thirty-five years. Again, Wolf holds that, in addition to the eleven-years period in sun-spot variation, there is also a long-period variation, fifty-five years in length, which has claims to consideration in reference to weather-cycles. In the face of such divergent opinions as to the length of the supposed cycle, we may well ask, is there any weather-period at all? Ordinary weather statistics do not show any obvious periodicity. For instance, years of heavy rainfall at Melbourne appear to be simply capricious in their recurrence; and Symons, for example, denies that there is any regular oscillation in the British rainfall. Such indisputable irregularities, and the fact that cycles of different lengths are advocated by different authorities, appear at first sight to be convincing proof that there is no weather-cycle at all. The view is accordingly still prevalent that the wind bloweth where it listeth, and many meteorologists still adopt an agnostic attitude in regard to the existence of any regular periodicity controlling the weather of the world.

The fact that inconsistent lengths are assigned to the weather-cycle shows conclusively that there is no simple weather-cycle of precise and unvarying length which affects the whole world in the same way at the same time. But there is no reason to expect any such crude and simple arrangement. To search for such is to chase a will-o'-the-wisp. The weather of our infinitely complex earth is not likely to be controlled by any governor so clumsily mechanical in its action. It does not follow that there is no system at all. If there be a system, we must expect one which is subtle, refined, and complex.

BRUCKNER'S THIRTY FIVE-YEARS CYCLE.

Owing to the complexity of our world and the delicacy of our atmosphere, minor variations are so numerous and apparently capricious that a vast mass of material must be examined in order to secure satisfactory results and to eliminate local irregularities. The most serious attempt to handle this question has been made by Brückner, of Vienna, whose great book, "Klimaschwankungen" the "Variations of Climate" published in 1891, first placed this subject on a satisfactory footing. Brückner was led to his investigation by consideration of the changes that take place in the level of the Caspian Sea. It has been long known that the waters of the Caspian alternately advance and recede. The records go back to the tenth century, and they are complete since early in the eighteenth century. Brückner found that there was a regular cycle in this rise and fall of the Caspian waters, and the average duration of a complete cycle was from thirty-four to thirty-five years. As the Caspian is an inland sea, its level must depend upon the amount of water supplied by rainfall, and upon the rate of its removal by evaporation. The Caspian acts as a great rain gauge for its vast drainage-area. Brückner found that the levels of other inland lakes, which also had no outlets, varied in cycles of the same length, reaching their maximum at about the same dates as the Caspian. Brückner next considered the rainfall of 321 localities, some of which have rainfall-records for over two centuries. Brückner's study of the rainfall showed that the variation of the lakes was a result of the variation in the rainfall.

As rain is a product of distillation, its amount should vary with periods of warm and cold weather. Bruckner therefore inquired whether there was any connection between the temperature-records and these dry and wet periods. He found that from 1736 to 1885 there has been the same thirty-four or thirty-five years cycle of variation in temperature. Severe winters and the freezing-over of European rivers are recorded in history since early times; records are available as far back as the year 800, but they are too incomplete to be of much use before the year 1000; and the records show a temperature-variation of the same length as the rainfall and the lake-levels. The date at which the rivers of northern Russia and Siberia are opened to trade by the melting of the ice in the spring becomes alternately earlier and later, and the length of this oscillation is consistent with the rest. The snouts of the Alpine glaciers advance down their valleys, and then recede, and advance again; and though, owing to the local variation in snowfall, all the glaciers do not act simultaneously, the movement as a whole also shows the same thirty-four to thirty-five years cycle. The beginning of the grape-harvest in France, Southern Germany, and Switzerland is celebrated as one of the great national festivals of the year: the harvest is ripe earlier when the summer is warm and dry than when the season is cold and wet. And the dates of the first day of harvest are known far back into the Middle Ages. These dates show a similar advance and retreat in an oscillation of the same length. The price of grain is a good index to the nature of the seasons; and Brückner claims that the price, looked at broadly, shows the same vicissitudes as the various meteorological factors which control it.

The weather-cycle thus established is not invariable in length, and it does not affect the whole world similarly and simultaneously. The cycle has varied in different centuries from thirty-four to thirty-five or thirty-six years. Moreover, we must remember that the variation of any one of the meteorological elements is the result of the action of a complex of varying and opposing agents. It is inevitable that there will be irregularities, which will be exaggerated in appearance by the artificial divisions of annual weather-records. The calendar year is not altogether satisfactory, meteorologically; from spring to spring or autumn to autumn would give better results than our present system of dividing the southern summer and the northern winter between two years' records. We must be prepared for unexplained inconsistencies in the data; and when we consider the extreme sensitiveness of the atmosphere, the surprising fact is that only 8 per cent. of Brückner's material gave discordant results. The most important of the apparent inconsistencies were due to obvious geographical causes.

THE APPARENT CONTRADICTION OF OCEANIC AND CONTINENTAL WEATHER-RECORDS.

Brückner found early in his investigations that, while the level of the continental lakes, which have no outlets, rose and fell in correspondence with the Caspian, yet many other lakes, though they varied in a cycle of the same length, were at their highest when the Caspian was at its lowest. Brueckner, therefore, described these lakes as being in areas of permanent exception. Such exceptions prove his rule. When the centres of the continents lie under anti-cyclonic conditions, and are passing through dry years, the coastal regions will be undergoing cyclonic conditions and periods of comparatively heavy rainfall. Therefore the Caspian and great inland lakes should be emptiest when the coastal lakes are fullest. And we cannot expect all the rainfall records of a great continent to rise and fall together. The movement will be a great see-saw; the interior and coastal districts will vary inversely.

This important fact is well illustrated by the rainfall returns for Australia. Rainfall curves for the localities in the western plains of New South Wales and in the Mallee of Victoria vary in common. But if we contrast the rainfall curve for one of those localities with that of Sydney it is seen that the conditions are reversed. When the rainfall is heavy at Sydney it is light in the interior. This fact is illustrated for the whole of New South Wales by the rainfall map for the year 1894, prepared by Dr. Russell. The whole of the inland and western district then had a heavier rainfall than usual, while the coast lands had less than their average. The reverse is illustrated by the map for 1899. The rainfall conditions for Sydney and Adelaide, as Russell has pointed out, are also reversed. Years of heavy rainfall at Sydney are years of light rainfall at Adelaide, because Sydney has entirely a coastal rainfall and the Adelaide rainfall is mainly continental. We can now understand the apparent caprice of the Melbourne rainfall. Melbourne is intermediate between the conditions of Sydney and Adelaide. It receives some of the rains of the Australian coast lands, while it shares the inland rains, which are the most powerful at Adelaide. If we could separate the Melbourne rainfall into its two distinct sources, we should probably find that each of them could be represented by regular curves; but when combined the results are capricious and unintelligible. Looked at from this point of view, instead of the rainfall statistics of Adelaide and Sydney being fatal to belief in a periodic system, they are in full agreement with it, and those of Melbourne are not inconsistent. This case illustrates the necessity of considering Australia as composed of separate meteorological provinces, of which, according to Supan, there are four. The weather data must be grouped by these natural provinces, and not by the arbitrary divisions of political States.

THE WEATHER CYCLE AND THE SUN.

There is another essential precaution to be observed in the search for a weather cycle. We must not expect periods, even if they are due to sun-spots or to solar changes, to be absolutely the same length. We cannot expect maximum to follow maximum with the mathematical precision of clockwork. There is no sanctity in the number 11, any more than the number 13 is unhallowed. The statement that the sun-spot period is 11.111, &c., years in length looks very precise; but that period is only an average. Any one solar cycle may differ in length from the mean by as much as two years. Therefore our weather-cycles also will vary from nine to thirteen years. This fact shatters for ever any hope of our getting certain predictions as to the weather of future years from simple averages. Professor Armstrong once had a German chemical student who, considering his nationality, was abnormally lazy but normally systematic, and who used to determine the weights of his precipitates by asking all the students in the laboratory to guess the amount, and then taking the average. That student's method was as reliable in chemical research as the use of blind averages is in meteorology. The statements that you can prove anything by statistics and that there is nothing so misleading as facts is largely true of the weather of Australia.

The existence of these thirty-five-years periods, which Brückner has established with such a convincing array of evidence, is remarkable, because it is in agreement with a long-period variation in the sun, which was quite unsuspected when Brückner wrote his monograph. Brückner was so confident that his thirty-five-years cycle must be caused by changes in the sun that he turned to solar records, confident that he would find in them some variation of which the weather-variation on earth was an echo. At that time it was believed that, in addition to the $11\frac{1}{9}$-years sun-spot variation, there was a longer sun-spot cycle, of which the length was fifty-five years. That was the cycle determined by Wolf. Brückner searched the weather-records for any trace of this fifty-five-years period He found none. So he was driven to the conclusion that sun-spots had no influence upon the weather. Brückner therefore predicted that some other unknown variation of the same period as his own would be discovered in the sun. Brückner's confident prediction has been fulfilled. The main argument against any relation between sun-spots and the weather has been removed. For it is now known that there is a longer-period variation, of which the length has been established by Dr. W. J. S. Lockyer at about thirty-five years.

It may, however, be urged that if this Brückner's period has any real existence it ought to have been discovered long ago, and be as well known as the succession of the seasons. But the meteorological cycle will only be recognised in areas of unusual meteorological simplicity, and where one meteorological factor is of great importance, and under such conditions it was recognised centuries ago. Holland occupies such a position. It is part of the West European meteorological province, and floods are of extreme importance to it. Bacon's essay on the "Vicissitudes of Things" announces the Dutch belief in a thirty-five-years cycle in the following remarkable passage: "There is a toy, which I have heard, and I would not have it given over, but waited upon a little. They say it is observed in the Low Countries (I know not in what part) that every five-and-thirty years the same kind and sute of years and weathers comes about again: as great frosts, great wet, great droughts, warm winters, summers with little heat, and the like; and they call it the 'prime.' It is a thing I do the rather mention, because, computing backwards, I have found some concurrence."

Australia has also contributed to the evidence in favour of the thirty-five-years period. Mr. Charles Egeson, of Sydney, a clear-sighted meteorologist, found by a study of some of the meteorological elements for Sydney, for the month of April, that they varied in a cycle of from thirty-three to thirty-four years. Mr. Egeson's conclusions are of especial interest, as they were published two years before the appearance of Brückner's great work.

THE LOCKYERS' LAW OF FAMINE-RECURRENCE IN INDIA.

The Australian weather-records, however, are not in a suitable form for satisfactory treatment. The meteorology of India, which has had its weather more carefully studied than any other tropical country, affords more instructive lessons. It was naturally to India that meteorologists first turned for traces of the effects of the sun-spot cycle. Some facts were found in agreement with this cycle, and some of them were so striking that even such cautious meteorologists as Blanford could not but be impressed by them. But India, as a whole, gave no clear evidences of an eleven-years cycle, and the few agreements were dismissed as mere coincidences. But during the last three years Sir Norman Lockyer, in conjunction with his son, Dr. W. J. S. Lockyer, has found a clue to the apparent irregularities of the Indian weather. Sir Norman Lockyer, with Dr. Meldrum, first called attention to the possible connection of sun-spots and the rainfall variations in 1872. Sir Norman Lockyer's pursuit of the cycle has been inspired by the most steadfast faith in its existence, and his thirty years' steady work has been rewarded by the most fruitful and suggestive results yet obtained. The Lockyers' explanation of the apparent caprice of the Indian rainfall is based on their study of the spectra of sun-spots since 1876. Their work has enabled them to use sun-spots as chemical thermometers, showing the variation in the temperature of the sun. The Lockyers have studied the spectrum of every sun-spot since 1876 which was sufficiently large for spectroscopic measurement. They find that the sun-spots indicate changes in the heat of the sun, and they are numerous at periods of intense solar activity when the sun is hottest.

After the Lockyers had established this point, their next step was to study the records of the rainfall in Mauritius and India, to see if these variations in the solar temperature had any recognisable effect on the rainfall. They found that when the sun is hottest the south-western monsoon gives India its greatest rainfall. At the same time Mauritius, which is an oceanic island and therefore under different conditions, has a minimum of rainfall. The rainfall of Mauritius is comparatively simple and shows an eleven-years cycle: but the rise and fall is reversed when compared with parts of India. At Mauritius the rainfall-curve is comparatively simple, there being the one maximum and one minimum in the course of the eleven years. The Indian curve for the rainfall from the south-western monsoon is more complex. The conditions that determine a year of high rainfall at Mauritius extend their influence to India, and thus, in addition to its proper maximum of rainfall corresponding to the Mauritius minimum, India has a secondary maximum at the same time as the Mauritius maximum. India has two maxima during the course of the one sun-spot cycle. It is not surprising, therefore, that if we lump the whole Indian rainfall together we fail to find any simple agreement with the eleven-years period. The Indian rainfall, having two maxima during the course of the one sun-spot period, has also two minima, which occur one on either side of that secondary maximum, which corresponds to the minimum of Mauritius. The Indian famines naturally occur after the minimum of rainfall; they therefore do not come at eleven-years intervals, and thus have hitherto appeared independent of sun-spot influence. But the Lockyers point out that all the Indian famines have occurred at the time of the minimum rain beside the secondary maximum. This discovery promises to be of high importance to India. The agreement between Lockyers' results and the distribution of famine in India is so remarkable that Sir John Eliot, the Meteorological Reporter to the Indian Government, says that all the famines of the past half-century could have been predicted by the Lockyers' law, and that it will be of great service in the future administration of India.

Australia is more directly concerned with another important point revealed by Lockyers' comparison of the rainfalls of India and Mauritius. Sometimes important meteorological events in India occur in the same year as in Mauritius; at other times they occur at intervals a year apart. Thus the heavy rainfall, which occurs when the sun is hottest, occurs simultaneously in India and Mauritius; but that maximum of rain, which occurs at the minimum of the solar intensity, affects Mauritius a year earlier than it affects India. This fact the Lockyers explain by the probable assumption that the maximum of solar temperature affects the continental areas of Africa and Asia directly, and thus India, Batavia, and the Cape are influenced together. But the secondary maximum produced at the period of solar cold affects these countries indirectly through changes which take place in the Southern Ocean. Such changes do not affect Mauritius in the same year as they influence India.

That great periodic changes do take place in the Southern Ocean is shown by the distribution of the antarctic ice. In some years the icebergs drift into comparatively low latitudes, and are a serious danger to shipping. In 1892 one group of bergs floated along the eastern coast of New Zealand almost as far as Cook Strait. Two years later one berg in the South Atlantic in April, 1894 actually got within sight of the tropics (it was seen in lat. 26 deg. 30 min. S.); in other years the detached ice is kept far to the south.

These antarctic icebergs migrate northward periodically. One well known ice irruption occurred about 1850 to 1855, and another from 1892 to 1895. Icebergs this year, again, appear to be unusually far to the north and to the east. And the cold weather of the past few months was probably caused by the proximity of this ice. The northward voyage of these icebergs must reduce the temperature of the sea through which they float and chill the winds which pass them. But they are themselves, perhaps, more important than their effects. They are symptomatic of less conspicuous but more powerful agencies. The long life of these icebergs may indicate the absence of the warmer sub-surface waters, in which under ordinary conditions they would soon melt away. I have not been able to recognise any direct effect on Australian weather-records of these ice-drifts; but probably the extremely cold, changeable weather of the past two months is a consequence of the proximity of these ice-fields. And Mr. W. M. Hales kindly tells me that it is a matter of experience in southern New Zealand "that in years when abundant antarctic icebergs are reported by ships between New Zealand and the Cape the spring season in New Zealand is invariably cold and showery, and the succeeding summer and winter has abundant rains."

I have recently called attention to the striking case, knowledge of which we owe largely to the work of H. N. Dickson, in which an unusual condition of weather in north-western Europe was due to an unusual position of the North Atlantic anti-cyclone eighteen months before. The Indian Meteorological Reporter, Sir John Eliot, has pointed out the direct connection of the Southern Ocean with the climate of India: so it is hardly open to doubt that Australian weather will be found to have a still closer relation to the changes in the Southern Seas.

CONCLUSION.

We have thus seen how changes in the Southern Ocean may affect the Australian climate; that it is clearly recognised that movements in the Southern Ocean determine some of the most important events in the Indian weather; and that it is claimed that the earlier discovery of the Lockyers' law would have enabled all the Indian famines of the last century to have been accurately foretold.

Meteorology in Australia is far behind that of India, and will require to make up much ground before Australia is in the same position of vantage as India. The continent which gave meteorology that powerful agent of research—the Hargreaves kite—is the only continent which has not employed it for meteorological work. Professor Schuster, in a recent address to the British Association, deplored the conservatism of meteorological work. He declared that meteorologists were enslaved to continuity; that the brilliant progress in the science during the past few years has been achieved not by meteorologists at their observatories, but, in spite of them, by experimental work along fresh lines. If Schuster could make such complaints in Europe, one wonders in what terms he would express his opinions on the condition of meteorology in some other countries. Australian meteorologists have done wonderfully well with the means at their disposal; but Federal Australia wants a united meteorological service, which will adopt the same methods of observation and the same system of publication for the whole of Australia and for New Zealand, and which will be so organized that the data collected will be fully and promptly used. There should be a united meteorological service, working on a uniform plan and publishing uniform records; and that service should have a sufficient staff and sufficient money to undertake experiments outside the ordinary routine of observatory-work. Such a service, to be efficient, must be as elastic and free from red-tape rules as a Government Department can be. Its officers must carry on their work animated by a love of scientific research, and not in a spirit of business routine.

The benefits such a meteorological service might confer on Australasia are incalculable. Proposals have been made to introduce into central Australia a sheet of salt-water, which, though large enough to be somewhat costly, would be small in comparison with the vast waterless plains it was proposed to benefit; but in the summer, when rain would do the most good, the country is often already covered with a vast sea of water. Day after day in the summer of 1901 - 2 the districts around Lake Eyre lay under a heavy pall of morose grey cloud. The fall of one tithe of that sea of moisture would have broken the long spell of drought which had laid that country waste. The clouds at times descended, as if endeavouring to reach the earth; but the ground was too warm, and they were repelled again to the sky. More than once we had a few drops of rain, which showed that the clouds were so near the precipitating-point that the slightest impulse would have upset the balance and brought down heavy rain. How high those clouds were above us, how thick they were, how much their temperature was above the precipitating-point, we could not tell. No one knows. As I watched those clouds drifting steadily overhead I used to long for a meteorological kite to sound that great sea of wasted moisture; and I dreamt of the time when kites would spray those clouds with liquid air and discharge their now wasted contents on to the wasted plains below.

Few investments offer Australia a higher return than meteorological research, but to be successful that research must be conducted patiently and on well-considered lines; it must sound the ocean of air above us, and must watch, by the collection of water-samples, the fundamental changes in the circulation of the seas around our shores.

There is no chance of our determining the future weather without trouble or expense. The solar changes which act upon our weather act indirectly by variations in the temperature and the currents of the surrounding seas. The variations in solar radiation are probably insufficient to cause any appreciable direct change in the temperature of the surface waters. The changes in the sun act on the far more sensitive atmosphere, and the winds disturb the oceanic circulation, change the surface temperature of a wide expanse of ocean, and thus affect the temperature and rainfall of the adjacent lands. It is this fact which, while it renders the problem of long-distance weather-predictions complex, offers the best hope of its solution. If Australasia adopts this love of research as India has done, we can hope to share the benefits of the seasonal weather-forecasts which the Indian meteorological service has been issuing with brilliant success.

If the changes that take place in the sun affected our weather at once, we should always be liable to disturbances that are extra-terrestrial in origin, and which at present we cannot foretell. But the main effect of solar variations upon our weather is an indirect effect, and works by a series of changes which may take years to run their course. Man may never be able to modify abnormal weather seasons, but he can watch their formation and be forewarned of their approach. Perhaps nothing would add more to the commercial prosperity of Australia than knowledge, a year or so ahead, of the seasons that are coming. They are already determined, and they are advancing upon us silently and resistlessly as fate. Some men distrust the possibility of weather-predictions for any long distance ahead, but I have more faith in the future progress of science. We can see a little ahead already; we cannot see farther because of our ignorance, and more knowledge would widen our range of vision.

In the Southern Ocean our conditions are much simpler than they are in the North Atlantic, so that we may expect greater certainty in weather-predictions. I see nothing to prevent future Australian meteorologists foretelling correctly, a year ahead, the general nature of the approaching seasons. But such a power will never come to us until we have done our part, and studied the hydrography of the Southern Ocean with the same methods which have yielded such profitable results in the North Atlantic and to India.

In meteorology each continent must work out its own salvation. Europe and America may help us with methods, but we must apply them ourselves to our own waters before we can share in the rewards. Patiently and excellently meteorologists all over Australia are recording the daily changes of our weather: but far out in the great Southern Ocean the fundamental processes that are determining the rainfall a year or two years ahead are passing unnoticed and unknown. Australia has spent vast sums in irrigation-works that have failed through lack of water, and provides for the records of present weather; but for the sake of a few hundred pounds a year we are leaving unstudied the causes that produce and control it. What gift would be of more benefit to the vast agricultural interests of Australia than a warning as to whether the country next year will be paralysed by drought or washed by a deluge? The apparent fickleness and severity of our climatic changes introduce as large an element of gambling into our farming as there is in many of reckless mining ventures. The dragon of uncertainty that now preys on our agriculturists could be defeated by foreknowledge of approaching seasons of fair weather and of foul. That knowledge is available if we but seek it; for though science holds out no hope of any quack formula that will tell us the future weather without trouble and expense, ultimate success is promised us if we work so as to deserve it. Like the seer of old, modern science assures us, cast thy bread upon the waters, for thou shalt find it after many days, if those days be spent in earnest and patient search.

No. 1.—A PHYSIOGRAPHICAL ACCOUNT OF "THE GREAT LAKE," TASMANIA.

By Colonel W. V. Legge, late R.A.; F.Z.S., late F.L.S.; &c.

The central portion of Tasmania consists of a plateau, remarkable for its large size compared with the proportionately small area of the island, and famed for the large number of lakes of all sizes which diversify the rugged country characteristic of the uplands. In the south of the island the plateau rises gradually from the Derwent Valley until an altitude of about 2,000 ft. is reached. The same gradual rise takes place on the eastern side as far north as Oatlands, this part of the country being well known to all travellers by the Main Line from Hobart to Launceston. On the western side groups of rugged mountains, commencing at Wyld's Craig and King William Ranges, and running thence north, bound the table-land. Some of the highest mountains in Tasmania, such as Eldon Peak and Cradle Mountain, are included in this system, which forms our largest watershed, and supplies the Gordon and Pieman with their respective tributaries, as well as the Arthur, Forth, and Mersey. It is, however, on the north-east side where the plateau is chiefly in evidence; here it suddenly terminates in a gigantic wall looking down on the pastoral lands of the Midlands and known as the Great Western Mountains. The lofty buttresses of greenstone which project from this fine range form some of the grandest mountain scenery in Tasmania; but they are so familiar to all who live in and travel through the Midlands that they almost stand unnoticed except by tourists and lovers of nature.

It is directly at the back of these mountains, as seen from the Main Line Railway, that the lake-system lies. So soon as their ascent is accomplished, either from Tunbridge or Deloraine, the plateau is entered upon and the lakes are seen. In the south-east the series commences with Lake Sorell, one of the tourists' resorts, and from here the table-land rises gradually as it stretches north, intersected in all directions by low and rocky ranges until the Great Lake is reached, to the north-west of which the country is dotted with innumerable lakes and tarns.

In spite of their proximity to the north-eastern edge of the plateau—the Great Lake being but four miles in a direct line from the summit of the Great Western Mountains—nearly all these lakes drain to the south by the Rivers Clyde, Shannon, Ouse, and Dee, which are all tributaries of the Derwent; and included in the same system is the queen of our lakes as

GREAT LAKE
TASMANIA.
TO ILLUSTRATE SOUNDINGS TAKEN BY
MESSRS. H. KINGSMILL M.A., AND COL. LEGGE, R.A.,
MARCH, 1903.
0 440 880 1320 1760 2200 2640 YARDS
REFERENCES
Sh. indicates Shingle.
r Rock
Blue mud
Yellow mud
These streams have not been examined.
Times of soundings as taken consecutively.
LITTLE LAKE
Police Station
MYRTLE I.
GARDEN I.
Breton's Rivt
NORTH LAKE
PINE I.
EAST BAY
REYNOLDS' NECK
MIDDLE REACH
LAKE ELIZABETH
HOWELL'S PT
Outflow only in flood time
LITTLE NECK
The Point
SOUTH LAKE
KANGAROO I.
BEEHIVE PENINSULA
GREAT BEEHIVES
BECKET'S BAY
SWAN BAY
River Shannon
SHANNON LAGOON
CENTRAL PLAINS — TREELESS
BUT CLOTHED WITH ALPINE VEGETATION

regards scenery—Lake St. Clair—which discharges by the main stream of the Derwent. The exceptions to this rule are two lakes of considerable size—Lake Woods and Arthur's Lake—which lie in a depression at the head of the longest valley which penetrates the Great Western Mountains, and which discharge by the Lake River into the South Esk and so into Bass Strait.

The Great Lake is by far the largest sheet of water in Tasmania, and is likewise the largest fresh-water lake, for its elevation, in Australia. Its great height above the sea, when taken in conjunction with the small size of the island, its remarkable shape, and the extraordinary levelness of its bottom, combine to make it the chief geographical feature of Tasmania, and as such it has been chosen for the subject of this paper.

With a view to obtaining information of a reliable nature on the climate, with the rainfall and winter temperatures, a meteorological observing-station was established in June, 1902, by the Government Meteorologist of Tasmania, Mr. H. C. Kingsmill, and the writer. An intelligent observer, police trooper Archer, stationed at the north and wet-climate end of the lake, was found willing to take charge of the rain-gauge and self-registering thermometer, and observations were commenced by him on the first of the month in question, being continued without a break for the past sixteen months. It may be mentioned here that until now no accurate data had been procured as to the climate of this remote region. The only people living in the vicinity of the lake are the shepherds of the pastoralists in the low country—chiefly the Midlands—who own summer sheep-runs round the lake-shores, and who seldom visit the lake country in the winter. Vague ideas have consequently obtained in reference to the amount of snow and ice prevalent during rigorous winters, and very little at all was known about the climate in the mountainous district at the north end until the establishment of the aforesaid observing-station at that part.

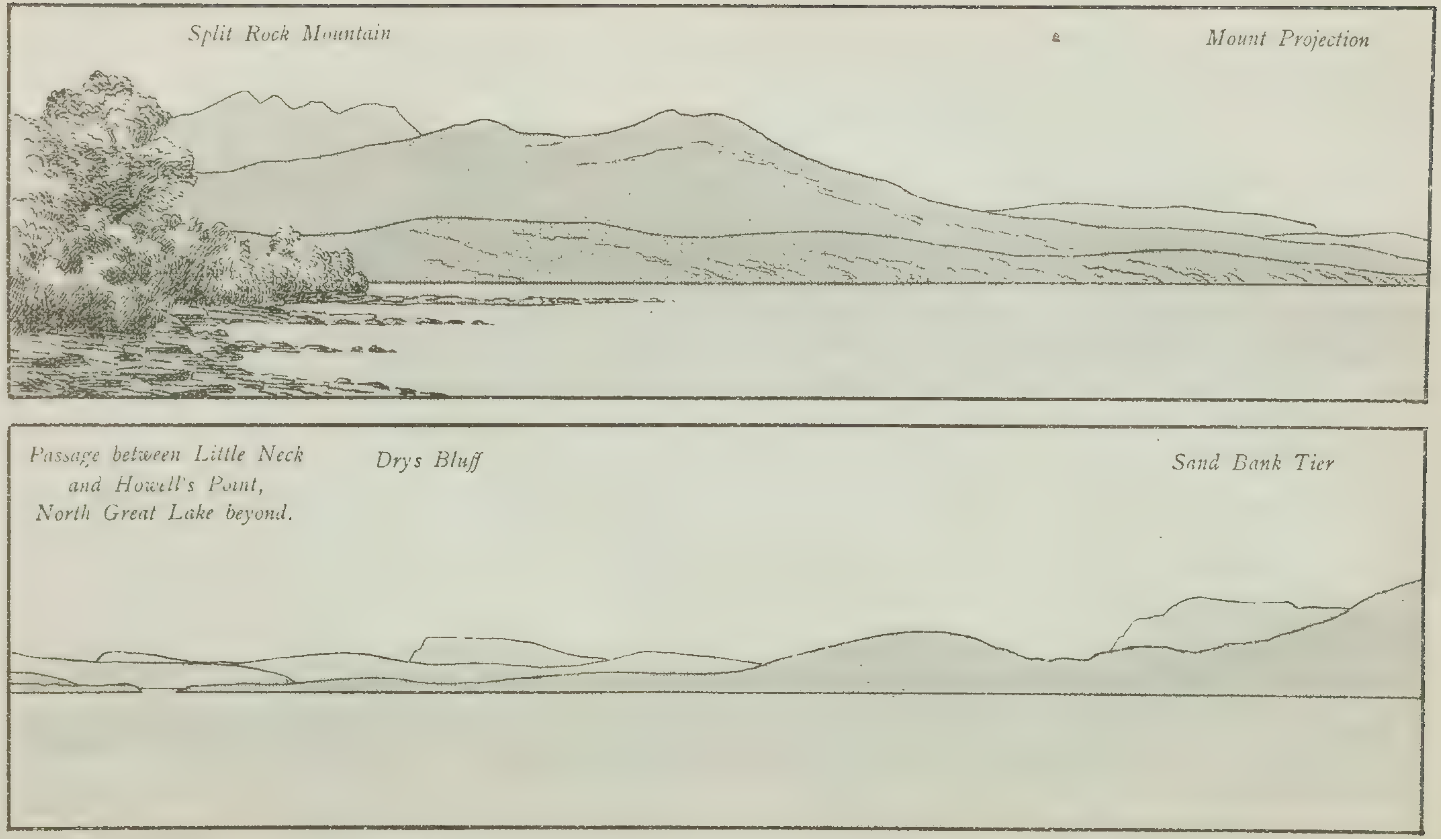
In March last year Mr. Kingsmill and the writer proceeded to the lake, and spent a fortnight in sounding it, gauging the principal streams and creeks in the north from whence comes the water-supply, examining the rock-terraced shores, collecting botanical specimens, and exploring as much country in the vicinity of the lake as the time would permit of. The ascent was made from Deloraine, a picturesque township on the Meander River at the foot of the Great Western Mountains. From here a fair track, made by the Improvement Association of the township, leads from a settlement at the foot of the ranges, called Golden Valley, up a fine gorge in the vicinity, and, passing behind a prominent mountain—

Quamby Bluff lands the traveller on the top of the divide at the nineteenth mile from Deloraine. At a distance of four miles farther the track, leading past a picturesque sheet of water -Pine Lake brings him to the "Saddle" of the rocky tier at the head of the Great Lake, and from which the magnificent expanse of its water bursts suddenly on his view. The remarkable shape of the lake, demonstrated by the chart shown, and which is caused by the curious peninsulas which project east and west from its shores, lessens the view of the larger portion at the south end, as the saddle, or hollow, in question is only 375 ft. above the water; at the same time the irregular outline adds much to the appearance of the prospect from a scenic point of view.

As there has always been some doubt as to the correct altitude of the lake above sea-level, care was taken to ascertain as accurately as possible the height by aneroid. The known height of the rails at the station at Deloraine was taken as the datum point, and two barometers were used, one of which was kept at the station under lock and key and read at 7 p.m. on the day of the ascent as a check for weather-variation. The result was 3,332 ft. This figure, though more correct, it is thought, than the altitudes formerly taken at the south end the journey to which from Hobart occupies two days should not perhaps be taken as final, there being a fall on the day in question of 0.40 in. in the glass as shown by the check-barometer at Deloraine. Still, there is no doubt that it is nearer the mark than 3,500 ft. and 3,700 ft., which have been given as the results of former observations, for the barometer used is graduated so finely that a height of 3 ft. can easily be read upon it.

The length of the lake from the entrance to Swan Bay to its extreme north-west corner is about fifteen miles, and its greatest width, from the latter point to the south-east end of East Bay, is nearly eight miles. So extraordinary, however, are the sinuations of its shore-line that this is reported to be between eighty and ninety miles in length. The peninsulas, which contribute so markedly to indentations of the shore, are locally called "necks." There are three on the west side and two on the east. The largest of the former, Reynold's Neck, contains about 2,000 acres, and is thickly wooded, with open glades, tolerably flat, and is one of the few sheep-runs in the district on which sheep can be kept, in spite of the snow, in winter.

The lake is constantly swept by strong north-west winds, and in winter by heavy "south-westers," and these peninsulas, across the line of wave-direction, apparently assist in raising or damming up the water at the opposite end of the lake, the narrow channel at Little Neck being evidently the



Panorama of Mountains North of Great Lake, taken from Beehives.

chief factor of resistance. After a gale of twelve or eighteen hours' duration the lake-level is said to be raised at the leeward end by nearly a foot, and correspondingly lowered at the other. This phenomenon can be better realised when we consider that it takes an inflow at the north end of about 600,000,000 gallons to raise the 28,000 acres of water by 1 in. only. The circumstances which combine to assist the wind-effect on the lake-level are the extreme shallowness of the water in proportion to its great extent and the almost dead level of the bottom. A slight breeze suddenly springing up covers the surface of any of the three large divisions of the lake with wavelets in about ten minutes, and should the wind increase to even a strong breeze, in half an hour there is a short and very unpleasant sea on; and as the prevailing winds are up and down the lake, the wave-action on the shallow water must necessarily have a considerable effect in raising and lowering its surface.

The country round the lake is diversified in character. At the south end a series of low rocky hills cross from east to west, and, with the depressions between them, complete the lake-basin in that direction. Running towards the north on the east side for half-way up the lake are higher wooded hills, while opposite them a low treeless tract stretches westward to the valley of the Ouse.

Northward of Little Neck and Howell's Point the scenery alters very materially and becomes strikingly picturesque. Rocky ranges of considerable altitude, covered along their crests with vast masses of greenstone talus, are present on both shores, and continue on the western side to the extreme north as far as the valley of the Pine Rivulet. The outline of this range, locally called "Stony Tier," is bold and rugged, the highest point reaching an elevation of probably 1,200 ft. above the water.* At the head of the lake, just above the Little Lake, a picturesque hill with fluted greenstone precipices completes the amphitheatre of the highland. At the foot of the ranges round the head of the lake the land slopes to the water's edge in park-like glades, which are covered with the usual alpine herbage characteristic of the highlands of Tasmania.

Among the most interesting species of plants are the Native Artichoke (*Astelia alpina*), which often affords, with its stiff tussocky growth, a convenient foothold when one is crossing these moorland wastes, thoroughly oozy and sodden as they are after heavy rain.

More curious still is the handsomely coloured and rigid lichen-like growth *Abrotanella fosterioides* (Pudding Moss),

* Unfortunately, no opportunity was afforded for the ascent of this mountain in order to ascertain the correct altitude.

which grows in all moist places, and looks as if it had been poured out of some gigantic vessel and spread on the ground in green and grey masses, moulded into fantastic circular shapes, some of which are absolutely hemispherical and so hard that the traveller's horse makes but little impression on the surface. In summer the emerald cushions of this curious growth are dotted with small scarlet berries, which give them a very pretty appearance.

Although on suitable ground there is a considerable growth of the common Cattle or Thatch Grass (*Poa cæspitosa*), other fodder-grasses are for the most part absent, the ground being mostly clothed with *Epacris* and similarly erect, straight-stemmed plants, such as *Pultenæa rubumbellata, Bæchia gunniana*, &c. Scattered about among these low growths are examples of the curious genus *Richea*, with its stiff, sharp foliage and singular-looking flowers; also the Yellow Bush (*Orites revoluta*), and other shrubs, which will be dealt with further on when speaking of the botany of the islands.

The character of the ground along the banks of the lake alters from Howell's Point southward, where the moorlands and the vegetation alluded to above are replaced by drier and slightly rising ground, clothed with more grass and less of the strong plant-forms of the northern part. Here the climate, which is much drier, alters the character of the plant-life, and on the western side the soil, which is reddish and of a dry nature, induces a different growth, furnishing on the large "Central Plain" fair pasture for sheep.

We turn now to the principal characteristics of the lake itself, the chief feature of which is its extraordinary shallowness, coupled with the remarkably level character of the bottom. The northern portion, generally called North Lake, is formed of two large bays, or bights, and a wide reach extending down to the narrow strait at Little Neck.

The greater part of the shore-line round this expanse is composed of a low terrace of greenstone rock and stones, alternating in places with flat stony reaches in which the material has a horizontal position. The stones forming these latter tracts are usually flat pieces of greenstone of small size, which have been laid or imbedded horizontally by ice-pressure; and the greenstone terraces, against which the water beats, are piled in long, even sweeps rising from 3 ft. to 5 ft. above the surface, and composed of rocks containing from 1 to 12 or 15 cubic feet. The face of these long rock barriers inclines to the water at an angle of 35 deg. in most places, the inclination, especially in one or two of the islands, being so uniform that in the distance the material has the appearance of being artificially built, and testifying unmis-

Pinnacle of Greenstone at Point of Little Neck.
Matrix of Shore-line Rocks.

Ideal Section of South End of Kangaroo Island above Water.

Ideal Section of Helen's Isle, South Shore.

takably to the long-continued influence of wind and ice-pressure. In only one place in this part of the lake, the north side of Reynold's Neck, is the shore at all raised, and here low cliff-banks of 10 ft. in altitude are present in places, the material being a decomposed reddish rock, or "cement," containing ferruginous-looking pebbles, of which the beach also at the foot of these banks is composed.

It must be mentioned that wherever the rock terraces, alluded to above, exist there is always a matrix of greenstone adjacent to the shore either in the form of rocky "tors" or strewn boulders in the forest. This is especially noticeable at the point of Little Neck, where there is a remarkable pinnacle of about 35 ft. in height, rising from the ground adjacent to the shore. The column or formation in this is almost perpendicular—that is, between 75 deg. and 80 deg. - and the rock is in flat slabs, varying from 9 in. to 2 ft. or more in thickness. The "tor" has been broken through in the middle, leaving a wide gap, the huge fragments from which are strewn around the base; and, further, the ground stretching across the point is paved at intervals with horizontal slabs of large size worn quite smooth. The shore-line for about three-quarters of a mile on each side of the point is formed of more or less ponderous slabs of greenstone, lying at angles of about 20 deg. with the horizon as shown in the photograph, and as they are of such large size they lie in more irregular positions than in other parts of the lake, where the material is smaller and would have been more easily heaped into regular lines by ice-pressure.

Around the South Lake the littoral belt alters in character, and there is consequently a corresponding change in the shore-line, although this is much diversified. In the vicinity of Little Neck and Howell's Point flat pebble beaches alternate with the same low cliffs of disintegrated rock as at Reynolds's Neck. At Hakea Point, south of Little Neck, where the land gradually rises to form the extensive downs which stretch westward to the Ouse, the ground is strewn with ferruginous pebbles, nodules, and stones of greater size lying on a deep red soil, and the adjacent beach-line is composed of smaller stones of the same class, which Mr. R. M. Johnston characterizes as small agglomerated masses and concretionary nodules "arising from the decomposition of felspathic basalt." These are of all shapes and sizes, as can be seen from the specimens exhibited, the material in some being run together in a molten state, while others appear to contain iron in their composition. South of this point the shore consists of long reaches and intervening bays, until the remarkable Beehive Peninsula is reached, which divides the main body of the water from the inlet known as Swan Bay.

Along the coast of this peninsula are groups of basaltic cliffs at intervals, the land at the back of them for some miles being thickly strewn with basalt stones, which make it difficult to traverse with any degree of comfort. The cliffs are of uniform height, from 25 ft. to 30 ft. above water-level, the land at the top being at first flat and then gently sloping down to a table-land which stretches westward to the Ouse Plains. Each group consists of about half a dozen perpendicular masses of basalt of the small-columnar type, each mass projecting outwards so as to form a corrugated or wavy line which, when viewed from the water, resembles a number of gigantic bee-hives. The entire cliff is composed of small disjointed columns, which are inclined at an angle of 70 deg. with the horizon and dip to the west, so that their fractured ends form a perpendicular face. Individually, the columns are chiefly hexagons, each little group appearing to contain one or two irregular pentagons, which are apparently adapted for the proper fitting-together of the hexagon group.

The next cliff further north is styled the Little Beehives, and between the two an interesting formation occurs, inasmuch as there is a total change there to a greenstone cliff about the same elevation above the water, with the columnar structure at an altogether different angle, dipping about 75 deg. to the south.* At the northern extremity of this latter cliff the declivity gradually disappears, the material having been precipitated as a mass of talus to the shore and forms a gentle slope to the water's edge. Here its margin has been piled into a regular parapet about 3 ft. high, which passes round the next point in the form of a low detached wall, superimposed on the basaltic talus fallen from the cliff above. The formation of the parapet of greenstone at the foot of the basalt cliff and some distance from its matrix is certainly most remarkable, and seems to indicate the constant action of ice-floes under very heavy pressure of the elements across the wide stretch of water existent at this part of the lake. The longest distance, however, is in a north-easterly direction, from which quarter but few heavy winds are experienced at the present day, and this makes the formation of the terraces the more singular.

On the opposite side of the lake is another example of the usual east-and-west peninsulas, called McClanaghan's Neck, where again the formation is greenstone, which crops out on the shore, dipping westward at an angle of 60 deg., and standing out on the land here and there as a dyke in the shape of isolated tors. The foreshore is composed of talus, as shown in the photograph, which is tossed about in horizontal form

* The basaltic formation constituting the Beehives has intruded through this greenstone, as is often the case.

Basaltic Cliffs, Great Beehives, looking South.

Basaltic Cliffs, Little Beehives, showing altered Angle, also the Greenstone Terrace at Foot.

and shows signs of ice erosion, this spot being one of the most exposed on the whole lake to the north-western gales.

The islands of the lake are mainly interesting on account of their shore-lines and general geological formation. There are five in all, four of which are in the northern division, where the largest—Pine Island—is situated. At the north end the two smallest—Garden and Myrtle Islands—which are uncharted, lie close to the shore, and have been perhaps formerly connected with it, though at a remote period. The south-western end of Garden Island consists of a low hill of greenstone, disintegrated at the shore into large blocks and boulders, lying mostly at a small inclination to the water. The remainder of the island is flat, the land terminating everywhere at the shore in a fringe of boulders. Myrtle Island is not much more than a low stretch of greenstone boulders, arranged around a solid mass of the same at the west end. On the south shore, again, there is evidence of the effect of wind and ice-pressure in the manner in which the large blocks of stone are pressed into a slope against the solid background. There is but little soil on this islet, yet it is thickly covered with vegetation, the characteristic bush being the *Richea*, which prior to the island having been fired must have covered most of it. To the south-east, in the opening between North Lake and East Bay, is situated Pine Island, which consists of an elevated central tract of greenstone, evidenced principally by a semicircular series of tors, the central and highest of which attains an altitude of 45 ft. above water-level. The remainder of the surface is composed of talus from this matrix, covered with soil, on which flourishes the usual alpine flora, which will be hereafter alluded to. At the water-line this talus is heaped into one of the most plainly marked and interesting ramparts anywhere around the lake. It encircles the island completely, except at a small cove facing the east. Its height is from 4 ft. to 7 ft. above summer level, and the water face is evenly arranged, the boulders varying from a ton down to a hundredweight or less, piled up at an angle of about 35 deg. The eastern coast of the lake opposite the island has a similar shore terrace extending a considerable distance to the north. The water close to the shore is not deeper than 3 ft. or 4 ft. all round the island, the bottom beyond the foot of the terrace being composed of greenstone shingle, resting probably on a bed of the same. On the south side the rocks show principally the traces of ice-action. This island was formerly covered with King William Pine (*Arthrotaxis cupressoides*) and Cider Gum (*Eucalyptus gunni*); but these beautiful trees have been utterly swept out of existence by the stupid and reprehensible practice of "firing" the bush, which, unfortunately, prevails here as elsewhere. The only shrubs which fringe the coast-line here and there are a few Pepper-trees (*Drimys aromatica*) and *Pittosporum* (*P. bicolor*).

Continuing down the lake the traveller comes to the picturesque Helen's Isle, which lies near the south shore of Reynold's Neck, and is interesting on account of its miniature mount of greenstone in the centre, from which a beautiful view down to the south of the lake is obtained. The island is about 15 acres in extent, and above the centre rises a "hog-back" or mount of greenstone to a height of 115 ft. above the water. The precipitous side faces south-south-west, and the top consists of a plateau 80 yards long, on which stand one or two Cider Gums and Hakea bushes, and among the vegetation were noticed Wild Geraniums, and Everlastings (*Helichrysum*), three varieties of which grow on the isle. On the south shore there is an irregular terrace of greenstone above water-level, from which the foreshore slopes down to the water at an angle of from 3 deg. to 5 deg., and discloses the pentagonal tops of columnar basaltic rocks, this formation having intruded through the greenstone. These are of much larger section than those at the Beehives, the columns having, moreover, a perpendicular position. The formation in the mount itself, though columnar, is oblong in horizontal section and almost perpendicular, dipping but slightly to the south-west. No pentagonal structure was detected in its cliffs, which seems to indicate that originally the two intrusive masses basalt and greenstone—rested against one another, and that subsequently the latter became in course of time denuded to the water's level. The geological structure of the isle and the luxuriance of the vegetation, considering its altitude, make it perhaps the most interesting of the lake islands.

In the South Lake, Kangaroo Island is the only one existent. It lies in the eastern portion, two-thirds of the way down and about one mile from the shore, and being exposed to the north-westerly and south-westerly gales is seldom visited. It consists of two hills or eminences rising to 50 ft. above the water, and connected by a low "saddle," with a small cove on the east side, which furnishes usually a sheltered landing. The southern hill terminates in a bold cliff of greenstone, dipping slightly to the south, and standing back about 40 yards from the shore, between which and its foot is a flat tract of talus consisting of large boulders and terminating in the usual bulwark of rocks at the water's edge. There is, perhaps, no spot in this interesting geological region where such striking evidence exists of the tremendous forces of nature as exemplified in the levelling-down through the long ages of the Quaternary era of this cliff on Kangaroo Island. It is as if some Titan hand had torn the columns successively from the face of the escarpment and hurled them to the ground.

The bleak and lonely appearance of this wind-swept isle is accentuated by the fallen and bleached trunks of the beautiful pines which once clothed it before being ruthlessly destroyed by fire. Among the few alpine shrubs and bushes that were noticed was the handsome *Golferia*, or Native Currant, which nestled in the cliffs and rocks of greenstone.

The breaking-down and wearing-away of the greenstone formations on the islands of the Great Lake, pointing as it does to the fact of the denudation having taken place below the surface of the water, brings one to the consideration of the lake-level of the present day. This is considerably lower now than it was originally. At the north end of the lake, opposite Garden Island, this fact is evidenced by the well-defined ancient shore-line, which follows the present one in the form of a raised bank at a short distance from it. On Helen's Isle there is another example of the same, and the rock parapets round Pine Island, Garden Island, along the eastern shores, and more particularly at the Beehive Peninsula, all give evidence of having been formed, or piled up, when they were at a lower level than now, and in which position the talus, from which they were formed, would have been more easily moved by the force of ice-floes and waves. We must further assume that the climate in the past* was colder than it is now, and that the lifting and driving power of the ice was therefore greater than in the present day.

Allusion has been already made to the traces of ice erosion visible on the greenstone rocks on the lake shores and islands. This was very interesting, and was the point which most absorbed our attention wherever we landed. The traces of ice erosion, particularly on the island-shores and at Little Neck, take the form of a smooth band or edging where the reticulations on the surface have been worn away by friction all round the margin of the boulders. This is more plainly visible where the boulders are in a horizontal position or inclined, as they often are where they are flat, at a small angle to the water. The shores of the islands were carefully examined, and it was found that the rocks in the "terraces" at those parts which faced a wide stretch of wind-swept water were always the most worn, whereas little or no traces of erosion were noticeable on the sides facing the shores of the mainland across a narrow strait, such as at Pine Island or Garden Island.

In connection with the theory of piling-up and erosion

* In the great frost of 1833 ? large tracts of forest, notably King William Pine, on the Southern Mountains were killed by frost.

of the lake-shore rocks by ice, it is right here to allude to the winter climate of the island at the elevation in question, from the effect of which satisfactory evidence can be drawn in proof of the work done in past ages by ice-floes.

At the present time the winter frosts set in between the middle of May and middle of June. After about a week's frost, should the temperature fall to about 22 deg. the lake freezes over, and with a drop to about 16 deg. the ice thickens quickly till, if there is a continuance of severe frost, it attains a thickness of 4 in. or 5 in. From accounts given by the shepherds living round the lake, the frost seldom lasts beyond six weeks at one time, a strong northerly gale with a rise in temperature breaking up the ice. Sometimes this is temporary, a frost setting in again and the lake freezing afresh, more or less solidly. As the thaw usually commences with a strong north-wester, the ice breaks up in large floes, which drive before it with great force, owing to the rough nature of the water in the lake. The prevailing winds are from the above quarter, but strong gales also come from the south-west, and it is, as has been pointed out, on the lee shores to these winds that the "ramparts" of rock and stones are piled in the most conspicuous manner. It is here also where the greenstone rocks of flat structure are pressed up at a small angle, 15 deg. to 20 deg. with the horizon, and dipping towards the direction of the wind. Instances of these formations, which have been incidentally referred to, exist on the south shores of Myrtle and Garden Islands, on the north-west and south shores of Pine Island, on the north and south edges of the point of Little Neck, on the north and west and south shores of Kangaroo Island, and on the north end of the Beehive Peninsula. At all these positions, likewise, do the rocks show the most marked indications of wear and smoothing-down round their upper or exposed edges. The ice-floes, it is ascertained from the inhabitants living on the lake, are often piled up high on the lee shores after a break-up, and this must cause a gradual, but of course very slow, heaping-up process, which during the course of thousands of years has resulted in the remarkable walls of the present time. On our Pacific coasts it is no uncommon occurrence to meet with immense raised terraces of rounded boulders heaped up and worn into their present shape by the enormous force of ocean-wave action, and the spectacle imbues the mind with wonder and admiration, but not with surprise. The rampart walls of the Great Lake shore, however, when taken in connection with the comparatively small area of the water and minor "sea" on its surface, strike one with astonishment and wonder. As regards the size of the waves, the highest we experienced were not more than

4 ft. or 5 ft. from trough to crest, but they are broken and confused in character under the force of a heavy wind, and their movement is very rapid, owing perhaps to the lightness of the fresh water and the shallowness of the lake.

LAKE-FLOOR.

We now come, in the natural sequence of detail here set forth, to the depth and soundings taken of the lake. The bottom in the several divisions of the lake is practically a dead level, with a slight alteration in the depth of water in each. There is more variation about the middle of the North Lake than elsewhere, as there appears to be a channel running across the centre in a direction slightly south of east. The East Bay is shallower than North Lake, and the reach from Reynold's Neck to Little Neck still shallower, the water deepening south of the latter and reaching its greatest depth in the South Lake.

Soundings were taken in a boat, which in the upper divisions was rowed, the time taken to come a certain distance having been first of all ascertained on a measured course, and intervals of time, representing so many yards, thereafter taken for the soundings.

In the North Lake and East Bay the water deepens gradually from about 3 ft. close to shore to 9 ft. or 10 ft. four or five hundred yards out, and then continues at almost one uniform depth, the variation lying within a foot till the opposite shore is neared, when it shoals again on the same scale. An exception to this rule is found at the east shore of the bay under the so-called "Sandbank Tier," where the water at the time of our visit (summer level) was only a foot deep at 800 yards from the land. The greatest depth, found in the depression above mentioned, in the North Lake was 16 ft.; but this must have been quite a local depression, as the soundings on either side east and west of it for more than a mile varied from 12 ft. 6 in. to 13 ft. This is shown on line C; the soundings on line A and line B in the same direction do not show the same depth, the maximum on the former being 12 ft. 6 in., and on the latter 14 ft., but the same remarkable uniformity exists in them, as will be seen on reference to the chart, which shows a variation of from 6 in. to 18 in. in a stretch of more than a thousand yards. In East Bay the greatest depth, shown on two transverse lines across the centre, is 12 ft. 6 in., the depth varying between that and 10 ft. over a length of about two miles in each direction.

In the reach down to Little Neck from Helen's Isle the water is shallower, owing probably to silt caused by wave-action. Although depths of 9 ft. to 10 ft. were found off the south-east point of Reynold's Neck while approaching

Helen's Isle, the water is shallower going down the reach, as on a zigzag course from the isle to the Little Neck Strait no greater depth than 7 ft. 6 in. was found.

On entering South Lake from the Strait the water quickly deepens. On a course from the neck to Kangaroo Island a depth of 11 ft. exists about 350 yards from the neck, the next sounding, 250 yards further out, giving 16 ft. The bottom is then remarkably level, varying from 17 ft. to 18 ft. for a distance of two miles and a half to the north-west end of the island. From there to the north-east end of Beehive Peninsula the depth remains at from 17 ft. to 18 ft. for a distance of more than two miles, the last sounding within 150 yards of the shore being 16 ft., proving that there is a step near the basaltic cliffs, and the only well-defined one met with in any part of the lake. From the Beehives to the opposite peninsula, McClaneghan's Neck, a distance of a mile, the depth ranges between 15 ft. and 16 ft., except near the shore, where it begins to shoal, soundings of 11 ft. and 7 ft. being taken. From this neck north to Kangaroo Island a uniform depth of from 15 ft. to 18 ft. was found, in two spots only 18 ft. 6 in. being marked. The soundings, however, show a bank near Helen's Isle.

Soundings across to the Beehives were taken on a parallel course to the above with the same results -17 ft to 18 ft. A number of soundings were also taken in the western portion of South Lake, extending northwards on a line to a point named by us "Hakea Point" on account of the large number of Hakea bushes (*Hakea microcarpa*) growing on it. Here the depths averaged from 15 ft. to 10 ft. 6 in. until opposite an intermediate point, where the water shoaled, and gave depths from 10 ft. to 6 ft. 6 in. From this last position a long line of forty-three soundings was taken on a bearing of 70 deg. to the north-east corner of South Lake, where the depths—after the usual very gradual slope into deep water was passed—ranged from 15 ft. to 20 ft., this being the maximum figure obtained on the lake. This point was south-east of Lake Elizabeth and in the track of the north-west winds through the strait at Little Neck.

Taking the axis of the lake along the course of about from north to south as fifteen miles, the length is 4,168 times its maximum depth of 19 ft.

The lacustrine character of the lake is amply proved by the results of the soundings, although it would be necessary in order to arrive at a satisfactory conclusion concerning its origin to put down borings and ascertain the depth of the mud and the composition of the substrata; this could be done through the ice in hard winters. Near the shore, particularly where the coast is flat, the bottom is composed of shingle, mostly flattish, composed of fragments of greenstone, but when the deeper level is reached in all the "divisions" of the lake it consists of an adhesive and slimy mud, which is in many places yellow in colour and in others blue, and which was brought up in the naval-pattern sounding apparatus used. On this mud, probably where there are patches of shingle intermingled with it, grows the curious "Lake-weed," which is broken off in all heavy winds, and, rising to the surface, floats in patches, and drifts to the shores, where it is thrown up in masses like kelp on the sea-shore, quite covering the rocks for considerable distances. This aquatic plant, *Isoetes lacustris*, grows in consolidated patches of more or less extent, according to the character of the bottom, and has a spinous, fleshy leaf of 2½ in. to 3 in. in length, or rather height, of an opaque-green colour, with bunchy black roots. It comes to the surface usually in patches from a couple of inches to 6 in. in diameter, and, owing to the prevalent boisterous weather on the lake, is always to be met with floating about on its murky green waters. A cross-section of one of the spines reveals a singular structure of four tiny cells, placed concentrically round the centre, each containing a small rounded seed. In portions of the lake, which are as deep even as 15 ft., a long grass, some 6 ft. to 8 ft. in length, with lengthened narrow blades at intervals up the stalk, was dredged up. Mr. Rodway, our Government Botanist, identifies this singular grass as *Potamogeton obtusifolius*, and states that it is fairly common in the lake district waters.

Between 480 and 500 soundings were taken on the transverse and coastal lines shown on the chart; unfortunately, adverse rough weather prevented our taking, as we intended, a larger number in the South Lake. A north-and-south line from Little Neck to the Shannon River, and one from Kangaroo Island to the eastern shore, would have completed the sounding of that section of the lake. From information we received, however, from Mr. Archer, who managed the boating part of our expedition, we learnt that a few soundings have been taken down the centre of South Lake, which showed a depth of about 19 ft.; at the same time it has been thought a greater depth exists between Kangaroo Island and the eastern shore, but on what grounds we did not learn, and it is extremely improbable in the face of the evidence afforded by the chart now produced that any such depression exists in the lake-floor in that part of the lake. This is a point that could only be elucidated by continuing the sounding which has been begun by Mr. Kingsmill and myself. What is really required for the Great Lake, and all the splendid sheets of water which diversify the grand plateau of Tasmania, are bathymetrical surveys, such as are being now carried out on the lakes of Scotland under the direction of Sir John Murray, K.C.B., and a staff of geographers. No work of greater interest to the geographer and geologist could be carried out in this State than this, and certainly in Tasmania nothing can be done in the direction of physiography which would afford such interesting results.

It is also necessary, in the interests of science, that a properly designed lake "level" should be erected at the Shannon outlet and the data kept by the observer at the meteorological station at Swan Bay. The maximum height of the lake-water on the break-up of the ice and the minimum during summer, as shown by this level, are necessary data in connection with a lake of this importance, and would be of much interest.

RAINFALL AND WATER-SUPPLY.

In connection with the physiography of the Great Lake, one of the most interesting points is that dealing with its water-supply. Particular attention was devoted to this during the trip made last year by Mr. Kingsmill and myself. Until recently very little was publicly known concerning the topography of the country surrounding the head of the lake, nor of the climate of the district, as until the recently made track from Deloraine was opened over the Great Western Mountains the north end was inaccessible to travellers and tourists. The meteorological station established at the police trooper's newly erected residence at the north of the lake, and the observations commenced by him on the 1st June, 1901, furnish me with the data given below.

For many years there has been an observing-station at the south end, which, however, is quite removed from the Great Western Mountain zone. The results of observations there showed a moderate rainfall, and, as the creeks flowing into the north end were known to be of very moderate size, it was thought that the inflow was almost nil and that the lake-water must be largely supplied by subaqueous springs!

As a matter of fact, however, so soon as observations at the Little Lake Station commenced, the existence of a wet climate around the crest of the Great Western Range, which is within six miles of the lake, was discovered, and the torrential rains, which almost monthly fall on the steep watershed, proved to be an important factor of supply for the lake water.

It will be convenient here to give a digest of a paper written on this subject by Mr. Kingsmill and the writer for the Royal Society of Tasmania in August last, in which the following observations on the climate are contained.

The time of the trip alluded to, in March last year, proved to be very opportune, as in the course of a few days two heavy falls of rain took place, in which 2 in. fell during the night and brought down all the creeks in heavy flood. These rains usually come from the north-west, the moisture from Bass Strait being condensed on the Great Western Range. Occasionally heavy falls take place with south-westerly winds, but as often as not the precipitation is then in the form of snow.

There are four principal creeks flowing into the head of the lake—the Shannon Rivulet, Breton's Rivulet, Kimberley Creek, and Pine Creek. Other small streams flow in in the north-western and north-eastern sides, but some of these are dry in the summer. Besides these, innumerable rills course through the oozy ground at the foot of the tiers after heavy rain. This is particularly the case on the shores of the Little Lake, which, you will observe, discharges into the Great Lake by a channel carrying the water from the latter sources, in addition to that of the Shannon Rivulet, which, draining a small but well-supplied sheet of water on the east of the mountain-range, is the chief feeder of the Great Lake. The streams above enumerated are all under twelve miles in length, so that their flow is inconsiderable except after heavy rain This, however, so frequently occurs that in the aggregate the annual supply is fairly large. The result of the observations for the twelve months ending the 31st May, 1902, gives a rainfall of 63.62 in., that at the South end—Swan Bay—for the same period being 18 in., and the distance apart only fifteen miles. The heaviest monthly fall during the above period was 11.39 in., in July, 1903.

The gauging of the streams was undertaken the day after a flood, commencing with the principal creek at twenty-two hours after the same; a current-meter was used, and careful sections, so far as was practicable, made of the stream-beds, with the following result as tabulated:

Stream.	Time after Flood.	Velocity per Minute	Volume, in Gallons, per Minute.
Little Lake Channel	22 hours	156 ft.	66,812
Breton's Rivulet	24 "	150 "	31,171
Kimberley Creek	27 "	140 "	6,344
Pine Creek	28 "	147 "	34,912
Brandon's Creek	29 "	86 "	2,150
Total flow per minute ..	..	..	141,389

Rate per twenty-four hours, 203,000,000 gallons.

As is well known, the shorter the stream from the head of supply the quicker the fall; and when the flood was at its height the day before, the inflow to the lake would have been about two-thirds more, or 138,000,000 gallons, making a total of 341,000,000 gallons. This rate of fall is proved to be near the truth by the gauging of the Little Lake channel the next day, forty-eight hours after height of flood, when the result per minute was 48,218 gallons, a reduction of more than one-third of the inflow on the day previous, when the proportionate amount of drainage was far less than during the first twenty-four hours.

As the lake water covers about 28,000 acres, the amount of increase to its height at the time of the first gauging would be about ¼ in. only per twenty-four hours. Notwithstanding this small figure, it may be of interest to mention that on approaching our anchorage after a trip down the lake at the time of the flood in question we found the dark peaty water discolouring the lake three-quarters of a mile from shore.

On the south side of Brandum's Creek there are nothing but diminutive streams, owing to the high stony tier there flanking the shore being covered with large fields of greenstone "talus," taking the place of moisture-holding vegetation. Along this area, therefore, the supply after heavy rain is limited to copious soakage immediately following the rain. On the east coast of the lake there are also small rills and two creeks flowing into East Bay from the Eastern Tier, which is crowned and flanked on the western side by vast masses of talus. Unfortunately, no opportunity was afforded during our twelve days' stay of visiting and measuring these creeks. In the winter they probably carry a considerable amount of water after flood rains, but as the tier is out of the track of the summer rains from the north-west the drainage from it at that season would be but small. On the south shores of Howell's Neck lies Lake Elizabeth. This sheet of water, which is barely two miles in circumference, is a typical Indian *jheel* or deep-water rush-bordered lagoon. It has no permanent outlet into the Great Lake, the only connection being a sort of natural spillway through the flat land for the discharge of winter overflows. Further south along the east shore of South Lake there are some watercourses which carry winter rain, but are not permanent.

The outflow at the south end of the lake must now be dealt with. This is by the Shannon, a tributary of the Ouse, which is the chief affluent of the Derwent. It is partially dammed with a course of loose stones in order to keep up the water in Swan Bay, the favourite resort of anglers, to a convenient height for fishing. The river was gauged by us four days after the flood alluded to, at the north end. The flood by that time had barely reached it so as to make any appreciable difference in the lake-level.

The total outflow for twenty-four hours at the time of gauging was only 13,848,000 gallons, which we will look upon as practically 14,000,000 a few hours previous to our measuring it. Any such small increase, therefore, that occurred even from the effect of the flood in question would take a considerable time to drain off. It must be further mentioned that at the time of our visit—1st to 10th March—the lake was about 2 ft. 3 in. below winter level; the volume of water to make up which difference amounts to 16,443,000,000 gallons. At the period of winter level there is, of course, a very large outflow from the Shannon, which tends to lower the lake much more quickly than when it is at the summer level: but after the first month's rush is over the reduction in the level of the lake, as well as in that of all other large sheets of water, is principally due to evaporation, and perhaps assisted by percolation. Some idea of the astonishing effect this has on the level of the Great Lake is gained by dividing the amount gauged by us in the Shannon for twenty-four hours—which is apparently 14,000,000 gallons—into the volume of water between summer and winter levels—namely, 16,443,000,000 gallons—which gives us the time required to drain it off at 1,174 days! We might take one-third of this time, perhaps—391 days—to compensate for the average outflow over the dam, and as only about ninety days had elapsed since the lake-level had commenced to fall after the winter rains, we see the enormously greater amount taken up by evaporation in the last-named period. The consideration of this part of our subject—the inflow and outflow of the Great Lake—has been dealt upon somewhat lengthily, inasmuch as the question of using the lake-waters for "power" and irrigation has recently been considered by the State Government. The daily outflow of about 14,000,000 gallons, representing 2,333,000 cubic feet per twenty-four hours, would be insufficient for practical purposes: and as the loss from evaporation in summer is evidently so great, in spite of the frequent inflow from summer floods, the effect of a large daily consumption of water for national work would be to destroy the present shore-line by creating wide foreshores from 250 yards to 800 yards in extent in several parts of the lake. At the time of our expedition, it may be remarked, a boat could not, in very many places, approach within 150 yards from shore. The only means, therefore, by which a heavy call on the lake-water could be made would be by the construction of a low dam across the glade connecting the two rocky hills between which the Shannon emerges. By thus raising the water 2 ft. 6 in. more than the winter level an additional 18,000,000,000 gallons would be conserved. This could be done without much injury to the low-lying lands at the north end.

The following table gives the rainfall at the north and south ends respectively for the period between the 1st June, 1902, and the 1st October, 1903—seventeen months.

Mr. Archer, the police trooper, an intelligent observer and field naturalist, whose help has been of much value to the writer, both as regards weather statistics and biological work, was removed from his station, and with his departure ended the collecting of scientific data for this paper.

TABLE I.—Temperature for Three Coldest Months of 1902, Little Lake Station; Elevation, 3,347 ft.

Date.	Temperature.		Date.	Temperature.		Date.	Temperature.	
	Max.	Min.		Max.	Min.		Max.	Min.
1902.	°	°	1902.	°	°	1902.	°	°
June 1	44	30	July 1	43	26	Aug. 1	36	31
„ 2	39	28	„ 2	41	30	„ 2	42	23
„ 3	48	32	„ 3	43·5	36	„ 3	36	22
„ 4	45	40	„ 4	38	33	„ 4	42	32
„ 5	48	29	„ 5	40	31	„ 5	38	25
„ 6	44	30	„ 6	36	25	„ 6	34	25
„ 7	44	39	„ 7	34	22	„ 7	44	24
„ 8	44	33	„ 8	35	23	„ 8	40	29
„ 9	45	34	„ 9	37·5	29	„ 9	39	20
„ 10	42	29	„ 10	39	30	„ 10	45	29
„ 11	44	26	„ 11	39·5	30	„ 11	41	23
„ 12	46	24	„ 12	38	24	„ 12	38	14
„ 13	43	21	„ 13	34	23	„ 13	41·5	15
„ 14	39	32	„ 14	37·5	23	„ 14	39	26
„ 15	41	32·5	„ 15	38	23	„ 15	43	21
„ 16	42	35	„ 16	37	28	„ 16	47	26·5
„ 17	39	33	„ 17	38	29	„ 17	42·5	25
„ 18	34	24	„ 18	42	32	„ 18	42	27
„ 19	37	30	„ 19	44	28	„ 19	43	24·5
„ 20	38	23	„ 20	43	31	„ 20	45·5	27
„ 21	38	22·5	„ 21	44	32	„ 21	42	32
„ 22	36	21·75	„ 22	39	26·5	„ 22	47	25
„ 23	44	18	„ 23	40	28	„ 23	42	23
„ 24	48	28	„ 24	48	28·5	„ 24	41	21
„ 25	39	13·5	„ 25	38	22·5	„ 25	45·5	30·5
„ 26	37	15	„ 26	44	33	„ 26	46	28·5
„ 27	44	23	„ 27	40	34	„ 27	45	27
„ 28	45	25	„ 28	42·5	35	„ 28	44	26
„ 29	45	21	„ 29	41·5	31·5	„ 29	43	35
„ 30	43	23	„ 30	39	19	„ 30	48	31
			„ 31	40	31	„ 31	53	33
Mean for month	35		Mean for month	34		Mean for month	34·5	

TABLE II.—Tables of Rainfall at Little Lake (north end) and Swan Bay (south end) for undermentioned Periods.

Little Lake. Month.	Rainfall.	Swan Bay. Month.	Rainfall.
1902.	In.	1902.	In.
June	7·98	June	1·81
July	6·95	July	0·79
August	3·54	August	1·60
September	4·92	September	1·04
October	2·64	October	0·42
November	3·07	November	1·09
December	3·10	December	1·39
1903.		1903.	
January	2·09	January	0·10
February	4·42	February	2·30
March	10·05	March	3·30
April	9·40	April	2·29
May	5·44	May	1·90
Total, twelve months	63·60	Total, twelve months	17·93
June	8·96	June	4·47
July	11·39	July	2·89
August	10·78	August	2·65
September	6·63	September	2·88
Total, sixteen months	101·36	Total, sixteen months	30·83

TABLE III.—Showing the Maximum and Minimum Temperature in each Month, and the Mean Maximum and Mean Minimum and the Mean Temperature during each Month.

Month.	Maximum.	Minimum.	Mean Maximum.	Mean Minimum.	Mean Temperature.
1902.	°	°	°	°	°
June ..	48	13·5	42·2	27·1	34·7
July ..	48	19	39·8	28·9	34·1
August ..	53	14[a]	42·3	26·4	34·3
September ..	54	20	44·5	26·5	35·5
October ..	68·5[b]	25[c]	57·1	34·5	45·8
November ..	85	26	66·6	36·1	51·85
December ..	77[d]	31	65·1	40·9	53·0
1903.					
January ..	87[e]	33	66·5	42·5	54·5
February ..	86	32	64·1	41·8	52·9
March ..	74	32	59·3	39·5	49·4
April ..	64	28	50·5	35·9	43·2
May[f] ..	59	21	43·9	30·4	37·1
June ..	47	19[g]	38·4	30·9	34·6
July ..	44	16·5	39·0	27·8	38·4
August ..	50	16	37·9	27·8	32·8
September ..	58	25	47·06	31·08	39·07

(a) 12th; maximum 38°. (b) 28th. (c) 14th. (d) 25th. (e) 31st.
(f) Lakes frozen 27th; 1½ in. in South Lake. (g) 11th; maximum 39°.

The above data show that the rainfall at the north end of the lake is three times that at the south, from which it is distant about fourteen miles in an air-line. This superabundance of rain fully accounts for the marked difference above referred to in the physical aspect of the land at the two places.

The maximum daily temperatures shown in the tables for the three coldest months of 1902, during the annual period of frost, lead to the supposition that the thaw in the daytime, which must take place with such a rise in the temperature, would materially affect the progress of the lakes freezing Such is, however, apparently not the case. Mr. Harold Bisdee, a landed proprietor at the lake, and one who takes considerable interest in the physiology of the district, has frequently observed that the sun's rays on warm days, after an intensely cold night, have but little or no effect upon the ice. At the same time the heat of an Australian winter sun at such high elevations must retard the freezing of water exposed to its rays more materially than in a climate with a less clear atmosphere.

I may here refer to the constant mirage effects, which are to be seen on any fine day on the lake, particularly when there is a slight breeze. On sailing down the reach, after passing the east end of Reynold's Neck, a supposed mirage of the mouth of the Shannon is often observable. Directly to the south and between the observer's boat and the position of the river's mouth the long low shore of Howell's Point crosses the line of vision, and above the level of the land is seen the mirage in the form of a thick bluish line looking like very distant water. On the day, however, that it was seen by us, by using a strong binocular, as the boat got nearer to it and the mirage gradually lowered, it was found that the mirage was really caused by the presence of a large dead and bleached gum-tree bole lying above the beach. This was an interesting testimony of the effect produced by the combination of the sun's rays and the very light atmosphere of the lake region.

It may be incidentally mentioned, however, that the greatest test of the lightness of the atmosphere and its bracing effect is the singular immunity from fatigue after the hardest exercise that one experiences at the lake. This is best proved by our "fitness" one day after a hard day at the oars, battling against wind and waves in the struggle to make the north end of the lake in the teeth of a north-wester.

The temperatures noted for the winter months during the time the observing-station was in existence are interesting, as showing a high range between daily maximum and minimum during the prevalence of frost. The warmth of the winter sun affects the snow, but it evidently does not produce any thaw in the ice, or it would not increase in thickness to the extent which is annually observable. It has been thought sufficient to tabulate the observations for June, July, and August, 1902, as the winter of that year may be taken as one of average rigour. The snow was about 18 in. to 2 ft. in depth, but occasionally it is much deeper. The mean maximum and minimum are also given above for the sixteen months, June, 1902, to September, 1903.

BOTANICAL DATA.

The vegetation on the shores and the islands of the lake has been incidentally referred to above, and it will now be proper to deal with the subject at greater length.

In the moister climate of the northern part it has a more alpine character than on the drier plains at the south, where the soil and topographical features of the country are different.

Speaking generally of the forest, this consists, as elsewhere, except in the wet myrtle districts of the West Coast, of Eucalypti. The park-like slopes which descend from the Fluted Tier, Stony Tier, and the other hills and small ranges, which form the picturesque scenery of the north and central parts of the lake, are clothed chiefly with the umbrageous and graceful Cider Gums (*Eucalyptus gunni*), which is almost the only really shapely Eucalypt in Tasmania. Growing among it on the rocky knolls and on Reynold's Neck are Mountain Peppermint (*E. coccifera*) and another species of the Peppermint section. The handsome King William Pine (*Athrotaxis cupressiformis*) formerly grew on the islands and round the lake, but it has been destroyed by fire, and isolated trees are now the only evidence of its existence. At the Pine Lake, four miles from the Great Lake, on the crest of the Great Western Mountains, and about 490 ft. higher, there are a good many Pines, and a grove of them at the west end. This Pine differs from *A. selagenoides*, the timber-tree of the east coast of Tasmania. It does not attain the same height, has a thick bole for the stature of the tree, and assumes a cypress-like form. At the south-west end of the lake is the Great Lake, or Central, Plain, the largest expanse of treeless land, perhaps, in Tasmania. From opposite the Little Neck these undulating downs stretch to Swan Bay, with but one or two solitary Gums on their surface, and extend westward for several miles to the Ouse, beyond which the open, treeless tract reaches for some distance. This river flows in a sinuous course parallel to the lake and, in the same latitude as the Beehive Peninsula, is about 45 ft. lower.

The plains are well clothed with grass and alpine herbage, such as *Epacris serpillifolius* and other stiff and erect-growing plants, the most interesting of which are the dwarf *Richea acerosa* and *Exocarpus nana*, a bushy shrub; *Olearia lepidophylla*, with its erect-growing branchlets; a bristly thick-growing plant, *Cyathodes acerosa;* and the pretty little *Bellendena montana*, with its white leaves and red flowers. To these may be added *Bœckia gunniana* and other shrub-like plants, none of which attain a height of more than 3 ft., if we except the curious shrub *Ozothamnus hookeri*, locally called the Gas Bush from its bursting into a bright blaze when set alight. The uniform height, therefore, of the vegetation on these elevated downs imparts a green and uniform appearance to the scene, which, with its background of tiers in the direction of the highlands of the west, forms a very picturesque landscape.

Away from the downs and along the western shores of the lake there is here and there a growth of Hakea bushes, which in some places form scattered little copses; while on the peninsulas, such as Little Neck, the *Ozothamnus hookeri* grows to a height of 7 ft. or 8 ft. On damp places on the plains, as well as the oozy slopes (wet all the year round in many places) which lead from the hills at the north end to the water's edge, the singular Pudding Moss, alluded to above, is found, being very abundant in the latter district, and usually associated with clumps of Native Artichoke (*Astelia alpina*).

The beautiful green hemispheres and dough-shaped masses of Pudding Moss are often combined with grey map-like patches which are spread over its surface, and which Mr. Rodway identifies as an ally of it which is named *Pterygopappus lawrencii*. The association of the green and grey colorations gives a picturesque appearance to this extraordinary alpine plant, which is accentuated by the beautiful little scarlet berries which, as it were, cling to its surface in the autumn. When crossing boggy places the horses in use in the lake district invariably make for both these plants, the Moss and the Artichoke, knowing that their surfaces give a sure foothold. With the exception of these last-named plants, the shrubs alluded to above, with the addition of Mountain Currant (*Coprosma nitida*), the Wallflower (*Pultenæa rubumbellata*), the Crocus (*Comesperina retusum*), the Yellow Bush (*Orites revoluta*), the Pittosporum, and Pepper-tree (*Drimys aromatica*), combine to form the vegetation of the islands. On Pine and Kangaroo Islands, where the Pine-trees have been ruthlessly destroyed, the only sign of arboreal growth as one approaches them on the water are a few trees chiefly of the two latter species, which grow in rear of the rock ramparts of the shore-line.

All the grasses and flowering-plants in the list given here are found on the islands, which in the season are bright with several sorts of Everlastings (*Helichrysum*) and a species of Iris (*Diplarrhena moræa*), which is extraordinarily abundant on Garden Island.

It is worthy of mention that the soil on all the islands mainly consists of black and purely vegetable humus, which overlies a bottom of strewn greenstone boulders, rocks, and stones, and it is remarkable, in the absence of any subsoil beneath this porous deposit, that the land supports the vegetation which is found upon it.

The identifications in the following list are kindly supplied by Mr. Leonard Rodway, F.L.S.

CONSPICUOUS VEGETATION OF THE VICINITY OF THE GREAT LAKE.

Ranunculus rivularis, Banks. River Buttercup.
,, *gunnianus*, Hook. Gunn's Buttercup.
Pittosporum bicolor, Hook. Waddywood.
Boronia pilosa, var. *citriodora*, Hook. Lemon Thyme.
Drimys aromatica, F. V. M. Pepper-tree.
Comesperma retusum, Lab. Purple Broom.
Pultenæa rubumbellata, Hook. Native Wallflower.
Acæna sanguisorbæ, Vahl. Bidgee-widgee.
Haloragis depressa, Walp. Creeping Haloragis.
,, *micrantha*, R. Br. Small-flowered Haloragis.
Bæckia gunniana, Sch. Gunn's Bæckia.
Leptospermum scoparium, Forst. Manuka.
,, *rupestre*, Hook. Creeping Manuka.
Eucalyptus gunnii, Hook. Cider Gum.
,, *coccifera*, Hook. Mountain Peppermint.
,, *acervula*, Hook. Red Gum.
,, *coriacea*, Cunn. Weeping Gum.
Coprosma nitida, Hook. Mountain Currant.
,, *repens*, Hook. Creeping Currant.
Olearia myrsinoides, F. v. M. Rough Daisy-tree.
,, *lepidophylla*, B. Scale-leaved Daisy-tree.
Celmisia longifolia, Cass. Mountain Aster.
Brachycome scapiformis, D. C. Mountain Daisy.
Abrotanella forsterioides, Hook. Cushion Moss.
Craspedia richei, Cass. Bachelor's Buttons.
Ozothamnus hookeri, Lond. Hooker's Sweet Shrub.
Helichrysum bracteatum, H. Coarse-flowered Everlasting.
,, *apiculatum*, D. C. Yellow Everlasting.
,, *pumilum*, H. Dwarf Everlasting.
Pterygopappus lawrencii, H. Sage Cushion Moss.
Hypochœris radicata. Deep-rooted Dandelion.
Pernettya tasmanica, H. Native Cranberry.
Cyathodes straminea, Br. Mountain Cheeseberry.
,, *acerosa*, Lab. Pinkberry.

Lissanthe montana, Br.
Epacris serpillifolia, Br. White Coral-flower.
Richea scoparia, H. Honey Plant.
,, *acerosa*, F. v. M. Small-leaved Honey Plant.
Villarsia reniformis, Br. Yellow Gentian.
Gentiana saxosa, Br. Mountain Gentian.
Veronica formosa, Br. Native Speedwell.
Euphrasia brownii, F. v. M. Native Eyebright.
Pimelea drupacea, Lab. Toughbark.
Bellendena montana, Br. Mountain Rocket.
Orites acicularis, Br. Yellow Bush.
,, *revoluta*, Br. Yellow Bush.
Hakea microcarpa, Br. Small Pear.
Banksia marginata, Cav. Honeysuckle.
Fagus cunninghamii, H. Myrtle.
Exocarpus nana, H. Dwarf Cherry.
Arthrotaxis cupressoides, Don. King William Pine.
Eriochilus autumnalis, Br. Autumn Orchid.
Prasophyllum patens, Br. Fly Orchid.
,, *fuscum*, Br. Brown Fly Orchid.
Diplarrhena moræa, Lab. White Iris.
Astelia alpina, Br. Mountain Artichoke.
Potamogeton obtusifolius, Mert. Pondweed.
Hierochloe redolens, Br. Tall Holy Grass.
Deyeuxia scabra, Br. Rough Bent Grass.
Poa cæspitosa, Forst. Tussock Grass.
Danthonia pauciflora, Br. Alpine Wallaby Grass.
Isoëtes lacustris, Linn. Quillwort ("Lake-weed").
Clathrina retipora. Coral Moss.

It would be gratifying to the biologist and the lover of the beautiful in nature if the Government of Tasmania would take over the care of the islands in the lake and prevent all burning-off and lighting of fires on them. By this means the dwarf flora would be preserved intact, as also scores of beautiful trees, such as *Arthrotaxis cupressiformis*, as well as handsome shrubs, which have been destroyed. On the mainland there is no doubt that the depasturing of sheep will in time alter the character of the vegetation, as it has done elsewhere, and the islands would therefore form nurseries (in spite of there being very little grass for departuring) for the alpine flora of the district. At present they are let to the pastoralists who lease the adjoining runs, thus giving an incentive for the destruction of their flora for no purpose.

Although somewhat foreign to the subject treated of in this account, a passing notice of the water-birds found on the lake may, perhaps, be given before concluding the paper, and likewise mention made of the fish which have been introduced in its waters.

The shallowness of the water and the amount of vegetation on the lake-floor are conducive to the easy pursuit of their food by diving-birds. Hence are found there the well-known Musk Duck (*Biziura lobata*) as abundant as anywhere in the island. The Blue-billed Duck (*Erismatura australis*), another member of the Diving-ducks, *Erismaturinæ*, is plentiful. This duck was a rare stranger to this island prior to the last fifteen years, but I have nowhere seen it in such numbers as at the lake. One or two examples of the Freckled Duck (*Strictonetta nevosa*) were seen in the North Lake, as well as great numbers of the White-winged Duck (*Nyroca australis*). The common Black Duck was met with in considerable numbers, as well as the Teal (*Nettion castaneum*). All three species of Australian Grebe, *Podiceps cristatus*, *P. nestor*, and *P. novæ-hollandiæ*, were observed. The former, the Crested Grebe, was often put on the wing by our boat and took long flights. Very few Cormorants appear now to frequent the lake, preferring the greater seclusion afforded by the maze of small lakes lying to the north-west in the little-frequented tract of country called the Nineteen Lagoons, and which are all stocked with fish which have ascended the River Ouse.

The well-known and widely distributed Little Gull (*Larus novæ-hollandiæ*) has become a permanent resident of the lake, living all the winter round there and breeding on the islands. Mr. Archer informs the writer that when the lake is frozen over these birds ascend the running streams at the north end, and live on food procured there until the thaw sets in.

The Ducks and Grebes, according to the same authority, after having disappeared on the lake's freezing, are immediately in evidence after a thaw, which is certainly remarkable when we consider their weak powers of flight. It is probable that a portion of the centre of the South Lake does not freeze, and that the water-birds resort to it during periods of frost. Large numbers of ducks are known to frequent the Great Lake Lagoon, an enlargement of the Shannon, a mile below its outlet, and which for some reason often remains unfrozen.

The only other sea-bird observed on the lake was the Caspian Tern (*Sterna caspia*), a solitary example of which was met with on the North Lake in March, 1901.

The history of the stocking and acclimatisation of the Brown Trout (*Salmo fario*) in the lake is interesting. They were introduced into the lake and the Shannon in the year 1875, and quickly adapted themselves to the favourable conditions of life existent in the shallow, weedy waters of Swan Bay, where they so rapidly increased in size that this locality became the favourite fishing-ground of the colony, and is now resorted to by anglers from the Commonwealth, and also by tourists from England.

As has been the case in other localities, these fish have by this time become a specialised form, owing to food and climatic conditions, and are much of the same silvery character as the Salmon, but would be at once distinguished by any close observer from that beautiful fish by their ugly heads and shoulders and by the absence of the shapely lengthened proportions of the Salmon. For many years the Trout were almost exclusively confined to Swan Bay, but they are gradually forming separate "colonies" up the coasts of the lake, as there are now fishing-grounds half-way up the South Lake.

A singular trait in their economy is a periodical "run" of fish in September to the North Lake, where, however, they do not seem to remain in any quantity. A few, however, stop, after the manner of their kind, in snug holes and pools at the mouths of the creeks, in one of which the writer saw, in March, 1901, two fish apparently about 12 lb. and 18 lb. weight respectively.

Eels are common in parts of the lake, as I was informed. Prior to the introduction of the Brown Trout one of the native fishes of Tasmania, the "Fresh-water Flathead" (*Galaxias* sp. ?), was abundant in the waters of the lake; this, I am informed, is scarce now.

It may be interesting to those who are anglers among our members to give at the close of this account a summary from the Hobart *Mercury* of the Trout taken in the season of 1901. The mode of fishing is wholly with a spinner, the "eelskin" being the favourite.

The Great Lake Trout Fishing. — The following are some of the records of English Trout taken at the Great Lake, Tasmania, from January of the present year to the last day of the season, the 30th April :—January 13th to 17th : Three rods, Messrs. C. J. and B. Smith and McKenzie, 24 fish ; total weight, 225¾ lb. ; heaviest fish, 12½ lb. ; smallest, 5 lb. January 23rd to 25th : 18 fish ; total weight, 164¾ lb. ; heaviest fish, 13¾ lb. ; smallest, 6 lb. Messrs. D. Cole, C. J. Smith, B. Smith, Langton, and C. Field, 5 rods, February 12th and 13th : 7 fish ; total weight, 57½ lb. Two rods, Messrs. A. Ibbott and A. C. Hirst : Heaviest, 12½ lb. ; smallest, 3¾ lb. February 9th to 13th : 7 fish ; total weight, 46 lb. ; heaviest, 9½ lb. ; smallest, 4 lb. : Messrs. F. Philpot and T. Mackay. March 7th to 9th : 16 fish ; 6 fish averaging 13 lb. each ; 10 fish averaging 9 lb. ; 1 rod, Mr. W. H. Valentine. March 10th to 21st : Total weight, 332½ lb. ; 35 fish, averaging 9½ lb. March 9th to 24th : Mr. Critchley Parker ; 20 fish, weighing 171 lb. March 19th to 24th : Messrs. P. C. Smith and Aubrey Weedon ; 6 fish ; weight, 44 lb., averaging 7½ lb. April 9th to 12th : Messrs. C. J. S. Smith, Dr. Cole, and Basil Smith ; 87 fish ; total weight, 831½ lb. ; average 9.6 lb. (the record). April 12th to 23rd : Mr. R. Taffin ; 13 fish ; total weight, 118 lb. April 17th to 30th : Dr. Hallowes, Messrs.

Champion and F. Horsham; 69 fish; total weight, 666 lb. April 25th to 29th: Messrs. M. and J. Burke and G. Kelly; 16 fish; total weight, 148 lb. Making a grand total of the catch from January 13th, 1902, to April 30th, of 308 fish; total weight, 2,972½ lb.

In concluding this paper I desire to offer my thanks to Mr. H. Kingsmill, M.A., Government Meteorologist, for the very kind assistance he rendered me in sounding the lake, gauging the streams, and computing the water-supply.

No. 2.—ANTARCTIC EXPLORATIONS.

By Hon. C. C. Bowen, M.L.C.

Section F.
ETHNOLOGY AND ANTHROPOLOGY.

PRESIDENTIAL ADDRESS.

By Baldwin Spencer, M.A., F.R.S.

(Delivered Thursday, 7th January, 1904.)

TOTEMISM IN AUSTRALIA.

During recent years our knowledge of totemism in regard to Australian tribes has been considerably extended. There can be little doubt but that of all people amongst whom totemism may still be studied the Australian aborigines are the most primitive or backward race, and therefore it is amongst them that we must look for ideas concerned with the significance of an institution which seems to have played an important part in the early development of the human race.

My object in this address is to bring together the salient features of such knowledge as we possess in regard to the various phases of totemism as revealed in different parts of Australia. In many works dealing with anthropological matters it is common to find a particular custom or belief—which is often limited to a small area, or perhaps to one or two modified tribes in some special district—described as that of the Australian aborigine,* whilst, as a matter of fact, there is no justification for such a general, sweeping statement. To the general reader statements of this kind are apt to be misleading.

In regard to important and fundamental points there exists a remarkable uniformity amongst the large nations into which the tribes can be divided; but at the same time there is naturally a considerable amount of divergence in respect of various features connected with the organization, customs, and beliefs of various tribes, and in nothing is this more evident than in the matter of totemism.

* Mr. Lang, for example ("Social Origins," p. 160), speaks of "the secret animal friend of each individual Australian." Or, again (p. 26), he says, "The sexes in Australia have each a friendly and protecting species of animal." The belief in a secret animal friend is extremely rarely met with, and is eminently non-characteristic of Australian aboriginal beliefs, whilst the belief in an animal friendly to and protecting the sex is of rare occurrence, and very far from being typical of Australian tribes.

Before going further it may be advisable to indicate clearly what I mean by the word "totem." I use the word "totem" as the name of some material object, animate or inanimate, which is applied to a group of individuals between whom and this material object a special association is supposed to exist. Beyond this somewhat vague and broad definition it is not possible to venture in view of our present knowledge. In 1887 Mr. Frazer* wrote, "A totem is a class of material objects which a savage regards with superstitious respect, believing that there exists between him and every member of the class an intimate and altogether special relation." In 1899† the same author wrote, "A totem is a class of natural phenomena or material objects most commonly a species of animals or plants—between which and himself the savage believes that a certain intimate relation exists."

I have used the word "group" in the definition because primitive savages, if we may judge by what we know of Australians, are essentially associated together in groups, and the characteristic feature of almost all names used by them is that they are group as opposed to individual names. It may therefore, I think, be regarded as certain that originally totem names in Australia were applied to groups and not to individuals.‡ We may reasonably conclude that any system expressive of relationship between one particular individual and a material object is of later date than, and different in nature from, one expressive of relationship between a group and a material object.

In dealing with Australian tribes the name "totem" has been applied in at least three distinct senses.§

We have, first of all, the clan or, as I prefer to call it more simply, the group totem—that is, the material object giving its name to a clan or group of individuals who commonly believe themselves to be descended from it. The name of the totem passes by inheritance from generation to generation, usually in the maternal or the paternal line.

Secondly, we have what is called the "sex totem," discovered first by Mr. Howitt as existing in the Kurnai Tribe. This may, as in the Kurnai, exist by itself or in other tribes, such as the Wotjoballuk, where the bat is associated with the men and the owlet-nightjar with the women; it may exist side by side with a system of group totems. It is thus quite

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* "Totemism." Edinburgh, 1887. P. 1.

† *Fortnightly Review*, 1899, p. 654.

‡ In this matter I thoroughly agree with what Mr. Lang says ("Social Origins," p. 189), "The Australian divisions show that the totem is, in the first place, the badge of a group, not of an individual. The individual takes it, in common with his fellows, only because he is a member of the group."

§ Howitt and Fison: "Kamilroi and Kurnai," p. 40, &c. In "Totemism" (p. 2) Mr. Frazer enumerates the three here dealt with, and on page 84 says, further, that each man may have five distinct kinds of totems—viz., phratry, sub-phratry, clan, sex, and individual totem.

clear that these sex totems are perfectly distinct from the group totems, and are not derived from them. For the most part they are met with amongst tribes which inhabit the very south-eastern corner of the continent, and are much modified in regard to organization both in respect of class and totemic systems. This part of Australia, together with the coastal district generally in the south and eastern part of the continent, is the home of the most modified and least primitive of our Australian tribes, just as the centre is undoubtedly the home of the most primitive and backward tribes. The so-called "sex totem" is undoubtedly a relatively modern innovation, and I much doubt the advisability of applying to it the term "totem" at all.

Thirdly, we have the individual or personal totem, which, though frequently met with in America, is of very rare occurrence in Australia. This, again, is radically different from the true group totem. It is associated with one individual, who acquires it usually by dreaming of some animal, and it is not hereditary. That is, in its two important features it is totally at variance with the true group totem, and it seems illogical to apply the same term "totem" to both of them. These two—viz., the sex and personal totems, so called—will be dealt with fully by Mr. Howitt in his forthcoming work, which embodies the results of his investigations into the organization, habits, and customs of the tribes of south-eastern Australia. Whether we regard them as strictly totems or not, it must be granted that they lie, as it were, to one side of the main trend of totemism—that is, of a system the essential feature of which is that certain groups of individuals, the groups including both men and women, believe themselves to be intimately associated with some one material object which is usually, but not always, an animal or plant.

So far as our Australian tribes are concerned, I think, for the sake of clearness, that it is advisable to restrict the term "totem" to a material object which (1) gives its name to a group of individuals which normally includes both men and women, and (2) is hereditary usually in the male or female line; and the term "totemism" to a system based upon the recognition of these two factors. If this does not fall in with the significance of the terms "totem" and "totemism" as generally accepted by workers amongst the American tribes, to whom we owe the words, and who consequently have the prior claim to them, then the only thing to be done is to employ different terms in regard to Australian tribes, and to adopt others, such as "kobong" instead of "totem," and "kobongism" instead of "totemism." At the same time it must be pointed out that the Australian tribes are in a much more primitive state than the American tribes, and that if we apply the term "kobong" to a material object which in Australian tribes is associated with human beings, and the term "kobongism" to a system based upon the ideas associated with "kobong," then "kobong" and "kobongism" imply respectively a term and a system the customs and beliefs associated with which are more primitive than those associated with "totem" and "totemism." Any attempt to apply the terms "totem" and "totemism" to both Australian and American tribes, and then to explain Australian customs and beliefs by a reference to those of American tribes, cannot be other than misleading. If the term "totemism" be applied to both, it must at the same time be clearly realised that the Australian is in a much earlier stage of totemism than the American, and that the ideas of the more highly developed totemic people must be interpreted in terms of the more primitive, and not *vice versâ.*

In what follows we will deal simply with the group totem, and will deal with it under three aspects—(I.) the social, (II.) the ceremonial or dramatic, (III.) the magical.

(I.) THE SOCIAL ASPECT OF TOTEMISM.

By this is meant the relation of the individuals of a totem group to each other and to individuals of other totem groups. Amongst Australian tribes there is very wide divergence in this respect, and before proceeding further it will be advisable to make a few general remarks with regard to their organization. In early days R. C. W. Schurman* noticed briefly that the Port Lincoln Natives "are divided into two distinct classes—viz., the Mattiri, and Karraru people"; and the Rev. William Ridley, dealing with the languages of the Kamilroi and other tribes, gave the names of the divisions into which various tribes were divided. The first serious attempt to study tribal organization in detail was made by Messrs. Howitt and Fison, whose work, "Kamilroi and Kurnai," may be justly regarded as having laid the foundation of our knowledge of Australian anthropology. In this they laid stress upon the existence in Australian tribes of the division into two exogamous moieties, which were in some cases divided into two classes. They also revealed the existence of totemic groups, and showed clearly that the terms of relationship were group and not individual terms. In the case of the Kamilroi the organization of a typical Australian tribe was set forth for the first time. Since then the organization of the same and of other tribes has been dealt with in further memoirs by Mr. Howitt and other workers, such as Messrs. E. Palmer, A. L. P. Cameron, Rev. J. Mathew, Rev. L. Schultze, Dr. E. C.

* "Native Tribes of South Australia." 1879. P. 222.

Stirling, Mr. F. J. Gillen, and myself, and there have also been published the valuable compilations of Messrs. Brough, Smyth, and E. Curr.* In addition to their published memoirs, I have had the great advantage, through the kindness of Mr. Howitt, of perusing the manuscript copy of the chapters dealing with tribal and social organization which are to appear in his forthcoming work dealing with the Native tribes of south-eastern Australia. These embody the results of his own and his correspondents' investigations during the past forty years, and, regarding Mr. Howitt as our great authority upon this subject, I have relied entirely upon the work so generously placed at my disposal for the information about to be given in reference to the tribes of Victoria, New South Wales, and part of Queensland. For the information regarding north-west central Queensland I have relied upon Mr. Roth's work, though, as that author does not refer to the existence of totems or totemism, I have only been able to deal very slightly with these tribes. That totems exist amongst them there can be no doubt whatever; in fact, in all probability they are on all-fours in this respect with tribes such as the Wakelbura, the organization of which is practically identical in other respects with theirs.

For part of central Australia I have relied upon Mr. Howitt's work, and for another part of the same area and for the whole of the northern central area I have used the results obtained by Mr. Gillen and myself. West Australia, from an anthropological point of view, is still almost a *terra incognita*.

Different names have been used by various writers in regard to the divisions into which a tribe is divided. In the present account I use the following terms, quite regardless of the terms which may have been used in the first instance by the original investigator. The two main exogamous divisions of the tribe I call "moieties." Thus, for example, I call each of Kiraru and Matteri, in the Dieri Tribe, or Uluuru and Kingilli, in the Warramunga Tribe, a "moiety."† When each moiety includes two divisions I call these "classes." Thus in the Arunta Tribe one moiety includes the classes Panunga and Bulthara; the other includes the classes Purula

* More recently Mr. R. H. Mathews has published a somewhat extensive series of papers which, so far as they refer to the organization of New South Wales, Victorian, and partly Queensland tribes, for the main part simply corroborate or make use of the work of Messrs. Howitt, Fison, Schurman, Ridley, Roth, and others without adding any matter of importance. Mr. Mathews, however, deals also with the organization of certain tribes in the northern parts of central Australia. In regard to them all of his information is secondhand. In every tribe he arbitrarily arranges the subclasses so as to fit in with maternal descent. Several of these tribes have been investigated by Mr. Gillen and myself. In every case in which I have been able to test Mr. Mathews's description of the organization by the aid of personal knowledge gained on the spot I have found that either his information, or the conclusion which he has drawn from it, is incorrect. I am therefore unable to accept Mr. Mathews's work as sufficiently reliable to base any conclusion upon.

† Called by some authors "phratry," by others "primary class," and by others "class."

and Kumara. When these classes are again divided I call the resulting divisions "subclasses." Thus in the Warramunga there are eight subclasses with distinct names. Two of these are the equivalent of the class Panunga, two of the class Bulthara, two of the class Purula, and two of the class Kumara. Not only is this so, but distinct subclass-names are applied to men and women, giving us thus sixteen subclass-names in all.

By a "totem group" I understand a group of individuals, both men and women, who bear in common the name of some material object which is their totem, and between whom and the totem some special association is supposed to exist.

As an example of a tribe in which these divisions are well developed we may take the Warramunga, inhabiting a district in the centre of the continent:—

Moiety.	Subclass. Male.	Subclass. Female.	Totem.
Uluuru	Thapanunga Tjunguri .. Tjapeltjeri .. Thapungarti	Napanunga Namagili .. Naltjeri .. Napungerta	Wollunqua (a mythical snake), thalaualla (black-snake), tjudia (deaf-adder), emu, echidna, muntikera (carpet-snake), and others.
Kingilli	Tjupila .. Thungalla .. Thakomara Tjambin ..	Naralu .. Nungalla .. Nakomara Nambin ..	Utu (wind), tjalikippa (white cockatoo), thaballa (laughing boy), winithonguru (native cat), lirripitji (a lizard), itjilpi (ant), and others.

In all of our Australian tribes, with very rare exceptions, a child inherits a moiety-name from its father or mother, if one be present, together with a corresponding class or subclass name; the totem-name we will refer to later. Even when the moiety-names have been lost the two large divisions are still clearly marked, and the fundamental feature of a typical Australian tribe is that a man of one moiety must marry a woman of the other—that is, the tribe is divided into two strictly exogamous moieties. In some tribes the children pass into the moiety to which the mother belongs, and in others into that of the father, so that we can divide the tribes up into those with maternal and those with paternal descent. In the accompanying map I have roughly indicated the distribution of these tribes. Excluding the western half and the York Peninsula, of which we know little or nothing, it will be seen that female-descent tribes occupy by far the greater part of Queensland and New South Wales, together with nearly the whole of South Australia proper. Victoria is very largely occupied by male-descent tribes, which, however, are without doubt highly modified. It will be seen also that there is a fringe of male-descent tribes occupying the coast at intervals from the Gulf of St. Vincent round the east to Queensland. A large compact group of male-descent tribes occupies the whole of the Northern Territory, extending eastwards on to the shores of the Gulf of Carpentaria. The exact locality of the boundary-line between the Queensland and Northern Territory tribes is not known, but it must lie somewhere along the western boundary of Queensland.

It is a well-marked feature that, if we desire to find a tribe, whether it be one with male or with female descent, which has become specialised or highly modified in regard to its organization, we must search along the coast-line. The most backward and primitive tribes occupy the central area. Now, a very striking feature in the physiography of Australia is the presence of a series of Ranges, of which a very characteristic example are those commonly known as the Great Divide, in the south-east part of the continent, separating a comparatively well-watered coastal fringe from a dry interior, where, over very wide areas, conditions of life are more unfavourable. It will be seen that tribes, which will subsequently be shown to be modified, such as the Narrinyeri, of South Australia, the Victorian tribes generally, the coastal tribes on the east of the continent, and those on the west of the Gulf of Carpentaria, all inhabit areas where conditions of life are relatively favourable.

The map also indicates very clearly that we can divide the western and central part of the continent into a series of large areas, occupied by groups of allied tribes, each group being distinguished by certain important features in regard to the organization of its component tribes. Before proceeding to deal in detail with the organization of typical tribes we will briefly glance at their general distribution. Broadly speaking, they may be grouped as follows:—

Group A.—A group of tribes extending from Port Lincoln in the south to approximately half-way across the continent. Their westward limit is not exactly known; eastwards they spread slightly over the boundary between South Australia and New South Wales, the Grey and Barrier Ranges indicating about their most eastward extension. This group has the two moiety-names Kirara and Matteri (or variants of these). There are no classes, but a series of totem groups is associated with each moiety, and descent is in the female line.

Group B.—A group of tribes occupying the western part of the State of New South Wales, and spreading at its northern limit slightly across the boundary into Queensland. They have the two moiety-names of Mukwara and Kilpara, no classes, a series of totems belonging to each moiety, and descent is maternal.

Group C.—A small isolated group consisting of three tribes, of whom very little was known before they became extinct. They occupied the country round about the headwaters of the River Murray. Each of them had two moieties with names which were said to stand for "eagle-hawk" and "crow." Each moiety had a series of totems, and descent was apparently in the female line.

Group D.—Excluding York Peninsula and certain parts of the eastern coastal district, where we meet with tribes such as the Kiabara, Murraburra, and Turribul, the whole of Queensland, except small areas on the border of South Australia and New South Wales, is occupied by a large number of tribes, all of which have fundamentally the same organization. They may, though very closely allied, be divided again into two groups. Of the latter, one, which has been investigated by Mr. Roth, occupies the north-west part of the State, and, with variations in certain parts, has the moiety-names Utaru and Pakuta. Utaru has two classes, Kupuru and Wungko; Pakuta has Kurkilla and Bunburi. Descent is in the female line. Mr. Roth* makes no mention of the existence of totemic groups, yet the fact that they do exist amongst contiguous and very closely allied tribes, whose organization is otherwise practically identical with Mr. Roth's tribes, and the fact also that Mr. Roth mentions certain articles of food as forbidden to individuals of the different classes, would appear to indicate that totem groups do really exist amongst Mr. Roth's tribes. The second group occupies practically the eastern and south-eastern part of the State. Its moiety-names are Wuturu and Yungaru or Wuthera, and Malera, and, with very slight variations throughout the whole of the very large area occupied by this homogeneous group of tribes, the class-names are Wungo and Obu, Kurgilla and Banbe. Descent both of moiety, class, and totem group is in the female line.

Group E.—The eastern part of New South Wales is occupied by a large group of tribes, all of which have the organization which is well known as that of the Kamilroi Tribe. This, together with the Wiradjuri, Wonghibon, and numerous other tribes, has the division into the two moieties for which the Kamilroi name is Kupathin and Dilbi, and four classes, Ippai and Kumbo, Murri and Kubbi. At its northern limit the tribes encroach upon the southern boundary of Queensland. Descent both as to moiety, class, and totem is in the female line.

Group F.—An extensive and, on the whole, very homogeneous group of tribes occupying the greater part of the Northern Territory. There are eight subclasses, and the

* Roth: Ethnological Studies, &c., p. 57.

organization of all of them, so far as moieties and subclasses are concerned, is based on the Arunta type. Descent of moiety and subclass is in the male line. Totemic groups are universally present. In the southern half of the area the totemic name is not of necessity inherited from either the father or mother; in the middle section it is usually, and in the northern always, inherited from the father. This is a remarkably homogeneous group of tribes, the class organization of which is closely comparable to that of the Kamilroi group, except that descent is counted in the male line. The names of the moieties are usually preserved, but not always. At its southern limit it is in contact with tribes of Group A. Its eastern and western limits are not known, and on the west side of the Gulf of Carpentaria it is in contact with modified tribes, in which the descent is counted in the direct male line.

Occupying the south-eastern part of the continent we have a series of tribes which, as pointed out by Mr. Howitt, are evidently considerably modified in regard to their organization. They fall into three main groups.

Group G.—Tribes occupying the western part of Victoria from the River Murray southward to the sea. At their northern extremity they are in contact with tribes of Group B. They have two moieties, Kumite and Krogi, or Gamutch and Kroki. To each of these a number of totem groups are attached, and to each of these again a number of subtotems. Descent is in the female line.

Group H.—A series of tribes occupying the central part of Victoria, and forming what Mr. Howitt has called the Kulin Nation. Each tribe is divided into two divisions—one called Bunjil (Eagle), the other Waang (Crow); and there is only one totem, Thara (a star). In some parts the groups Bunjil and Waang are localised. Descent is counted in the male line.

Group I.—Includes only the Kurnai, inhabiting the eastern part of Victoria. There are no names for moieties, classes, or group totems.

We will now take a typical example of each of these groups in order to indicate the descent of the moiety, class, and totem group.

Of Group A, the Urabunna will serve as an example. There are two moieties, Kirara and Matthuri, and each of them has a number of totem groups attached to it which we can show, thus—

Kirara	Cloud, carpet-snake, lace-lizard, crow, water-hen, and others.
Matthuri	Wild duck, cicada, dingo, emu, black swan, and others.

A Kirara man must marry a Matthuri woman—that is, a woman who belongs of necessity to a totem group other than his own—and the children belong to the moiety and totem group of the mother. Thus, for example, a Matthuri wild-dog (dingo) man marries a Kirara water-hen woman, and the children are all Kirara and water-hen.

In Group B the organization is closely similar. In the Wilya Tribe, inhabiting the Grey Ranges, there are two moieties, Mukwara and Kilpara, with totem groups attached to them, thus—

Mukwara	Eagle-hawk, kangaroo, bandicoot, dingo, and others.
Kilpara	Emu, carpet-snake, fish, wallaby, and others.

A Mukwara man marries a Kilpara woman, and the children follow the moiety and totem of the mother.

In Group C we have a small group consisting of only three tribes, the Ngarigo, Wolgal, and Ya-itma-thang, of whom very little indeed is known. Each of them had two moieties and totem groups attached to them, thus—

NGARIGO TRIBE.

Menung (Eagle-hawk)	Lyre-bird, bat, flying-squirrel, black-snake, mopoke, and others.
Yukembruk (Crow)	Small hawk, rabbit-rat, kangaroo, emu, lace-lizard, and others.

WOLGAL TRIBE.

Malian (Eagle-hawk)	Kangaroo, emu, hawk, dingo, lyre-bird, and others.
Umbe (Crow)	Wombat, brown-snake, bandicoot, rabbit-rat, and others.

Descent was apparently counted in the female line, but the tribes were almost extinct before they were investigated, and the evidence concerning them is very meagre. A curious feature, to which we shall refer again later, and one in which they differed from almost all other tribes, was that what are apparently moiety-names are those of animals.

Group D is a very large one, and in it we find that the moiety-names are retained, and that each is divided into two classes, with which the totem groups are associated. We can take the Wakelbura as an example. Its organization is as follows:—

Maleru	Kurgilla	Opossum, ant-eater, eagle-hawk, lyre-bird, kangaroo, and others.
	Banbe	Great kangaroo, ring-tail opossum, lizard, and others.
Wutheru	Wungo	Emu, carpet-snake, gidea-tree, wallaby, and others.
	Obu	Black duck, carpet-snake, emu, hill-kangaroo, wallaby, and others.

A Maleru man marries a Wutheru woman, but the existence of classes gives rise to further restrictions. Thus a Kurgilla man marries a Wungo woman, and the children are Obu that is, they belong to the mother's moiety, but to the half of it to which she does not belong, and thus we have, so far as the classes are concerned, what is called indirect female descent. The descent of the totem is in the direct female line. As the children of a Kurgilla woman are Banbe, and *vice versâ*, and as those of a Wungo woman are Obu, and *vice versâ*, it follows of necessity that one group of totems is common to Kurgilla and Banbe, and another to Wungo and Obu.

Group E, in regard to its organization, is practically identical with Group D. We may take the well-known Kamilroi Tribe as an example. In this we have the two moiety-names yet retained. Each is divided into two classes. One moiety, Kupathin, has Ipai and Kumbo; the other, Dilbi, has Murri and Kubbi. The totem groups are divided between the two moieties. Following Messrs. Howitt and Fison, we can represent the organization as follows: –

Kupathin	Ipai	Ipatha	Kangaroo, opossum, bandicoot, black duck, eagle-hawk, and others.
	Kumbo	Butha	
Dilbi	Murri	Matha	Emu, carpet-snake, black-snake, red kangaroo, frog, and others.
	Kubbo	Kubitha	

Descent is counted in the direct female line so far as the moiety and totem are concerned, and it will be noticed that there are distinct names for the classes into which the males and females are respectively grouped. Thus the sisters of Ipai are Ipatha, of Murri they are Matha, and so on. It is quite clear that, in regard to the totems, these are divided between the moieties, and that Ipai-Kumbo and Muri-Kubbo have, respectively, totems in common. Owing to the existence of indirect female descent in regard to the classes this must be so. It is evident that if the child of an Ipatha woman is a Butha her totem will descend to the Butha woman, and, again, the child of this Butha will be Ipai or Ipatha, and will inherit its mother's totem. If we take the case, for example, of an Ipatha woman who is a kangaroo, her children will be Kumbo and Butha and kangaroos; the children, again, of the Butha daughter will be Ipai and Ipatha and kangaroos. It therefore follows that the kangaroo totem is common to the classes Ipai-Ipatha and Kumbo-Butha—that is, to the moiety Kupathin in precisely the same way in which the totem groups belong to one or other of the two moieties in such tribes as the Urabunna or Dieri, in which the moieties are not divided into classes.

It is a very remarkable feature of all the tribes in which we have two or more classes in each moiety, with the exception, so far as at present known, of only a few tribes on the coast of the Gulf of Carpentaria, that descent is counted in the indirect male or female line, as the case may be, so far as the class is concerned.

Whilst as a general rule the classes are strictly exogamous, yet in one of the Kamilroi tribes, as was shown in 1880 by Messrs. Howitt and Fison, from information originally supplied by Rev. W. Ridley, it is to a certain extent permissible for a man to marry a woman belonging to the same moiety as himself, but to a different totem group.* These marriages are strictly governed by the totemic organization. Thus, for example, an Ipai man of the emu totem may marry an Ipatha woman, but she must belong to the black-snake totem group, the children as usual following the mother's totem. An Ipai bandicoot, again, may marry an Ipatha woman who is a black-snake. Marriage with the maternal half-sister is prevented by the law which prohibits marriage within the totem group. The children of such inter-class marriages take the totem-name of the mother, but the class-name which they would have acquired had she married the proper husband. That is, for example, an Ipai man normally marries a Kubitha woman, and the children are Muri and Matha; but if he marries an Ipatha woman the children are Kumbo and Butha, just as they would have been if, under normal conditions, the Ipatha had married a Kubi man.

Group F we may divide into three divisions — (1) the Arunta Nation, (2) the Warramunga Nation, and (3) the Binbinga Nation.

(1.) The Arunta Nation, including the Arunta, Ilpirra, Unmatjera, and Kaitish Tribes. We can take the Arunta as typical of the nation. In the southern part of the tribe there are four classes, thus—

Moiety A			Moiety B
Moiety A	Panunga	Purula	Moiety B
	Bulthara	Kumara	

The moiety-names are entirely lost. A Panunga man marries a Purula woman, and the children are Bulthara—that is, we have indirect male descent as far as the class is concerned. The classes are strictly exogamous. The totem groups are not restricted to the moieties—that is, we may have, for example, individuals of the rain totem in both moiety A and moiety B, though for the most part they are confined to moiety B. So, again, we may have witchetty-grub men in both moieties, but for the most part they are confined to A. Marriage between individuals of the same totemic group is not forbidden pro-

* "Kamilroi and Kurnai," p. 45. In certain of the central tribes, such as the Warramunga, marriage with the father's sister's daughter is allowed, the children taking the class-names which they would have inherited had the woman married the proper husband.

vided they belong to the right intermarrying classes, but it rarely takes place. The totem group does not of necessity descend in either the maternal or the paternal line. We shall return to this later. In the Kaitish Tribe, the most northern division of the Arunta Nation, the totemic groups are more nearly divided between the two moieties, though the division is still incomplete. A man very rarely indeed marries a woman of his own totem group, and there is a strong tendency for the descent of the totem, as of the subclasses, to be in the male line. Except in the southern Arunta, each class has split into two, so that we have eight subclasses, thus—

Moiety A	Panunga	Purula	Moiety B
	Uknaria	Ungalla	
	Bulthara	Kumara	
	Appungerta	Umbitjana	

(2.) The Warramunga Nation, including the Warramunga, Worgaia, Tjingilli, Umbaia, Bingongina, Walpari, Wulmala, and Gnanji Tribes: In all of these we have eight subclasses, and also separate names for males and females, as in the Kamilroi group. We can illustrate the organization by that of the Warramunga Tribe. The moiety-names have been retained.

Uluuru	Thapanunga	Tjupila	Kingilli
	Tjunguri	Thungalla	
	Tjapeltjeri	Thakomara	
	Thapungarti	Tjambin	

The totem groups are strictly divided between the two moieties. Thus the subclasses of the Uluuru have one series of totem groups associated with them, and the Kingilli have another. Strict paternal descent of the totem has nearly, but not quite, been reached. No child apparently ever belongs to a totemic group other than one associated with its father's moiety. As a general rule its totem is identical with that of its father, but not always. Thus, for example, a leading man of the black-snake totem group belongs to the Uluuru moiety and the subclass Thapungarti. One of his sons, who is a Thapanunga, belongs to the rain totem group; his other two children are black-snakes like himself. So, again, a man of the Itjilpi (an ant) totem group, which belongs to the Kingilli moiety, is the son of a hailstone man. We have, indeed, surviving relics in the Warramunga Nation of the curious system of the Arunta, the Kaitish forming an intermediate link. As the moieties are strictly exogamous, it follows that the totem groups are so also.

(3.) The Binbinga Nation, including the Binbinga Tribe, occupying a large part of the country drained by the Macarthur River, and other tribes on the west coast of the Gulf of Carpentaria: The organization, save that the moiety-names are lost and the actual names of the subclasses differ from those of the Warramunga, is very closely similar to that of the latter. In these tribes, however, the descent of the totem is strictly in the paternal line, the totem groups being divided between the two moieties.

In these tribes marriage is allowed between a man and his father's sister's daughter. Thus a Thapanunga man may marry a Thungalla as well as a Tjupila woman, but the children of the former will be Tjapeltjeri and those of the latter will be Thapungarti.*

Group G is the first of three main groups which occupy the south-east corner of the continent. It may be exemplified by the Wotjoballuk Tribe described by Mr. Howitt. In this we have two moieties called Gamutch and Krokitch (the names are Kumite and Kroki, Kaputch and Krokitch in other allied tribes). Gamutch has four totem groups—viz., deaf-adder, the sea, pelican, and black cockatoo; and each of these has sundry subtotem groups attached to it. The deaf-adder has six, those of the sea were not ascertained, the pelican has eleven, and the black cockatoo has six. Krokitch has seven totem groups—the sun, galah cockatoo, a cave, pelican, carpet-snake, hot wind, and a tuber. The sun has seven subtotems, the cockatoo has seven; those of the cave, pelican, carpet-snake, and tuber are unknown; the hot wind has five.

Mr. Howitt includes this amongst his tribes with anomalous class systems, and suggests that some of the totem groups of a tribe with two moieties have grown in importance, leaving the others in obscurity. There is also what Mr. Howitt calls a mortuary totem, given to a man after his death, which sounds very unprimitive. Evidently development along some special line was taking place when further progress was effectually checked by the extinction of the tribe. The moiety and totem name descended from mother to child.

Closely allied to the Wotjoballuk, and forming one of the same group, is another tribe called the Gournditch-mara. In this we have the moiety-names Krokitch and Kaputch. Krokitch has one totem, the white cockatoo; Kaputch has one, the black cockatoo; both have numerous subtotems. This tribe is, I think, of some interest in connection with the group now to be dealt with.

Group H, the second of these south-eastern groups, comprises the nation, which Mr. Howitt has called Kulin. It occupied, in years gone by, the middle portion of Victoria,

* Distinct class-names are used for males and females, but for the sake of simplicity I have only used the male names. Thus the sister of a Thungalla is a Nungalla, the sister of a Tjupila is a Naralu, &c.

from Colac on the coast to Mount Baw Baw in the east, and from Wangaratta and Murchison on the north to Port Phillip and Western Port in the south. The tribe was divided into two main divisions called Bunjil, the eagle-hawk, and Wang, the crow; and there was just one totem, Thara, a small hawk, which was associated with Bunjil, but apparently nothing further is known of it. Descent was counted in the male line. In the northern tribes of the group, such as the Banjerang, "the people," says Mr. Howitt, "who were respectively Bunjil and Wang, were scattered over the tribal country in the same manner as the Krokitch and Gamutch of the Wotjo Nation. In the southern tribes, however, such as the Warunjeri and the Bun(w)urong, the Bunjil and Wang people were segregated into separate localities." The question of most interest in regard to this group of tribes is concerned with the division into Bunjil and Wang. Are we correct in applying the term "moiety" to each one of these —that is, are Bunjil and Wang strictly the equivalents and precisely comparable to, say, Mukwara and Kilpara? Such evidence as there is makes me think that they are not. We have already seen that the Wotjoballuk Nation, which hems in the Kulin on the west, has become much modified in regard to totemic matters; while on the other side, towards the east, lies the Kurnai, which has lost all trace of class and totems. *A priori*, one would scarcely expect to find a group of tribes retaining so primitive a feature as moiety-names in such a geographical position. Then, further, it would be a most remarkable thing, granting that Bunjil and Wang are true moiety-names, that they should have persisted, and all of the totem-names should have disappeared, except one solitary one—Thara—which has by good fortune been retained, and serves to show that once they were present. I am strongly inclined to think that the primitive appearance of Bunjil and Wang is highly deceptive, and that in reality these tribes are in a very much modified condition. They have probably passed through various stages of decadence in regard to totemic matters, until finally they have reached apparent simplicity, though even now the single totem Thara is rather of a telltale nature. I would suggest that what has taken place is probably somewhat as follows: There can be little doubt but that the ancestors of all of the tribes inhabiting the eastern half of the continent were organized in some such way as the tribes which now possess the moieties Mukwara and Kilpara, with totem groups attached to them. This is probably a very ancient system which has persisted in certain parts, and has become modified in others, as, for example, amongst the Kamilroi. The next stage leads us to the condition of the Wotjoballuk Tribe with two moieties, a few totem groups which have grown in importance and subtotems attached to them. The next stage is that represented by the Gournditch-mara Tribe. The moiety-names are retained, but of the totem groups one in each moiety has survived and has subtotems associated with it. Further modification leads, as it has done in some of the Wotjo Nation, to the loss of the moiety-name; the two totems then remain with subtotems. Finally, the subtotems, being of less importance than the totem groups, have almost entirely disappeared, leaving one to bear witness to their former existence. Bunjil and Wang, if this be true, are very far from being the equivalents of the moieties Matteri and Kirara, Gamutch and Krokitch, or Mukwara and Kilpara. The very fact that they bear the names of totem animals is in itself sufficient to excite suspicion. They represent probably a final stage in the decadence of totemism in a highly modified tribe.

In Group I, comprising only the Kurnai, which once, many years ago, inhabited the wild mountains of Croajingolong, we have the complete disappearence of the class system and of the totems. The tribe simply consists of a number of local groups, the only name applied to which is that of the locality in which they live and which each is supposed to own.

In Group J we meet with tribes which differ from any known elsewhere, in that, though they have four classes, descent is reckoned in the direct and not indirect male line. Taking the Mara Tribe as an example, we find that the organization is as follows :—

Urku	Murungun	Eagle-hawk, yellow-snake, hill-kangaroo, large crocodile, parrot, galah cockatoo, stone, salt-water, and others.
	Mumbali	Whirlwind, poisonous snake, white hawk, crow, opossum, salt-water mullet, stingaree, and others.
Ua	Purdal	Blue-headed snake, large kangaroo, crane, wallaby, little fish-hawk, barramunda fish, rain, little crocodile, and others.
	Quial	Emu, turkey, goanna, white cockatoo, grass-hopper, water-snake, jabiru, kite, groper fish, turtle, and others.

The two moieties, as usual, are exogamous, and the children pass not only into the father's moiety, but also into his class. Thus the children of a Murungun man are Murungun; of a Quial man they are Quial. The totem group also strictly follows the father, and there are groups of totems attached to each class.

On reference to the map it will be seen that, taking the eastern and central part of the continent, much the greater part is occupied by maternal-descent tribes. The tribes, counting descent in the male line, we may divide into two series—(1) strictly coastal tribes living in the south, south-east, and east of the continent, and (2) a large and, on the whole, very homogeneous group of tribes passing across the centre from the far north almost to Lake Eyre in the south, close to which they come into contact with the Urabunna Tribe, which counts descent in the maternal line. It looks very much as if there had been at least two main lines of migration across the continent—one down from the northern coasts and the west side of the Gulf of Carpentaria, and the other following roughly the course of the main streams inland on the east. What exactly served as a line of demarcation between the two streams it is hard to say. In probably Cretaceous times, but not since then, an arm of the sea stretched southwards across the continent for some distance, and, curiously enough, this was situated along the line which later on marked off the two migrating streams. The cause of separation was probably climatic in nature. The western migration may be roughly divided into two, one of which followed down the course of the Diamantina and the Barcoo, so into the Lake Eyre basin, and on southwards along the west coast of Spencer Gulf. The second followed down the Darling, roughly parallel to the first, but keeping to the east of the Eyre basin, crossed the west part of what is now Victoria, and reached the southern coast, and probably also spread gradually over the whole of the eastern part of the continent. Later on, modifications in the tribes comprising each migration must have taken place, and in each instance apparently the modification appeared in the north and gradually spread southwards. The modification of the tribes in the relatively rich and well-watered districts of the south-east corner, leading to great changes and irregularities in their systems of organization, is to be regarded as perfectly independent of the series of modifications to which we are now referring which gradually spread down from the north. Just as we find the simpler organization into two moieties only in the southern part of the migration of what we may call the maternal-descent tribes across the Lake Eyre basin, so in just the same way we find the simpler organization retained in the southernmost of the paternal-descent tribes.

We may now pass on to deal with the ideas and beliefs of certain tribes in regard to the totems and totemic ancestors. The tribes which I will take as examples are the Arunta and Warramunga, representing male-descent tribes, and the Urabunna, representing female-descent tribes.

According to the Arunta ideas, their ancestors who lived in the dream times, or, as they call it, the Alcheringa, were intimately associated with animals and plants—in fact, they were the transformations of these, and so, naturally, bore their names. These ancestors were possessed of greater powers than living men in fact, they made the various physical features, ranges, gorges, water-holes, and trees which now exist in the Arunta country. They were gathered into groups—kangaroo men in one, emu men and women in another, water men and women in another, wild-cat men and women in another, and so on. Every individual carried a sacred stick or stone, called a "*churinga*," with which his or her spirit part was supposed to be associated, and in many cases they carried extra *churinga* with spirits associated with them. Now, the Arunta say that, whilst in most cases all, and in all cases the great majority, of the members of any one group belonged to what is now one moiety of the tribe, there were certain of these early totem groups in which some belonged to one moiety and some to the other. Thus in a kangaroo group all were Kumara and Purula, so, again, in the case of the witchetty grub all were Panunga and Bulthara; but in the wild cats, while the great majority were Kumara and Purula, a few were Panunga and Bulthara. At the present day no totem group is absolutely confined to the one moiety of the tribe, but the great majority of members always belong to it. Right through the tribe we find totem groups scattered locally; one locality, it may be a few miles square, will be especially associated with a kangaroo group, another with a grub, and so on. The Native belief to account for this is as follows: In the Alcheringa the groups of ancestors walked across the country, kangaroos in one direction, cats in another, emus in another, hakea plants in another, and so on. At certain spots each group halted and performed ceremonies, and, more important still, some of the members, as the Natives say, went into the ground, leaving their spirit parts behind them associated with the *churinga*, or perhaps they left some of their extra *churinga* behind. Thus, as they travelled on, each group formed what we may call a local totem centre, which the Natives call an Oknanikilla. If we plot down on a map the routes followed by the various Alcheringa people, marking the Oknanikilla spots, the result is very much like the map of an intricate railway system, the dots representing the stations. Each Oknanikilla is, of course, associated with one totem, though sometimes those of different totems may be very close together. The *churinga* carried by the ancestors are supposed to be actually represented by those which are kept carefully concealed at the spot, in some crevice in the rock, or perhaps a hole in the ground, the exact position of which is only known to the fully initiated members of the group, who periodically visit it, and reverently take out, examine, and rub the *churinga* with grease and red ochre. It is the spirits left behind by these Alcheringa ancestors who are supposed to undergo reincarnation, and thus give rise to the living members of the tribe. If a woman conceives a child at a spot where kangaroo ancestors went into the ground, of course it is one of these come to life again, and therefore it belongs to the kangaroo totem group, and so on through the other groups. The spirits choose their own mothers, and, as a general rule, are careful to be born into the right moiety; but every now and again a spirit chooses the wrong mother, and is born into the wrong moiety. It will thus be evident that the totem follows of necessity in neither the male nor the female line, so that if we take any family we are liable to find its members belonging to different totemic groups. In the Arunta the spirit never changes its totem, but it may, when undergoing reincarnation, change its moiety. The two following actual examples will serve as illustrations of the totem arrangements in this tribe: (1.) Father, little hawk. Wife No. 1, rat; daughter, grub. Wife No. 2, kangaroo; no children. Wife No. 3, lizard; two daughters, one emu, the other water. (2.) Father, grub. Wife, grub; two sons, one kangaroo, the other grub; one daughter, grub.

In the closely allied Kaitish Tribe we find a variation in the belief in regard to Alcheringa ancestors. In a few cases there were a large number of ancestors in each totemic group, but in many there were only a small number, often only two, who walked about the country. They carried plenty of *churinga* and left them at various spots, each one associated with a spirit part. Thus they formed local totem centres, and subsequently the spirits underwent reincarnation. The belief is fundamentally similar to that of the Arunta, but, with comparatively few exceptions, the ancestors all belonged to one moiety, and at the present day it is somewhat rare to find members of any one totem belonging to each moiety. At the same time the descent of the totem groups does not follow, of absolute necessity, in either the paternal or maternal line.

In the Warramunga and allied tribes we find a still further development of the same idea. In every instance save one or two there was only one great ancestor who was in some cases decidedly an animal, but with supernatural attributes, and in others semi-human. He wandered about the country in just the same way in which the Arunta groups did, performing ceremonies and leaving spirit individuals behind him at various spots, the precise equivalents of the Oknanikilla of the Arunta. The black-snake ancestor, for example, left plenty of spirit children in the trees bordering the stream at Tennant Creek, and now no woman will strike one of those trees for fear of releasing a spirit child. Only in one or two groups do we meet with the *churinga* belief. For example, a group of women ancestors carried *churinga* with them with which spirits were associated, just as in the Arunta Tribe. North of the Warramunga this belief dies out. In one other respect also we see a gradual change in these tribes. In the Arunta the members of the two moieties are scattered over the whole country in very numerous groups, which consist mainly, but not exclusively, of Panunga and Bulthara men with Purula and Kumara women, or of Purula and Kumara men with Panunga and Bulthara women. In the Kaitish Tribe there is a greater aggregation of the two moieties, and in the Warramunga the whole of the southern part of the tribal country is occupied by men of the Uluuru moiety (=Panunga and Bulthara of the Arunta) with their wives, who belong to the Kingilli, and their children, who belong to the Uluuru; the northern part is occupied by Kingilli men with Uluuru wives and Kingilli children. In the Warramunga totem groups are strictly divided between the two moieties, so that the children always pass into a group belonging to the father's moiety, and usually, but not always, into the father's totem group.

In the Binbinga we meet with a still further stage in regard to the segregation of the totem groups. Each totem group has one great semi-human ancestor who produced spirit individuals from his body and left them in various places. They now undergo reincarnation in human form. The totem groups are strictly divided between the two moieties, and the child without exception follows the totem of its father. A man may marry a woman of any totem, provided she belongs to the right subclass.

The final stage in the segregation of the totems is met with in the Mara and Anula Tribes, amongst whom there are four classes, two in each moiety, and the totem groups are strictly divided between the classes. This is only possible when descent is direct, and cannot possibly take place in such tribes as the Kamilroi or Warramunga, where descent is indirect. Table I. represents the Kamilroi and Table II. the Mara organization. The moieties are indicated by the capital letters A, B; the classes by the small letters *a*, *b*, *c*, *d*; the totem groups by the numbers 1, 2, 3, 4, 5, 6, 7, 8.

I.

$$\mathrm{A}\left\{\begin{matrix} a \\ \\ b \end{matrix}\right. \left\{\begin{matrix} 1 \\ 2 \\ 3 \\ 4 \end{matrix}\right. \qquad \mathrm{B}\left\{\begin{matrix} c \\ \\ d \end{matrix}\right. \left\{\begin{matrix} 5 \\ 6 \\ 7 \\ 8 \end{matrix}\right.$$

II.

$$\mathrm{A}\left\{\begin{matrix} a\left\{\begin{matrix} 1 \\ 2 \end{matrix}\right. \\ b\left\{\begin{matrix} 3 \\ 4 \end{matrix}\right. \end{matrix}\right. \qquad \mathrm{B}\left\{\begin{matrix} c\left\{\begin{matrix} 5 \\ 6 \end{matrix}\right. \\ d\left\{\begin{matrix} 7 \\ 8 \end{matrix}\right. \end{matrix}\right.$$

In Table I. a man A*a*1 marries a woman B*d*5. The children are B*c*5, so that it is evident that totem 5 must be common to the classes *c* and *d*.

On the other hand, in Table II. a man A*a*1 marries a woman B*c*5. The children are A*a*1—that is, the totems keep within the class. It will be seen, however—arranging the table somewhat differently, thus—

$$A \begin{cases} a \longleftrightarrow c \\ b \longleftrightarrow d \end{cases} B$$

that, if we had only the usual plan met with in every tribe with indirect male or female descent, of men of class *a* marrying women of class *c* and *vice versâ*, and men of class *b* marrying women of class *d* and *vice versâ*, with direct male descent, we should for all practical purposes simply split the tribe into two perfectly independent halves, no one in the group *a* - *c* having any relationship of any kind to any one in the group *b* - *d*. The tribe, in fact, would simply divide into two.

It will be simpler if we use the names of the classes. One moiety consists of the two classes Murungun and Mumbali, the other of Purdal and Quial. In order at one and the same time to allow of descent being counted in the direct male line and to retain the integrity of the tribe as a whole, the marriage arrangements have been deliberately modified. In reality, just as in every male-descent tribe, there are really four groups in each moiety, though, as in the southern Arunta, there are only names for two. We will call the divisions in each case α and β, and can arrange the table thus—

Murungun, α, marries Purdal, α ; children are Murungun, β.
Murungun, β, marries Quial, β ; children are Murungun, α.
Mumbali, α, marries Quial, α ; children are Mumbali, β.
Mumbali, β, marries Purdal, β; children are Mumbali, α.

It will be seen how, under the guise of apparent simplicity—*i.e.*, direct male descent—we have in reality, when we inquire into details, great complexity and high development. We may regard this tribe and the Kulin people as being at two extremes, so far as male-descent tribes are concerned. One shows high development in regard to the class and totemic system; the other almost the complete disappearance of both. It may also be pointed out that, whilst there is no such complexity in regard to tribes with two moieties and direct female descent, yet even in these matters they are not so simple as they seem to be on the surface. It is quite true that a Matthuri wild-dog man marries a Kirara water-hen woman and their children are Kirara water-hens, but, though there are no names for them corresponding to the classes of the Kamilroi and Arunta, yet the groups are there all the same, and only the women of a particular group in any totem or totems are eligible as wives to a man of one special group, just as only a Purula woman is eligible to a Panunga man in the Arunta, an Obuan woman to a Kurgilla in the Wakelbura, or, nominally, a Kubitha to an Ippai in the Kamilroi.

So far we have only dealt with the beliefs of male-descent tribes. We will now turn to the Urabunna, a very characteristic female-descent tribe, closely allied to the Dieri, and sharing with it the moiety-names Matthuri and Kirara, or variants of the same. The tribe occupies the country around the north-west end of Lake Eyre. The Urabunna belief is that in the Ularaka (the Alcheringa of the Arunta) there existed comparatively few individuals, half human, half animal or plant. How they arose no one knows. They lived in the Alcheringa, and behind that it is useless to attempt to pry. These semi-human creatures were the ancestors of the present totem groups. A great carpet-snake creature gave rise to the carpet-snake group, two Jew-lizards gave rise to the Jew-lizard people, and so on. The belief differs from that of the Arunta and agrees with that of the more northern tribe—the Warramunga—in the fact that the ancestors are few in number, and, though *churinga* are now well known to the Urabunna, we hear nothing about their ancestors carrying them. They wandered over the country, creating the various features, hills, creeks, mound-springs, &c., and performing ceremonies. When and wherever they did this they deposited a number of spirit individuals, called *Miaurli* (or sometimes *Murra-murra*), in some natural feature, such as a rock or water-hole which arose to mark the spot. After a time some of these spirits became changed into men and women, who formed the first series of human totem groups. Since that early time the Miaurli have constantly been undergoing reincarnation. In certain cases one particular spot will be associated with Miaurli of only one totem group, but in others the Miaurli of two or more may inhabit the same spot place. Thus one water-hole* is the home of emu, rain, and grub spirits, whilst a group of granite boulders not far away is the abode of pigeon spirits only. Sometimes there appears to be a special relationship between totem groups thus associated with one spot, as, for example, in the case of a water-hole, which is inhabited by spirits of the following totem groups: mosquito, march-fly, blowfly, and sandfly.

In the Urabunna the totems are strictly divided between the two moieties, and the child must follow the moiety and totem of its mother. We meet, however, with the remarkable belief that, at each successive reincarnation, the child changes both its sex, moiety, and totem. Suppose, for example, a Kirara man of the emu totem dies. His spirit, which in the case of a dead man they call *Kumpira*, goes back to the spot

* Every spirit has some special object, such as a tree, rock, or water-hole, with which it is associated. In the Arunta this is called the individual's "*nanja*"; in th Urabunna it is called his "*watthilli*." No animal on or near this will be touched. In the Urabunna, for example, this water-hole is the *watthilli* of the men mentioned, and they will neither drink there nor eat fish caught in it.

at which, in the form of a *Miaurli*, it was left in the Alcheringa. Here it remains until, sooner or later, it is reincarnated. It will not go, the Natives say, into a Kirara woman; if it were to do so it would either be born prematurely or it would cause the death of the woman. It will only enter the body of a Matthuri woman, who, of necessity, belongs to another totem, and thus at every reincarnation every individual changes his or her moiety and totem. Not only is this so, but the sex is changed—a belief which is also met with in the Warramunga Tribe.

Despite this remarkable change of totemic group, the spirit, at the death of the individual, is supposed to go back to the spot at which it was left in the Alcheringa by the old ancestor. If, for example, it were originally a pigeon spirit, it would go back into one of the rocky boulders marking the spot where the ancestral pigeons performed ceremonies in the Alcheringa and left spirits behind them.

The statement is frequently made that tribes counting descent in the male line are in a considerably higher stage of development than those which count it in the female line. Mr. Lang,* for example, says, "as soon as descent of the totem comes by the male line a distinct step in the upward movement towards civilisation and a settled life is made." Without gainsaying the general truth of this, I merely desire to guard against the idea that if we have two Australian tribes, one with maternal and the other with paternal descent, we can therefore come to the *a priori* conclusion that the female-descent tribe, in its customs and habits, is likely to be in any way lower than the male-descent tribe. Nor does male descent lead in any way to a more settled life amongst our Australian tribes than female descents. As Mr. Howitt,† speaking of the Wakelbura Tribe, says, "The hunting-grounds which a man roams over are left by him to his sons, although they do not bear his name." By this Mr. Howitt does not mean "left to" in the sense of a definite act, but that certain tracts of country are regarded as belonging to certain definite groups, and the right passes down from generation to generation. In regard to inheritance of effects, it is somewhat difficult to understand how this should have had anything to do with the primary movement in favour of change from female to male descent. Apart from the fact that the class-name descends in the indirect female instead of the indirect male line, there is very little difference indeed between the customs, habits, and beliefs of two such tribes as the female-descent Wakelbura and the male-descent Kiabara. Everything is strictly governed by custom. Apart from the

* "Social Origins," p. 134.
† "Organization of Australian Tribes," Trans. R.S. Vict., Vol. i., pt. ii., p. 102.

right to roam and hunt over certain well-defined areas, which, as we have seen, is transmitted from father to son just as well in a female-descent as in a male-descent tribe, there is but very little to inherit. A Native's worldly possessions are not much, and really it matters very little to a savage whether he inherits a tomahawk from his mother's or his father's side of the tribe. As a matter of fact, in some male-descent tribes everything belonging to a man is burnt or broken as soon as he dies, so that there is no question of inheriting anything; and in others, such as the Warramunga, the line of inheritance is actually on the mother's side, a man inheriting his mother's brother's effects, such as they are. The important point to notice is that inheritance, where it takes place, is strictly defined in all tribes, and that there is just as much inheritance in female- as in male-descent tribes. It is at least very doubtful whether the idea of inheritance has played any part at all in the change from female to male descent, so far as Australian tribes are concerned.

(II.) THE CEREMONIAL OR DRAMATIC ASPECT.

This side of totemism, the purely ceremonial or dramatic, which must be clearly distinguished from the magical, has probably been strongly developed over the whole of Australia. We meet with it first of all, though not at that time naturally recognised as associated with totemism, in the account, written by Collins,* of the initiation of youths in a tribe on the east coast near to Sydney. He described the performance of a series of ceremonies in which men represented the actions of various animals, such as kangaroos and wild dogs. Howitt,† in his account of the *jeraeil* or initiation ceremony of the Kurnai, speaks of an "opossum game," and mentions also the numerous animal games and dances performed by the Murring Tribe in connection with initiation.

These are only fragmentary accounts, but they show clearly that one of the essential features of initiation is the presentation to the youth of certain ceremonies which are associated with the totemic groups.

Turning to the central tribes, we find that this side of totemism is very strongly developed, though I have no doubt but that, if we knew as much of the eastern tribes as we do of the central in this respect, we should find their totemic ceremonies just as strongly developed. Unfortunately, it is now too late to study many of these tribes. Amongst the central tribes, both in those which have female descent, like the Urabunna, and those which have male descent, like the

* "An Account of the English Colony in New South Wales." 2nd ed., 1804, p. 367.

† "The Jeraeil or Initiation Ceremonies of the Kurnai Tribe." J. A. I. May, 1885. P. 314.

Arunta, we find that these totemic ceremonies form a very important feature. In the Arunta, which we will briefly describe first, as a typical example of the central tribes, when a youth is initiated he is shown for the first time a series of ceremonies which refer to certain of the totemic ancestors of the tribe. The ceremonies have not, of necessity, any relation to his own totem group; the idea of the Natives is evidently to introduce the youth gradually into the secret ceremonies of the various groups.* For these performances, a characteristic feature of which is that the decorations consist of bird's down fixed on to the body with human blood, the Natives use the name "*quabara*," whereas the ordinary dancing corroborees, which any one may see, are called "*altherta*."

Up till the time of his initiation the youth, like the women and children, has known nothing of the secret matters, but during the time when he is kept out in the bush away from the main camp some of the older men will prepare totemic ceremonies which they have the right to perform and show them to the youth, who, it may be remarked, must afterwards make in return a present of food to the performers. Each ceremony is supposed to represent an episode in the life of one of the old Alcheringa ancestors. As a general rule there are only one or two performers, and the whole thing is very crude. Hours may be spent in carefully covering the whole of the head and upper part of the body with red and white down so as to form a definite geometrical design. Every ceremony has its own design, which has been handed down from the Alcheringa. When all is ready the performers squat on the ground, and the youth, who has not been allowed to see any of the preparations, is brought up and told to watch. Then the audience either squats to one side, beating time to the chanting of a refrain, the words of which have no meaning known to the Natives, or else the younger men, shouting "Wha! wha!" loudly, run round and round the performer, who sways about from side to side. Circling closer and closer round him, the men gradually come to a standstill, and the performance is brought to a close by one or two of them laying their hands on his shoulders. When all is over the decorations are removed and the old men tell the youth who the performer represents and what the ceremony means, and then, for the first time in his life, he learns the history of one of the Alcheringa ancestors. Often a sacred pole decorated with rings of down and *churinga* or a massive head-dress will be used. In either case the object represents the totem for the time being, and when the ceremony is over it is taken round and pressed against the stomachs of the old men. They are supposed to

* In the Urabunna an emu ceremony, amongst others, is always shown at this articular time to the youths, and in the southern Arunta an owl ceremony.

be so overcome with emotion when they see the representation of their ancestor that their insides become tied up in knots, which can only be undone by the external application of something which has been used during the ceremony. Everything so used is regarded for the time being as sacred, and is vaguely supposed to be endowed with virtue of some kind derived from its association with the totem.

It is by means of these ceremonies that a knowledge of Alcheringa traditions dealing with the supposed ancestors of the tribe is handed down from generation to generation.

With, of course, differences in detail in regard to the employment of *churinga*, sacred poles, &c., the individual ceremonies are fundamentally alike in all of the tribes from the Urabunna in the south to the Mara and Anula on the shores of the Gulf of Carpentaria. Everything in regard to them is governed by custom, and no variation of any kind is allowed or even thought of. In the Arunta Tribe, while they are regarded as belonging altogether to the totem group with which they are associated, each ceremony is to a certain extent the property of an individual, who inherits it from his father, and along with it any *churinga* or sacred object which may be connected with the ancestor who originally performed and is now represented in the ceremony. He only has, however, a life interest in the ceremony, and cannot give it away; it must pass to his eldest son along with all *churinga* which belong to him, provided that eldest son belongs to the totem group. Failing a son, it will pass to a brother's son.

One feature of importance which is very characteristic of the Arunta and all allied tribes is that only those men who belong to the moiety of the tribe with which the totem group is mainly associated have any right to be present during the preparations, and this right is really only accorded to the elder men. No man of the other moiety may be present without special invitation, and then there must be some very special reason for it. The man to whom the ceremony belongs may, if he choose to do so, delegate the performance of it to some one else, perhaps in return for a favour previously granted or desired in future. The first time that a young man is invited to perform and to actually personate one of the ancestors is a very important moment in his life. There is very considerable difference amongst the Natives in this respect, and if a young man be regarded as *irkun oknirra*—that is, frivolous and much given to talking—it will be long before the old men, in whose hands everything lies, accord him the honour of taking part in the ceremonies other than as a spectator.

In the Arunta, Unmatjera, and Kaitish Tribes only those men who have passed through the *engwura* are regarded as perfectly developed members of the tribe. The *engwura* consists in the performance of a very large number of totemic ceremonies, and may extend over a long time. The one which was witnessed by Mr. Gillen and myself began about the middle of September, 1896, and though the important part was complete just before Christmas, yet the finishing ceremonies were not actually performed until the middle of January. When an *engwura* is to be held one of the old men who is regarded as a leader in totemic matters and is entitled to the name "*oknirabata*" (which means "a great teacher"), after consultation with other old men, sends out a messenger carrying the *churinga*. This messenger is called "*iltjinkinga*" (which means "the beckoning hand"). When he arrives at a strange camp he waits some little distance off in the usual manner until he is approached by one or two of the older men, to whom he shows the *churinga* and delivers his message. Passing on from one locality to another the same performance is repeated, and at the appointed time the Natives assemble at the chosen spot. When once the *engwura* has started, the younger men who have not before passed through it are made to remain on the ceremonial ground, near to which no woman or child may go, or at times they are taken out into the scrub in charge of one or two old men, whose instructions they have to obey implicitly. The whole of the proceedings are under the control of the old *oknirabata*, who, however, constantly consults two or three others among the older men who may perhaps be themselves entitled to be called "*oknirabata*." Sacred ceremonies connected with the various totemic groups are performed day and night, sometimes as many as five or six during the twenty-four hours. Those connected with one moiety are prepared in one spot, which is hidden from that at which those connected with the other moiety are prepared. A striking feature of the *engwura* is the presence of a large number of *churinga* which are used during the ceremonies. These are brought in from various localities by the head men of different totemic groups. Those belonging to the different moieties are stored at special spots, each under the charge of the older men, who alone may approach of sacred objects. No quarrelling of any kind is allowed anywhere near to where the *churinga* are stored, those spots being regarded as especially sacred. Every day the leader decides on the ceremonies to be performed, and under his guidance everything works with perfect smoothness. At certain times large numbers of the *churinga* will be taken out and rubbed over with grease and red ochre, some of the younger men being invited to be present. This is a most solemn occasion, and as the *churinga* are unwrapped one after the other they are placed reverently on the hands of the younger men or pressed against their stomachs while the old men tell them the traditions connected with the Alcheringa ancestors to whom they originally belonged. In some cases they are the *churinga* of men now alive who are regarded as the reincarnations of these ancestors, or of men who have lived within the recollection of those who are now handling the *churinga*.

A curious feature of the *engwura*, with which also certain fire ceremonies are associated, is that at one special stage the whole of one night is spent in painting totemic designs on the backs of the younger men, such designs having of necessity no reference to the totem, either of the young man who is decorated or of the older man who decorates him. The object of this custom may possibly be simply that of keeping alive a knowledge of the sacred designs or *ilkimia* which are associated with the totems.

Passing north into the Kaitish Tribe, we find that totemic ceremonies commemorative of totemic ancestors are performed just as in the Arunta. They are the property of certain individuals, but they are "entailed," and can only be inherited along a certain line. There is only one difference of any importance between the Kaitish and the Arunta ceremonies. In the Kaitish the ceremony is enacted when the owner chooses or is requested to do so, but, in contrast to what takes place in the Arunta, men of the other moiety may not only be present during preparations, but are asked to undertake the actual decoration of the performer. This is an interesting intermediate stage between what takes place in the Arunta and Warramunga.

In the Warramunga group of tribes the ceremonial aspect of totemism is strongly marked, and the ceremonies are very clearly divided between the two moieties. Those belonging to one totem group are under the charge of the head man of the group, and there is no such thing as individuals having proprietary rights in any ceremony. This is to be associated with the different ideas of the Warramunga in regard to the totemic ancestors, as compared with those of the Arunta. Instead of a number of Alcheringa individuals, they have only, as a general rule, one great semi-human ancestor, who wandered about the country performing ceremonies. The head of the totem has, as it were, charge of all totemic ceremonies on behalf of the group, though he always consults with those of the older men, and together they decide upon the performers, &c.

In two points we find the Arunta customs markedly different from those of the Warramunga. The first is the order in which they are performed. In the Arunta there is no regularity in regard to this. Suppose an ancestor, or band of ancestors, performed in the order named a series of ceremonies A, B, C, D, E, F, &c.; the Arunta will perform them in any order, omitting any of them at pleasure. In the Warramunga they always begin at the first and go steadily through to the last one. The second point is of greater importance, and shows considerable and remarkable modification on the part of the Warramunga, as compared with the Arunta. During the preparation of the ceremonies in the latter tribe the members of the moiety with which they are concerned are particular, as a general rule, not to allow any member of the other moiety to go anywhere near to the decorating-ground. Now and again such a man is present, but only by special request. In the Warramunga Tribe the men of one moiety never perform any ceremony without being asked to do so by men of the other moiety. Further still, apart from the actual performers, who must belong to the moiety with which the group is associated, men of the other moiety are the only individuals who are allowed to be present on the decorating-ground. They actually also provide all of the material necessary, blood, ochre, and down, and themselves do the decorating. The Arunta or Urabunna Native would on no account allow members of the opposite moiety to take charge of the proceedings during the preparation of a totemic ceremony. The custom of the Kaitish shows, however, a transition between that of the Arunta and that of the Warramunga.

The totemic ceremonies of the Tjingilli, Umbaia, Gnanji, Binbinga, Anula, and other tribes, which occupy a very large area in the north central part of the continent, are essentially similar to those of the Warramunga, and need not be dealt with in detail.

(III.) THE MAGICAL ASPECT.

When writing in 1887 Mr. Frazer used the term "religious" in respect to the aspect of totemism with which we are now about to deal; but at a later time, when the fresh Australian evidence secured by Mr. Gillen and myself was forthcoming, he inclined to the opinion that the term "magical" would be preferable. In regard to our Australian tribes there can be no doubt of this, and I therefore adopt Mr. Frazer's suggestion.

Beyond the short statement made in some instances that a man will not injure or eat his totem, all of our information in regard to the magical side of totemism is derived from the tribes inhabiting the central area of the continent, from the Urabunna in the south northwards through the Arunta and Warramunga. Over the whole of the eastern area, except in some parts of Queensland where there is very little settlement, the tribes are too decadent to know anything reliable about such matters. In many instances they are quite extinct; but in any case no evidence worthy of credence could now be obtained in Victoria or the greater part of New South Wales. Customs and beliefs in regard to matters such as these, which are considered sacred by the old men and only to be revealed to the younger men after initiation, are amongst the very first to disappear when the white man comes upon the scene. The old men quickly lose their control over the younger men, and absolutely refuse to hand on to degenerate descendants the sacred customs and beliefs associated with the totems. The very first and often-quoted account of the relation between an individual and his totem in Australia is that given by Grey,* who says, "A certain mysterious connection exists between a family and its *kobong*, so that a member of the family will never kill an animal of the species to which his *kobong* belongs, should he find it asleep; indeed, he always kills it reluctantly, and never without affording it a chance to escape. This arises from the family belief that some one individual of the species is their nearest friend, to kill whom would be a great crime and carefully to be avoided."

This idea of a close association between an individual and his totem is widely spread, though the belief that one special individual of the species is a nearest friend is, at most, very rarely met with. The relationship is typically one between the human individual and all of the members of the species of animal or plant which he regards as his totem. In the Wotjoballuk Tribe a Native would not harm his totem if he could avoid it, but when very hungry he would eat it if he could get nothing else. In this tribe also there was apparently the idea, not often met with in Australia, that a person could in some way be injured by injuring his totem. The relationship between a man and his totem may be well exemplified by the remark made by an Arunta man when we had taken his photograph. We were asking him about the matter, and he said, pointing to the photograph, "That one is just the same as me; so is a kangaroo."

There is, however, in Australia very little trace of the feeling of mutual protection between an individual and his totem. They are of the same flesh, and the belief in original descent from the totem animal is, as we have seen, widespread; but there is very little idea of the totemic animal protecting the individual man or woman, and in many cases there is no objection, under certain conditions, to a member of the totem group actually killing his totem and handing it over to other individuals who do not belong to the group. The exact nature of the relationship, and the way in which the conduct of the Native is influenced by it, varies in different parts, and, speaking generally, the development of the magical aspect of

* "Journal of Two Expeditions," Vol. ii., p. 228.

totemism appears to be associated more or less intimately with climatic conditions, so far as these affect the supply of food and water. Unfortunately, no evidence of this side of totemism is available from the eastern side of the continent; but, judging by what we know of its very wide distribution in the central and north central area, it would appear to be very likely that if we could go back half a century or more in time and study the tribes before they became demoralised we should find that the magical aspect of totemism was well developed over the dry interior, and only met with in the form of surviving traces amongst the modified coastal tribes living in well-watered districts. The very centre of the continent is at present the home of its greatest development, and as we pass away northwards, where the tribes can still be studied in their natural condition, and come into districts where the normal rains afford a much more constant and dependable succession of seasons, we find that, though the social and ceremonial aspects are just as strongly developed as in the centre, the magical dies away, until across the watershed and on the shores of the Gulf of Carpentaria, amongst the more highly modified tribes, it is only represented by vestiges, which, however, may be regarded as evidence of its former greater development and wide distribution.

The magical side has been chiefly investigated in the central tribes who count descent in the male line, but it exists just the same in the Urabunna, who count descent in the female line. In the Dieri* also there are unmistakable traces of the existence of the magical side, though the records are very scanty, simply because no investigation into the matter was made in the early days.

In the Urabunna, which is fundamentally similar to the Dieri, the members of each totemic group perform a ceremony the object of which is to insure, by means of magic, the supply of the animal or plant after which it takes its name. In the Urabunna the general name for these ceremonies is "*pitjinta.*" In the case of a snake totem group, for example, the old head man when performing the ceremony was decorated with lines of red and yellow ochre, and wore a special ornament on his head, which, in some unknown way, is associated with the ceremony. When the decorations were complete, he kneeled down and extended both arms at full length. In each hand he held a pointed bone about 10 in. long. A man on his right took the bone from his right hand and pinched up the skin of his arm; at the same time the performer, with the bone in his left hand, pierced the fold of skin. The same operation was performed on the left arm, and then, with arms extended, he sang the refrain,—

* Attention was called to this in "Native Tribes," Appendix B, p. 642.

Lirri watthai umpai
Lara narali tjinta.

When this was over he drew out the bones, and the ceremony was at an end. It must be a rather painful ceremony for the performer, whose arm was marked with numerous scars. As usual, in the case of sacred ceremonies, the words have no meaning known to the Natives, but "*tjinta*" is evidently a contraction of "*pitjinta*." The bones used for piercing the arms was called "*paidni*," and are kept wrapt up in hair which has been cut from a snake man.

After the ceremony, and when snakes have become plentiful, men who do not belong to the totem group go out and bring some in to the old man, saying, "Auuta nanni obma," which means, "Look, here are snakes." He is then presented with a little of the fat, which he smears over his arm and also over the *paidni*, and says to the man, "Unta tana inquari," which means, "You all about eat it." The old man said that, if the men who did not belong to the totem group were to eat the snake without first bringing it in to him, and asking his permission to do so, he would warn them that by-and-by there would be no more snakes.

A somewhat similar ceremony is performed by the head man of a fish group in the Wonkgongaru Tribe, another of the Dieri Nation with female descent. When performing the ceremony for the increase of fish he goes to a special water-pool, and then, having painted himself all over with red ochre, he sits down in the water and pierces the skin of the scrotum and all round the navel with little pointed bones. The blood from the wounds mixes with the water, and is supposed to insure the increase of the fish.

These magic ceremonies, performed under the direction of the head man of the totem group, were first of all described in the Arunta Tribe, where they are known by the name of "*intichiuma*." We will briefly refer to the more important features of those associated with a grub group. When the head man decides to perform the ceremony, the men of the totem group, no one else being allowed near, set out from camp early in the morning, in perfect silence, leaving only one or two old men whose duty it is to prepare a long, low bush hut, which for the time being is supposed to represent the chrysalis out of which the adult insects emerge. The men go without arms or ornaments and fasting must be strictly observed, or else the ceremony would not be efficacious. Each man has a mark characteristic of the totem group on his face. On the rocky side of a gorge in the hills there is a small cave, and in this there is a special stone supposed to represent the body of the adult insect, and around it smaller ones which are its eggs. The large stone is reverently stroked by all the men of the totem group, who meanwhile chant refrains, the burden of which is an invitation to the insect to come and lay eggs. Finally, the party returns to the main camp, following exactly the same track which was taken by the great leader of the grub people in the Alcheringa. All of the men go into the bush hut, and there they "sing" the grub in its various stages. Once or twice the leader comes out and shambles about the ground immediately in front of the hut, in imitation of the adult insect emerging from the chrysalis and attempting to fly. While this is going on the men and women in camp who do not belong to the totem group have to lie face-down on the ground not far away. The women of the group stand peering about as their ancestors are supposed to have done in the Alcheringa, and at the same time they keep watch over the others. Finally, all of the men emerge from the hut, and, for the first time since setting out, more than twenty-four hours ago, are allowed to eat and drink. This is a sign for the men of the other moiety and for all of the women to run away. The men of the group spend the night close by the hut "singing" the grub.

Though the head man fixes the time, the ceremony is always performed when there is likely to be a fall of rain, and consequently an increase in the grubs. When it is over the grub people do not eat the animal at all until such time as it becomes plentiful. Then every one goes out, gathers it, brings it home, and cooks it. When a large supply has been secured the head man goes to the camp, where, under his instructions, all of the men of both moieties are gathered together with their supplies of the grub. First of all, the men who are not of the totem group place theirs in front of him. He takes a little up, grinds it between two stones, eats a few fragments himself, hands a little to the older men of the totem group, and then tells the other men to take all that is left. The same performance is gone through in the case of the supply gathered by the people of the totem group, and after this the latter will only eat very sparingly of the grub; in fact, a strict totemite will not eat it at all.

In the Ilpirra and Unmatjera Tribes the customs are practically identical in all essential features with those of the Arunta. In the Kaitish we find them also strongly developed. The following is an outline of the ceremony as conducted in connection with a grass-seed group. This particular seed is of great use as an article of food. The head man goes to the sacred storehouse, where the *churinga* are kept, clears the ground around it, takes out the *churinga*, and rubs them over with grease and red ochre. He then decorates two of them with dots of down, which is supposed to represent the grass-seed. Then he rubs them together, so that the down flies off in all directions. Meanwhile the men who do not belong to the group have been out in the bush, and bring the old man a present of food. Next day he performs a sacred ceremony associated with the totem group, and for this he is decorated by men of the other moiety, a feature to which we have already referred. For days the man walks about in the bush by himself, carrying one of the *churinga* and "singing" the grass-seed. At night he hides the *churinga* in the bush and returns to camp, sleeping on the opposite side of the fire to his lubra, with whom he must not have intercourse, or else the grass-seed would be no good, and his body would swell up when he tasted it. When the seed has grown he goes out and gathers some, which he takes to the men's camp. There he grinds it, and as it falls over the edge of the stone it is caught in the hands of men belonging to the other moiety of the tribe, one of whom puts a little seed into the mouth of the performer, who blows it away in all directions. Leaving the seed with the others, the old man says, "You eat the seed; it grows in my country and is good." He also instructs his lubra and, through her, the other women to go and gather seed, out of which cakes are made, which he hands over to representatives of the subclasses in the other moiety of the tribe.

In the Kaitish Tribe the fact that the totem group is not only held responsible for the reproduction of the totem, but is regarded as owning it, is very clearly brought out. If, for example, a stranger comes into the locality especially associated with the grass-seed people, he will not eat unless he has obtained the permission of the head man to do so. Even during their ordinary daily life the feeling is very clearly in evidence. If a man kills, say, a kangaroo, and a man of that totem group be in the camp, he will show it to him and obtain his permission to eat it. It is further abundantly clear that the men who do not belong to the totem group hold those who do responsible for providing a supply of the totem for food purposes. The head man is obliged to eat a little, or else he would apparently lose his intimate association with the totem and be unable to perform the ceremony successfully; but he must be careful not to eat too much, or the same result will follow. In the latter case he would, so he believes, be "boned"—that is, injured by means of a charmed bone—by the men for whom he was unable to provide the supply of food which it is the duty of one in his position to supply.

In the Worgaia Tribe, which extends right across to the Queensland border, we meet with precisely the same form of ceremony, and, in addition, the head man performs one or two totemic ceremonies similar to the one in the Kaitish, for which he is decorated by men of the other moiety. In the case of the yam totem, for example, the head man wraps a yam *churinga* up in bark and hides it on the spot at which yams grow. After that he walks about up and down "singing" them. When they have grown he tells the men of the other moiety to go and gather some. They do so, and bring a little up to the head man. He bites a small one, and throws the pieces out in all directions, after which he eats no more, but says to the other men, "I have made plenty of yams for you to eat; go and get them and eat them, and you make plenty of sugar-bag for me to eat."

In the Warramunga and allied tribes, which occupy a very large area in the Northern Territory, and extend eastwards nearly to the watershed of the Gulf coast, we find a further modification as compared with the Kaitish. This consists in a great development of the ceremonial or dramatic part* which has already in the Kaitish, Unmatjera, and Worgaia begun to find its way into connection with a ceremony which, in the Arunta, is purely magical, and is still mainly so in these three tribes. In the Warramunga the dramatic, for some reason, has almost completely ousted the special magical part. The *intichiuma* of each totem group consists, for the most part in all, and in the majority exclusively, of a complete series of ceremonies associated with the Alcheringa ancestor. That we are dealing with a modification of what is found in the more central tribes is shown by vestiges of customs which yet remain in connection with certain of the totem groups. Just as in the central tribes, the members of the totem group are held responsible for the supply of the totem; but, curiously enough, each group only performs *intichiuma* when requested to do so by the members of the other moiety. As previously described, the same men provide everything requisite and do the actual decorating, no men of the totem group, save the performers themselves, being present on the ceremonial-ground until everything is ready. In connection with one or two groups we have remnants left of the magical part. In the white cockatoo ceremony the head man of the totem makes a small object which is supposed to represent the bird, though it has no resemblance to it at all. At one stage during the proceedings he holds this in his hands, and all night long either he or his son imitates, without ceasing, the harsh cry of the bird. In some of the totem groups the whole thing is over when the performances are concluded; the totem is supposed to increase, and no further notice of it is taken by either moiety. In some groups, however, that is not so. In an ant group, the larva of which is eaten, the head man tells the others that they may go out and collect the larva which he has made for them. In the carpet-

* I am indebted to Mr. Frazer for suggesting the term "dramatic" as applied to these ceremonies dealing with and representative of the doings of Alcheringa ancestors.

snake group a man of the moiety to which it does not belong brings one in to the head man of the group and says, "Do you want to eat this?" He replies, "No, I have made it for you; all of you go and eat it." Exactly the same takes place in the case of the honey totem.

Amongst the coastal tribes on the Gulf of Carpentaria we meet with totemic ceremonies dealing with the Alcheringa ancestors, but none of them are performed with the object of increasing the food-supply, nor is it necessary for the head man of a group to perform any special ceremony for this purpose. The increase is supposed to take place without the intervention of any magic. At the same time, they can cause increase by magic if they care to do so, and the ceremonies, though simple, are clearly identical in nature with those of the Arunta. In the Mara Tribe, if they wish to increase the supply of honey for food purposes, the men to whose moiety the totem belongs repair to a spot on the banks of a creek where there is a stone which represents a large bag of honey, carried about by the Alcheringa ancestor of the totem group. They strike small fragments and powder off the stone, and blow this about in all directions, under the belief that it will give rise to bees. So, again, in the Anula Tribe, dugongs are a favourite article of food. At the mouth of a river are some rocks which are supposed to be full of dugong spirit animals which emanate of their own accord, but can also be made to do so by the dugong men "singing" the rocks and throwing pieces of stick at them. The same is true in the case of some rocks associated with an ancestral crocodile. The crocodile men can "sing" it and so increase the animals.

The various *intichiuma* ceremonies above described form an interesting series of stages leading from the fully developed ceremonies of the central tribes to the almost vestigial ones of the much-modified tribes inhabiting the west coast of the Gulf of Carpentaria.

There yet remain certain customs and beliefs to be dealt with in reference to the relationship which is supposed to exist between an individual and not only his own totem, but that of other individuals. The first which we can touch upon is concerned with the eating of the totem. From the time when Grey first stated that a man only injured or killed his totem with reluctance, it has generally been stated that, with certain exceptions, such as the Narrinyeri Tribe in South Australia, the Australian Native abstains from killing and eating his totem. Unfortunately, we have very little detailed information on the subject, and a mere bald statement of this nature told by a Native to an investigator is practically valueless, and may be very misleading. Concerning totemic matters the Natives are very reticent, and when a Native says that he does not eat his totem this may very likely be nearly but not quite the whole truth, and the very little which he omits, partly because it would take him too long to explain matters fully, and partly because he is not anxious to do so, will probably contain the one feature of importance. At the present time, if you ask an Arunta man whether he eats his totem the chances are that the answer will be "No." A strict man, though it is not absolutely tabooed to him, in very small quantities, will not touch it except on ceremonial occasions, but he will assist other men both to catch and to eat it; and, as we have seen, there are certain times when the head man, and, in fact, all of the older men, must eat it, or else they would lose their power of increasing the supply.

The various restrictions with regard to eating vary from tribe to tribe; those concerned with central and north central tribes are as follows: In the Urabunna the individual does not eat his totem at all; but he has no objection to other people killing and eating it. The Arunta practice we have already referred to, but there is one point to which attention may be drawn as indicating the supposed relationship between the man and his totem. An old man of one particular totem group, say the kangaroo, will not eat kangaroo at all under ordinary circumstances, but he will make and charm a *churinga* bearing a design characteristic of his group, and will give it to a man of another totem group so as to assist him to catch kangaroos. In the traditions of the Arunta people very explicit references are often met with to the eating of the totem. Thus, for example, one relates how some men who started out as wild-cat men changed into plum-tree men, and went on eating plums; another describes the wanderings of a hakea-tree woman who set out with a bandicoot woman. The latter painted the hakea woman with down used during a sacred ceremony of the bandicoot totem group, and thereby changed the hakea into a bandicoot woman, who after that went on eating bandicoots. Traditions such as these are on a quite different footing from the very numerous myths, such as those relating to the institution of the classes and marriage systems, which pretend to explain the origin of existing systems. On the contrary, they describe, apparently *à propos* of nothing, customs often totally at variance with those now in vogue, without in any way whatever attempting to lead up to or explain the latter. It is by no means beyond the region of possibility that they do refer back to a time when customs with regard to the eating of the totem were very different from those in force at the present day.

In the Arunta and Urabunna we find a special prohibition relating in the case of the first tribe to the wild-cat, and in that of the second to the eagle-hawk, and also to a smaller hawk called wantu-wantu. According to tradition the eagle-hawk is not eaten because, in the Alcheringa, it used to feed upon blackfellows; and the wantu-wantu, who was its mate, is not eaten because it used to befriend the Natives and assist them to escape.* In the Arunta the wild-cat is prohibited because it is supposed to be productive of a disease. It must at the same time be remembered that in both tribes these particular totems are regarded, apart from this one point, as precisely equivalent to any other totem, and are no more important in any way.†

In the Kaitish Tribe the restrictions are very much the same as in the Arunta; but, as described above, we see developed even more clearly than in the Arunta the ideas that (1) the totem belongs to the group which bears its name, and (2) that group is responsible for the maintenance of its numbers in order that other men may feed upon it. It is of normal occurrence for men who do not belong to a particular group to ask the permission of a man who does to eat his totem. The restrictions in the case of the water group will show the customs of the present day. In camp the head man receives water from a man who belongs to the other moiety. If a stranger comes to the place called Anira, which is the central spot of the water group, he first of all asks the permission of the head man to drink. The head man tells a man of the other moiety to give him some water. After this has been done he is at liberty to drink freely. The Natives say that if permission were not asked, and the same applies in all of the other groups, the head man would "bone" the stranger.

In the Warramunga Tribe and its allies, the Wulmala, Walpari, Bingongina, Tjingilli, and Umbaia, the restrictions are clearly marked. A man is absolutely forbidden to eat either his own or his father's totem. He may, if, for example, he be a kangaroo man, kill the animal and hand it over to men of the other moiety, and there is no objection to his assisting men who do not belong to his totem group to capture and kill his totem. In this group of tribes we meet also with

* A curious ceremony performed during the *engwura*, representing an attack by a party of wild-cat men on a camp for the purpose of killing and eating blackfellows, led Mr. Gillen and myself to the conclusion ("Native Tribes," p. 368) that it might be commemorative of a reformatory movement in regard to cannibalism. The wild-cat men are represented in tradition as feeding on Natives just as the eagle-hawk is in the Urabunna Tribe. The universal and special prohibition in regard to the eating of these two animals is, at all events, suggestive.

† In his article "Sur le totémisme" (L'Année Sociologique," p. 110. 1902) M. Durkheim makes the remarkable statement that the wild-cat is a totem common to the whole tribe. "Le culte de cet animal," he says, "est donc une sorte de culte publique, commun à toute la tribu." This is very misleading. There is nothing which can be called a cult. The wild-cat is associated with the members of the group which bears its name just as any other totem is with its totem group. It is simply an abnormal case of food-restrictions. M. Durkheim advances it as a notable proof of how highly developed the Arunta Tribe is. Unfortunately for his argument, precisely the same universal restriction applies to the two hawks in the, according to him, much more primitive Urabunna Tribe with its female descent and group marriage.

restrictions applying to the eating of the mother's totem. In the Walpari it may be freely eaten, but in the Worgaia it may not be eaten at all. In the Warramunga a man will not kill it himself, and will only eat it if it be given to him by a member of the moiety of the tribe to which it is supposed to belong. The restrictions apply not only to the totem itself, but in some cases to other objects especially associated with it. In the case of the black-snake, in the Warramunga Tribe, the totem group is associated with the Uluuru moiety of the tribe, and the animal ancestor arose at a water-hole close to what is now called Tennant Creek. No member of the totem group nor any woman may ever drink at that pool; the men of the Kingilli moiety may drink freely, and men of the Uluuru moiety, other than those belonging to the group, drink if the water be given them by Kingilli men.

In the more northern parts—in the Binbinga, Anula, and Mara Tribes—the restrictions are much as in the Warramunga; a man will not eat his own totem at all, and only sparingly that of his mother, or if, for example, the latter be a shark, then he will not eat large sharks, but he will eat small ones.

There is one further feature which is not infrequently met with. A Native will sometimes say that he belongs to more than one totem group. After further questioning you will find that, strictly speaking, he has one totem name in the ordinary way, but has a special association with one or more other totem groups. To take special cases: A man of a lizard group in the Arunta Tribe, on being questioned, said at first that he was both lizard and grass-seed; on further questioning, that he was really lizard but very nearly grass-seed. The explanation of this is as follows: In the Alcheringa he was a lizard man or man-animal, but some grass-seed men came near to where he was camped and performed sacred ceremonies of their group in the hope of transforming him into a grass-seed man. They were not successful, and he remained a lizard man; but owing to this Alcheringa incident he regards himself and is regarded as very closely associated with the grass-seed people. He does not eat the grass-seed when it is fresh and young. Or, again, two men of the Wulmala Tribe in the far north said that they had three totems—deaf-adder, opossum, and witchetty grub. The explanation of this was that in the Alcheringa the ancestors of all three totemic groups had left spirit individuals behind at spots very close together. These particular men had actually been left by the deaf-adder, and that was really their totem, but at the same time they regarded themselves as very intimately associated with the opossums and grubs. This locality association is very often met with, and is liable to be misleading unless careful inquiry is made.

In conclusion, we may briefly refer to one or two of the more important features which are revealed by a study of Australian totemism. Except in the case of one or two highly modified tribes, such as the Kurnai,* totemism is spread over the whole of Australia in which the Native tribes have been investigated. The characteristic feature is for the totem groups to be divided between the two moieties into which every tribe is divided, whether the names of the moieties be retained or not. In a few instances (Arunta, Kaitish, and Unmatjera Tribes), whilst the great majority of any totem group are found in one moiety, a smaller number is found in the other. The moieties of the tribes are typically exogamous, and, as the totem groups are usually divided between the two moieties, it follows that they also are exogamous. As a general rule, descent of the totem is counted in either the male or female line, but here again we have the same exceptions. In some tribes (Warramunga) the totem is occasionally not inherited, but it is always one associated with the father's moiety. Regarding the moiety and totemic restrictions on marriage, we find these sometimes coinciding, at others not. On the one hand we have the Arunta, Kaitish, Unmatjera, and Ilpirra, amongst whom the moiety restriction overrides, as it were, the totemic restriction; and on the other hand we have the half-sister marriage in the Kamilroi, in which the totemic restriction overrides the moiety restriction.

A matter of considerable importance is the widespread nature of the belief in the origin of totem groups from spirit individuals left behind by Alcheringa ancestors. These individuals are continually undergoing reincarnation, and give rise to the totem groups as we know them at the present day. Curiously enough, the belief in the Urabunna, a maternal-descent tribe, is more elaborate and less simple in this matter than that of the Arunta and other paternal-descent tribes.

In all of the tribes whose totemic arrangements have been investigated in detail we find the ceremonial or dramatic aspect to be well developed, and there can be little doubt but that the same held true of numerous other tribes now decadent or extinct. The ceremonies in themselves are crude, apart from the simple but often decorative nature of the design drawn on the ground, or on the performer's body. Each one is associated with some special group, and represents some episode in the life of an ancestor of the group. Every male member of the group, after he has been initiated, may be present, and is eligible to take part in the performance. It is by means of these ceremonies that an unwritten history of the

* Since the above was written Mr. Howitt has informed me that he has at last discovered the existence of totems in the Kurnai.

tribe, mythical, of course, for the most part, but none the less quite real to the Natives, is handed down. It may also be added that these ceremonies are just as strongly developed in female- as in male-descent tribes.

The magical aspect has only been studied amongst the tribes which occupy a very large area in the centre of the continent; tribes in other parts have not been studied from this point of view, and, unfortunately, many of them never can be now. That this side of totemism is not recorded in connection with, for example, the tribes inhabiting the eastern interior of the continent is no proof of any kind that it did not exist. It is a striking feature that, as far as can be told, we find this magical aspect most strongly developed in the regions where food and water supply are most precarious. Each totemic group is supposed (1) to own and have control over the natural object whose name it bears, and (2) to be responsible for maintaining the supply of the totem for the use of individuals of other totemic groups.

We have already pointed out* that there have been two streams of migration across the central area of the continent from north to south; of the two streams, one passed right on to the south coast, the other came into contact with it in the Lake Eyre district. Changes seem to have been introduced from the north and to have spread gradually southwards, so that now the most primitive and backward tribes are naturally those at the southern end of the lines of migration—the Dieri Nation in the one instance and the Arunta Nation in the other. Now, the differences between these, so far as we are concerned at present, are that in the Dieri we have female and in the Arunta male descent; and, further, that in the Dieri we have the totem groups strictly divided between the two moieties, whilst they are not thus strictly divided in the Arunta. On the other hand, they both agree in (1) a belief in the origin of the totem groups from Alcheringa ancestors, whose spirit parts are constantly undergoing reincarnation; (2) the strong development of the ceremonial or dramatic side; and (3) the development of the magical side, as represented by the performance of *intichiuma* and the presence of the beliefs associated with this.

There is one point on which it is perhaps advisable to lay some stress. Development does not proceed evenly along all lines at one and the same time. We may have one tribe more primitive and backward than another in regard to the class-organization, and more advanced in regard to totemic matters. It would be a great mistake, for example, to take the Dieri or Urabunna Tribe and say that everything in regard to its organization, customs, and beliefs must of neces-

* "Native Tribes," p. 113.

sity be more primitive and backward than anything met with in the Arunta Tribe, simply because the Urabunna and Dieri have retained the two moieties and have no classes like those of the Arunta. In that respect they are more backwards, but it is quite possible that in other respects they may be more forward. Undoubtedly, our most unmodified tribes are to be looked for in the central area of the continent, where they have been most shielded from outside influence; and, when amongst all of these tribes, whether they count descent in the male or female line, we find beliefs in the primary right of a totem group to its totem, and at the same time an obligation laid upon the members of the group to maintain the supply of the totem for the use of other people, who only eat it after obtaining the permission of its lawful owners to do so, we may feel quite sure that these two ideas are at least of very ancient standing in regard to totemism, so far as Australia is concerned.

So long as these and other beliefs above mentioned were only known with certainty to exist in the Arunta and other allied tribes, it was possible to regard these as "sports" or as highly modified; but in the light of our present knowledge this idea is clearly untenable. I would also point out what later work in respect to this matter has so clearly demonstrated—that negative evidence is of very little value. At the present time the Natives in central Australia carry on their ceremonies in secrecy, without the few white men who are scattered over the country knowing anything about them. Even an investigator, trusted enough by the Natives to be allowed to witness the initiation ceremonies, might very easily overlook the main mass of totemic ceremonies unless he happened to be present at the particular time when they were being performed or made special inquiries about them. That ceremonies and beliefs, possibly in detail different from, but probably in essential features akin to, those of the central tribes, have not been described is no evidence at all that they did not exist. I have myself very little doubt but that such did exist, very widely scattered amongst all of the interior tribes of Queensland and New South Wales, just as we know that they do amongst the central tribes of South Australia. At first they were supposed to be peculiar to the Arunta and allied tribes. Later on Mr. Gillen and myself were able to show that they were present in the whole of the large Warramunga Nation, stretching northwards to the watershed in the Gulf country, and still later we were able to add the Urabunna Tribe, with its maternal descent and still-existing group marriage.

With regard to the origin of totemic names and groups, we may, of course, as Mr. Lang does, form guesses, but they will at best be guesses, devoid of anything save the most indirect and shadowy evidence in support of them. The only evidence which we have, or can hope to have, of anything like an early totemistic stage is such as we can gather from a knowledge of our Australian tribes, and it is to central Australia more especially, I think, that we must turn for what evidence we can hope to secure.

Mr. Haddon has suggested that the name was originally given because in certain parts one animal or plant formed the staple food of the people. So far as Australia is concerned, there is but very little evidence in support of this theory. At the present day, except that, of course, sea-fish do not exist in the interior, and so the interior tribes do not have totemic groups of this name, nor *vice versâ* do the coastal tribes have groups named after certain grass-seeds which only grow in the centre, in every part we find that there are totemic groups bearing the names of all edible animals and plants, and, so far as we can judge, every group of Natives has simply used as food all the edible objects which were to be found in its district. Kangaroos and emus are met with everywhere in Australia, but they have never been the exclusive or even chief food of any one group of Natives. We may feel certain that the origin of totemic names is not associated in the first instance with the staple food of local groups of individuals, because the Native—and the more primitive he is the more likely is this to be the case—feeds upon everything edible which grows in his country. Mr. Lang has suggested that we had, to begin with, a series of families, each consisting originally of an old male with several females. At what exact period these originated or why and whether the families were cut off from larger groups we are not told. The old male is supposed to have jealously guarded his harem of wives and daughters, driving the sons forth to secure mates as best they might. In some way these groups were given names by outsiders, and thus in nicknames we have the origin of totemic names. It is at least somewhat curious, and also not devoid of suggestiveness, that, at all events, by far the great majority of such names should be those of edible objects. It is equally suggestive that they are never names implying some personal feature, such as Long-nose, Long-haired, Pot-bellied, and so on, which nowadays are the nicknames applied by savages to outsiders, as well as to one another. The sons had to marry outside the group, and thus we have strict endogamy so far as the father is concerned, and exogamy so far as the sons are concerned. The latter are supposed to have brought in their women to the paternal group. On this theory, as the original old males must have been at least fairly numerous, there must, one would think, have been a correspondingly numerous series of groups, each made up of a central family with younger men of the same totem and women of different totems—say, an old kangaroo male, with his kangaroo wives and children, and younger women, the wives of his sons, belonging to other totem groups—emu, rat, wild-dog, and so on. But to account for the moieties, Mr. Lang, if I understand him aright, supposes that there were only two original families, and so on this theory we have our two moieties developing out of two ancestral family groups and bearing the names respectively of the heads of these families. Quite apart from the remarkable mixture of endogamy and exogamy, or, at least, of marriage within and without the family circle, with which this presents us, and for the existence of which I am not aware of any evidence, it is difficult to understand why there should be just two, and no more nor less, of such families. Mr. Lang himself states that the sons would bring in emu, rat, wild-dog women, &c., which postulates the existence of groups bearing their names. Now, if so, surely in each one of these groups the same process would be taking place, and we should have in one locality a central emu with subsidiary kangaroo, rat, wild-dog groups; in another a central rat with subsidiary emu, wild-dog, kangaroo groups, and so on. Mr. Lang's theory, when examined closely, will in no way, I fear, help us to solve the problem associated with the bisection of the original horde.

In attempting to deal with the origin of the social, dramatic, and magical aspects of totemism, it appears to me to be useless to attempt to treat of groups of human beings at an earlier period than that at which they had acquired the power of speech and very considerable reasoning faculty. Even on Mr. Lang's theory the very fact that the sons with their wives returned to the father's group, and the fact that they had group names, show us a stage of development considerably higher than anything met with amongst the brutes.

We must start with a series of groups named after material objects—how they got their names it seems to me hopeless at present to inquire. The one striking and important point is that they are characteristically the names of edible objects, and have evidently nothing to do with nicknames. These groups probably varied in size, much as local groups do at the present day. I cannot see that there would be any more difficulty in the matter of commissariat in those days than there is now. It is not difficult to understand, granted the existence of names, that in accordance with savage logic the idea of a close connection between the members of a group and the material object after which it was named would inevitably follow. At this time, I take it, there was no objection to a man eating his totem. Gradually the idea would arise that the individuals of the totem group were responsible for the totem. An intense belief in magic is deep-rooted in the savage, and probably during a time when they were rather badly off for food some superior and ingenious old man may have hit upon the idea of using magic to increase his totem. The idea, once started, would spread from one group to another, more especially if, owing to the fall of rain at a fortunate moment, the old man's magic appeared to be successful. An institution such as *intichiuma* must have had its origin as a deliberate invention on the part of a Native. Possibly it may have been in the first instance the result of a dream—a fertile source of suggestion amongst savages.

The introduction of *intichiuma*, which I regard as the earliest function of a totem group as revealed to us in Australia, clinched still more firmly the belief in the close association of the members of the group and the totem. Myths would naturally arise to explain this, and so we find the Alcheringa ancestors introduced and ceremonies of a dramatic nature referring either to the ancestors or to the totem itself. Such ceremonies are those which are shown to the youths probably everywhere during initiation.

Later also than the introduction of *intichiuma*, and possibly side by side with the development of the dramatic ceremonies, the social aspect of totemism was developed, and here I can see nothing for it but to postulate deliberate action on the part of savage man. Mr. Lang even is inclined to allow this for certain of the later stages, and I do not see where to draw the line between what was and what was not deliberate action. As soon as groups were formed there would arise intercourse of some kind between them. It is sometimes assumed that primitive groups such as these must have been hostile, but this is a mere assumption. Curiously enough, we find, judging by such accounts as we have of them, that there was much more hostility amongst the much-modified groups of tribes in the south-eastern part of the continent than there is to-day amongst the much more primitive tribes of the centre. Unless we conceive the formation in some inexplicable way of two main totem groups and the subsequent coming-in of minor totem groups, two by two, in such a way that each attached itself to one of the moieties thus in course of formation,* I do not see how what has been called "the great bisection" of the tribe could have been other than deliberate. Not only is this so, but I cannot further understand how on Mr. Lang's theory

* If this implies anything, surely it is deliberate action. Mr. Lang's theory indeed, if I understand it aright, necessitates such deliberate action on the part of a considerable number of groups or individuals acting independently of one another. Our theory requires it on the part of one man of superior intelligence who has influence enough with his fellow-elders to make them agree with him and to aid him in carrying out his plan.

the attachment of minor groups to two original primary totem groups in such a way that the totem groups should be divided between the two moieties was otherwise than a most deliberate action, unless we are prepared to grant that it was an unparalleled piece of good luck.

I am quite at one with Mr. Howitt in regarding this deliberate action as an essential feature. There may have been what Mr. Lang has called a tendency to exogamy. I still prefer to say that at some early time the feeling arose that some further form of organization was necessary beyond that of the totemic groups. The idea, judging by the present-day savage, might simmer in the mind of some older man for a time, until, perhaps at some gathering of a number of groups, he spoke of it to one or two other old men, and between them they would evolve a scheme. The natural and simplest thing would be the division of the groups into two series. The scheme would be further discussed at subsequent gatherings, and finally adopted. At first it might apply to only a certain local area, but a change introduced at any one spot would have much the effect of a stone thrown into a pool; the circle of change gradually increasing in size would spread further and further. Groups in any one district adopting the change would pass it on to more distant groups. The change could only consist in the arrangement of the totem groups at first into two main divisions or moieties, and thus in the great majority of tribes the totems are strictly divided between the two moieties. I may say, in passing, that the evidence that the names of these two moieties were originally those of totems is extremely meagre. Tribes in which this is so, or is reputed to be so, occupy only a minute fraction of Australia, and in one of these, the Kulin, the chances are that the terms are by no means the equivalents of primitive moieties.

The formation of the tribes, with their widely different dialects, is a very difficult matter to explain. One of the most striking features in regard to the tribes occupying a very large area, such as that of the centre of the continent, is the remarkable agreement in essential points in regard to customs and beliefs, and, at the same time, the sharply marked difference in their dialects, which prevents a man of one tribe from understanding a man of another. Whilst customs and beliefs were undergoing development there could not have been any isolation of groups of people corresponding to the tribes and tribal divisions as we know them now. On the contrary, the striking fundamental agreement in regard to so many important points indicates that for a long time there must have been easy communication between the groups scattered over wide areas. These early groups on the present theory were totemic groups. At a later period there took place, for some reason, an aggregation of the groups, first into larger communities, outlining the nations into which the tribes can now be arranged, and, still later, further segregation took place within the larger communities, giving rise to the present tribes. In the case of the greater part of Australia, the climatic conditions in what were Pleistocene, probably even late Pleistocene, times were much more favourable than at the present time. Possibly the segregation of the early groups may have been associated with the oncoming of unfavourable climatic conditions, the segregation really consisting in the drawing-in of the groups towards various centres, where the physical conditions were more favourable than elsewhere. Intercommunication between the groups would become less and less frequent on anything like an extensive scale, and thus in course of time the various dialects arose. While words can become easily modified, it is quite otherwise with customs and beliefs, more especially those associated with sacred matters, and so it came about that side by side with remarkable homogeneity in regard to customs and beliefs we find an equally striking difference in regard to dialects.

There is a difficulty in regard to the somewhat irregular division of the totem groups between the two moieties in the Arunta Nation. Amongst some tribes, such as the Arunta, Unmatjera, Kaitish, and Ilpira, the subclasses strictly regulate marriage. Before the division into the moieties took place we must have had the totem groups, and probably what is true now was equally true then—there was a close association existing between certain groups. For example, we have a very large and important wild-cat group associated closely with a bat and a frog group. In other places we find the white bat, an important group with smaller groups associated with it. This association is supposed to exist because the various ancestors of the groups in question foregathered in the Alcheringa. Now, when the division of the groups into two moieties took place, this difficulty of associated groups would be met with. It is quite conceivable that in one area a large white-bat group might go into one moiety, and in another area a large wild-cat group might go into the other moiety. The latter, if it had a small and numerically unimportant white-bat group associated locally with it, might, so to speak, drag the white bat into its own moiety, and thus we should have the great majority of any one group belonging to one moiety but a small minority in the other. In connection with this, it must be remembered that, as a matter of fact, the great majority of the members of all local groups associated with any one totem always belong to one moiety of the tribe. In the Kaitish the cross-division is less strongly marked, and in the Warramunga it has not quite, but almost totally, disappeared. In early days probably the totem did not regulate marriage—that is, not until the groups were divided into two moieties; the idea of exogamy, as associated with the totem groups, arose with the deliberate formation of two exogamous moieties. In the Arunta and allied tribes we still see in the occasional, though rare, marriage of individuals of the same totem group a vestige of an older stage before there were any such things as the classes which now strictly regulate marriage in these tribes.

Taking all of the various beliefs into account, I am inclined to think that we meet with the most primitive ones, in regard to the ceremonial and magical aspects of totemism, in the tribes which occupy the secluded centre of the Australian Continent. These tribes comprise both the Arunta and its allies counting descent in the paternal line, as well as the Urabunna counting descent in the female line. In others the first to disappear has been the magical, just as it was the earliest to appear in history. At the present day we find this aspect of totemism most developed in the more interior parts, but vestigial amongst the modified coastal tribes, who also inhabit better country. The ceremonial or dramatic side of totemism was undoubtedly well developed over the whole continent, and it persisted in certain parts after the magical had disappeared. The social aspect of totemism, which plays so large a part in the organization of almost all Australian tribes at the present day, was the last to be developed. It was based upon the previous existence of totem groups in which the two beliefs were firmly held that the members of the group were closely identified with the totem, and were responsible for securing its maintenance as a food-supply by means of magic.

No. 1.—A COMPARISON OF WORDS IN THE MAORI AND CELEBES LANGUAGES.

By Edward Tregear.

In presenting a paper concerning a comparison between the languages of Polynesia and Malaysia it may be well, as a preface, to give a brief account of the position of the inhabitants of the Malay island in question.

Celebes is a large island to the eastward of Borneo, and is separated from it by the Straits of Macassar. It contains about half a million inhabitants, dwelling on four peninsulas which twist outward from a common centre, and thus, with many bays and harbours crowned with luxuriant tropical vegetation, the country presents a most picturesque and beautiful appearance. It is important in linguistic studies to note such characteristics, as the accessibility and trading capabilities of a people affect their speech and render it much more receptive than that of races dwelling in the interior of continents or large islands.

The Natives are divided into many tribes, and speak a great variety of dialects. The larger number of the inhabitants are of Malay stock, these having driven the original negrito inhabitants, the Minihassis, to the mountains of the interior. The Bughis occupy a southern peninsula, and in the same locality the Dutch have authority over the Kingdom of Goa, with Makassar as their chief town. It is these two dialects only—viz., the Bughese and Makassarese (properly Mangkasara)—which will be touched upon in this paper, as the Orang Baju, the Orang Malayo, the Turajahs, Minkokas, and others are either inferior and scattered tribes or have not had their languages properly collected. Dutch scholars have, however, devoted enormous labour and most exemplary diligence to the language of the leading peoples, the Bughis and Makassarese, and among these scholars Dr. Matthes, of Celebes, is one deserving the highest honour.

With the exception of the wild tribes, the people of Celebes profess Mohammedanism; but it must not be forgotten that up to the year 1600 A.D., even after the arrival of the Portuguese, they were of the Hindu religion. Remembrance of this important fact must be borne in mind during the difficult work of comparing languages in the Malay Archipelago. So far as scholars have been able to fix a chronological order, the ethnical history of this part of Malaysia was as follows:—

1. The islands were inhabited by a negrito or Papuan people known generally as Alfuros (a term given by the Portuguese), but in Celebes as Minihassis. These negrito tongues are as diverse as Papuan dialects—even in one island—usually are.

2. An invasion occurred, probably from south-eastern Asia, wherein a yellow people, known as Malays, drove the blacks back into the forests and mountains of interior districts of the larger islands. The Malay language contains many words apparently related to Polynesian.

3. The Malays received the Hindu religion somewhere about 70 A.D.

4. Arab traders appeared (*circum* 1206 A.D.), and converted the Natives of many islands to Mohammedanism. The people of the Celebes did not embrace Islam until 1495, the year before Vasco di Gama passed the Cape.

Considering, then, this very brief and bald statement of the position, some of the difficulties to be dealt with are at once apparent. Here is a people of unknown origin, but almost certainly an immigrant people. Their language has been certainly affected by the negrito words of the superseded aborigines; by Hindu and Sanscrit words learnt during centuries of religious teaching and practice; by Arabic and Persian terms introduced in creed and trade; by Portuguese, Dutch, and other modern European words borrowed during commercial and legislative transactions. This supersession of language on language is more common than we usually give credit for, just as we talk about an English language when it is British overlaid with Saxon, Saxon with Danish, Danish with Norman, and finally crowded down with Greek and Latin. However, we have here in Celebes, as in English, some knowledge of the processes through which the language has passed, and can thus partially avoid pitfalls.

It may be asked of what use is it to compare Celebese dialects with Maori. I answer that, to the best of my belief, it is in languages belonging to this locality that we may eventually get a key to the history and the wanderings of the Maori people. The Malays occupy the gateway through which the Polynesian people passed to the Pacific. Here and there in the Archipelago colonies were left, or remnants of the expeditions not fitted to go farther in search and exploration. At each successive stopping-place, necessary for safety or food-production, the weak and unadventurous would be left behind, and some of these resting-places are still to be found both in Malaysia and in the Papuan Islands. I am not aware that Celebes was one of these places, but I feel almost certain of Bima in Sumbawa, as of Sikayana (Stewart's Atoll) and of the Motu people at Port Moresby, in New Guinea. Nevertheless, the study of the Celebes dialects gives some very interesting facts, and, although these dialects are not so related to Maori as that of the people of Bima, they disclose much pregnant information.

Although I believe, as I have said, that much of the riddle of Polynesia will be solved in the Malay Archipelago—that is, as a stepping-stone interpretation to the further riddle of the place of origin in Asia or Europe—this will not be done by me or by any man now living. The work is enormous, even in regard to one or two dialects. A man could give up his whole life in preparation and in writing many volumes on the connection between Maori and the Celebes languages, but even then he would not be competent to speak with absolute authority until others who had been similarly occupied in Malacca, Java, Borneo, the Sumatras, the Philippines, the Sulu Islands, Timor, Flores, &c., had also brought to him the fruits of their labours. He would require also the whole languages of the Pacific and of Asia before he could view the subject with certainty, and he must know intimately the history of religion in India and Arabia to accurately estimate the influence of creeds on language. This would take him back beyond pre-Vedic Sanscrit and Zend, so as to know what Aryan words were borrowed from aboriginal languages, and *vice versâ*, before he could know which side had borrowed. That is to say, if students devote their whole time for centuries in getting together the material (material vanishing each hour with dying tribes), then the wise men who will follow long after we are dead will probably know where we can only conjecture.

I may instance as an example of the extreme difficulty at present the Fijian word *adi*. It is used as a woman's title, as we prefix "Lady": *e.g.*, "Adi Cakobau"—Lady Thakombau, a daughter of the late King of Fiji. There is reason to suppose that it was known in Polynesia proper and even in New Zealand formerly. In Malay it is a title of nobles, as "Adi Bernelam Rajah." I for a long time considered the use in Malay to have sprung from a Sanscrit word *adi*, "first prior, pre-eminent"; but later find reason to think there is a possibility that *adi* should be *adji*—that is, the Arabic *hadji*, a Mussulman who has made the Mecca pilgrimage, and from meaning "a holy man" has become a Native title, as even among the Sea Dayaks *aji* means "to enchant, charm, work miracles."

If we grant that words agreeing in sound and sense may be compared, and particularly if by either historical or geographical connection they can be linked together, then will arise this question, "If these peoples use the same words for the same thing, which way were the words moving—east or west?" I answer that if we can take as our guide the disappearance of letter after letter by attrition or neglect, then the movement has been eastward. Even in Polynesia we often (but not invariably) find this. The Maori *kaki*, "the neck," becomes in Tahiti *ai;* the Maori *whare*, "a house," is found in the Marquesas as *hae*. In Malaysia this, too, is a common rule, although there also not invariable. There is reason to think, for instance, that the Maori word *ua*, "rain," was originally *surangi;* and in the Archipelago we get the gradually depleted forms between the two—viz., *hurani, hulani, ulani, ulan, udan, uda, ua.* Now, *hurangi* or *sulani* has a transparent meaning—it is "heaven-milk," or "sky-drip" (the Vedic clouds were "cows")—whilst if we had only Maori *ua* to go on we could not even guess its meaning, although another Maori word—viz., *touarangi*, "rain"—has nearly kept the older form.

We will now proceed to details:—

Malay, &c. (B) = Bughis. (M) = Makassar.	Polynesian, &c.
1. (M) *Aka*, a root. Mal., *akar*, roots of a plant; a scandent plant: *ākar*, root, origin, principle (this latter word said to be Arabic). Salayer, *akar*, a root. Sulu, *akag*, a root. Dayak, *akar*, a root.	Maori, *aka*, long fibrous roots; the name of certain climbing-plants. Tongan, *aka*, the roots of trees. Rarotonga, Paumotu, Futuna, &c., *aka*, a root. Guadalcanar (the Solomon Islands), *oka*, a root. Fiji, *waka*, the fibres or roots of a tree.
2. (B) and (M) *Awu*, ashes. Mal., *abu;* Java, *awu;* Sulu, *abu*, *id.*	Tongan, *afu*, spray or mist of the sea; *efu*, dust; *efuefu*, ashes. Fijian, *dravu*, ashes. Samoan, *efu*, dust; *lefu*, ashes. Futuna, *afu*, smoke; *afuafu*, fine rain. Guadalcanar (Solomon Islands), *ravu*, ashes.
3. (B) and (M) *Anging*, wind. Sulu, *hangin*, *id.* Mal. and Sunda, *anging*, *id.* Java, *hangin*, *id.* Tagal and Bisaya, *hangin*, *id.* Silong, *angin*, *id.* Dayak, *angin*, *id.*	Maori, *angi*, a gentle breeze (cf. *matangi*, wind; *hengi*, to blow gently). Samoan, *agi*, to blow (of the wind). Tongan, *agiagi*, to begin, to spring up as a breeze. Mangarevan, *agi*, a zephyr. Paumotuan, *hagihagi*, light, elegant. Tanna, *agiagi*, a gentle wind. Bula'a, *agi*, wind; *agila*, breath.
4. (B) *Asso*, a day. (M) *Allo*, a day.	Maori, *aho*, radiant light; *ao*, daylight. Samoan, *aso*, a day. Tongan, *aho*, a day. Rotuma, *aso*, a day; the sun. Niue (Savage Island), *aho*, a day.
5. (M) *Ate*, the lung (*ati*, the heart). (B) *Ate*, the liver (*ati* and *ate*, the heart). Mal., *ati*, the liver, the heart; *hati*, the heart. Sulu, *hatai*, the heart, mind. Java, *ati*, the heart. Sunda, *ati*, the heart as the seat of affection, &c. Mindanao, *ati*, the liver. Tagal, *atay*, the liver. Malagasy, *aty*, the liver, the inside.	Maori, *ate*, the liver, the heart as the seat of affection, &c. All Polynesia, *ate*, the liver. Motu (New Guniea), *ate*, the liver. Efate, *ate*, the soul. Fiji, *yate-na*, the liver.

Malay, &c. (B) = Bughis. (M) = Makassar.	Polynesian, &c.
6. (B) and (M) *Bapa*, father. Mal., *bapa*, *id.* Malagasy, *baba* and *apa*, *id.* Dayak, *bapa.* (Probably a "sound-word"—known right through Asia and Europe.)	Maori, *papa*, father. Hawaiian, *papa*, an ancestor. Samoan, *papa*, a general name for the titles of high chiefs. Tongan, *aba*, to venerate; *abaaba*, the master of ceremonies at a *kava*-drinking party.
7. (B) *Baba*, the mouth, as of a river, of a gun, &c. (M) *Bawa*, *id.* Malagasy, *nava*, the mouth. Panayan (Philippines), *baba*, the mouth Dayak, *bah* and *bawa*, the mouth.	Maori, *waha*, the mouth (*waha-roa*, the entrance to a fort). Tahitian, *vaha*, the mouth. Futuna and Aniwa, *fafa*, the mouth. Espiritu Santo, *vava*, the mouth.
8. (B) *Baka*, the bread-fruit tree. (M) *Bakara*, *id.*	Maori, cf. *paka*, dried. Tahitian (loses *k*), *paa*, the external crust of bread-fruit.
9. (B) and (M) *Batu*, a stone. Mal. and Battak, *batu*, *id.* Java, *watu*, *id.* Sulu, *bato.* Dayak, *watu.*	Maori, *whatu*, a stone. Samoan, *fatu*, *id.* Futuna, *fatu*, *id.* Solomon Islands, *patu.* Ponape (Caroline Islands), *pat.* Bismarck Archipelago, *wat* and *watu.*
10. (B) *Baine*, woman, wife. (M) *Bahine* and *baine*, *id.* Mal., *bini*, a wife. Bouton (island south of Celebes), *bawine*, a woman. Sunda, *bebene*, a sweetheart. Madura, *bahine*, a woman.	Maori, *wahine*, a woman, a wife. Tahitian, *vahine*, a woman. All Polynesia, *vahine* or *vaine.* Yap (Carolines), *papine*, women.
11. (M) *Badji*, best, excellent, just; to gratify. Mal., cf., *bayik*, good, well, right. Dayak, *baik*, good. Salayer, *baji*, good. (Cf. Java, *butje*, good; but this word is apparently allied with Sunda *budi*, understanding, and this latter is Sanscrit *buddhi*, wisdom.)	Maori, *pai*, good, pleasing, suitable. (This is explained in a note further on.)
12. (B) *Baru*, new. (M) *Beru* and *bau*, new. Mal., *baaru* or *bharu*, new. Kisa, *wohruworhu*, new. Dayak, *bauch*, new. Bima, *bou*, new. (See No. 110, *waru*, hibiscus.)	Maori, *hou*, new (cf. *hou*, to fasten together). Tahitian, Marquesan, Mangarevan, Paumotuan, *hou*, new. Samoan, *fou;* Tongan, *foou;* Fijian, *vou*, *id.* Bakian (of Epi in Melanesia), *bou*, new. Efate, *fao*, new. Melanesian Futuna (there are two Futunas), *fau*, new.
13. (B) *Bila*, lightning. (M) *Kila*, lightning; *lepa*, to lightning. Mal., *kilat*, *id.* Sunda, *kilap*, to shine, glitter. Kawi, *kelap*, lightning. Java, *kilap*, lightning. Gani (Moluccas), *kuilat*, lightning. Kisa (Saraswati Group), *uila*, lightning.	Maori, *uira*, lightning; to flash (cf. *rapa*, to flash forth suddenly). Hawaiian, *uila*, lightning; *huila*, to give a sudden light; *lapa*, to blaze, as a fire.

Malay, &c. (B) = Bughis. (M) = Makassar.	Polynesian, &c.
14. (M) *Bodo*, short; to shorten. (B) *Pontjo*, short. Bima, *poro*, short.	Maori, Tahitian, Marquesan, &c., *poto*, short. Sikayana (Stewart's Atoll), *botoboto*, short.
15. (B) and (M) *Balawo*, a mouse. Matu and Kanowit (Dayak), *belabau*, a mouse. Kayan (Dayak), *lavo*, a mouse. Malagasy, *voalavo*, a rat. Bima, *kalavo*, a mouse.	Fiji, *kalavo*, a mouse. Nifilole (Santa Cruz Group), *lavu*, a rat.
16. (B) *Boko*, the after-part (cf. *bokoulu*, the occiput, back part of the head; *bokolima*, the back of the hand). (M) *Boko*, the after-part; to leave behind; a back door (cf. *bokong*, to take a weight on the back; *bobokong*, the part along the backbone, the buttocks). The Dayak dialects have *bok*, *abok*, *ubok*, hair of the head.	Maori, *upoko*, the head. Samoan, *ulupo'o*, the skull. Hawaiian, *poo*, the head (Hawaiian drops *k*); *pane-poo*, the back part of the head. Tongan, *ulupoko*, the skull.
17. (B) *Bola*, a house; *bolabola*, a small house, a crib. (M) *Balla*, a house. Tidore, *fola*, a house.	Maori, *pora*, a ship; a mat; flat-roofed. Samoan, *pola*, plaited cocoa-nut leaves enclosing a house. Tahitian, *fare-pora*, a small neatly thatched house on a Paumotuan canoe. Tongan, *bola*, the cocoanut-palm leaf plaited for thatching.
18. (B) *Bubu*, to well up, as water. (M) *Timbuburu*, *id.* Ilocan, *bubun*, a well. Dayak, *pupu*, froth, foam.	Maori, *pupu*, to bubble up, to boil (cf. *koropupu*, to boil; *puna*, a spring of water; *pupuhi*, to spout water, as a whale). Tongan, *bubu*, steam. Mangaian, *pupu*, to bubble up.
19. (B) *Bulu*, hair, down, feathers. (M) *Bulu*, *id.* Mal., *bulu*, *id.* Java, *wulu*, *id.* Battak, *imbulu*, *id.* Bima, *wuru*, hair on the privates. Dayak, *bulu*, coarse hair, down, feathers.	Maori, *huruhuru*, coarse hair, feathers. Samoan, *fulufulu*, *id.* Rarotongan, *uru*, *id.* Bula'a (New Guinea), *pulu-pulu*, feathers.
20. (B) *Buwa*, fruit. Mal., *buah*, fruit; *bunga*, a flower. Sulu, *bunga*, fruit. North Borneo, *buah*, fruit; *bunga*, flower.	Maori, *hua*, fruit; *pua*, a flower. Hawaiian, *pua* and *puwa*, a blossom. Samoan, *fua*, a flower, a fruit. Tongan, *fua*, fruit. Fijian, *vua*, fruit.
21. (B) and (M) *Bukku*, a knot, hump, protuberance. Mal. and Battak, *bungkul*, a hunch. Favorlang (Formosa), *bogh*, belly.	Maori, *puku*, a swelling; the abdomen. Rarotonga *puku*, the belly. Marquesan, *puku*, a knot in wood; a tumour. Paumotuan, *puku*, a protuberance. Efate, *buka*, swollen.
22. (B) and (M) *Dere*, to roll. (M) *Rere*, to ripple (cf. Mal., *leleh*, to flow, to stream). Bima, *leli*, to melt away, to run away.	Maori, *rere*, to run, as water; to fly, leap, sail, move, &c. Hawaiian, *lele*, to fly, jump, move swiftly.

Malay, &c. (B) — Bughis. (M) — Makassar.	Polynesian, &c.
23. (B) *Dara*, blood; also *rara*. (M) *Rara*, blood. Mal., *darah, id.* Java, *darah, id.* Dayak, *darah* and *rah, id.*	(Melanesian) Fijian, *dra*, blood; to bleed. Nengone, *dra, id.* Torres Islands, *dara, id.* Ysabel, *dadara, id.* Motu (New Guniea), *rara, id.* Pulawat, *tra, id.* British New Guinea, *rara, rala, lala, id.* Efate, *tra, id.*
24. (B) *Duwa*, two. (M) *Ruwa, id.* Mal. and Battak, *duwa, id.* Timur, *rua, id.* Salayer, *rua, id.* Silong (Mergui Archipelago), *twa, id.*	Maori, *rua*, two. Somoan, *lua, id.* Tahitian (obs.), *rua, id.* Redscar Bay, *rua, id.* New Britain, *ulua, id.*
25. (B) *Dama*, a torch; resin. (M) *Damara*, a torch. Mal. and Battak, *damar*, resin; a torch. Java, *dhamar*, a torch. Sunda, *damar*, a torch of split bamboos. Bima, *dama*, a torch.	Maori, *rama*, a torch. Samoan, *lama*, a torch made of candlenuts; to fish by torchlight. Tahitian, *rama*, a fisherman's torch.
26. (B) *Gappo*, to touch with both hands on a thing. Mal., cf. *kakap*, to hug, to embrace by folding in the arms. Dayak, *kap*, to feel by touch.	Maori, *kapo*, to catch at, to snatch. Hawaiian (drops *k*), *apo*, to embrace, to hold; a hoop-ring. Mangarevan, *kapo*, to receive in the arms anything that falls.
27. (B) and (M) *Gorodi*, a drill, a borer.	Maori, cf. *korori*, to stir round; twisted. Tahitian, cf. *taroria*, to be twisted. (See No. 46, *Loli.*)
28. (B) *Iko*, the tail (as of a bird). (M) *Ingkong, id.* Mal., *ikur*, the tail (of animals). Dayak, *iku*, the tail.	Maori, *hiku*, the tail (of a fish or a reptile). Mangaian, *iku*, the tail. Mangarevan, *iku*, the tail (of a fish).
29. (B) *Iya*, this, that. Panayan, *iyan*, that.	Maori, *ia*, that; the said. Hawaiian, *ia*, this or that. Samoan, *ia*, these.
30. (B) *Iya*, he, she, or it. Mal., *iya, id.* Kayan (Dayak), *hia, id.* Tagal, *siya*, he.	Maori, Samoan, Hawaiian, Tongan, &c., *ia*, he, she, or it. Motu (New Guinea), *ia, id.* New Britain, *ia*, he.
31 (B) *Inung*, to drink (also *minung*). (M) *Inung, id.* Mal., *minun* and *pinum, id.* Java, *nginum, id.* Bima, *inung, id.*	Maori, and all Polynesian dialects, *inu*, to drink. The Melanesian Islands, Efate, and Malekula have *min*, to drink.
32. (B) *Kali*, to dig. (M) *Karri*, a scratch; to scrape. Dayak and Sunda, *kali*, to dig. Mal., *gali, id.* Bima, *ngari, id.*	Maori, *kari*, to dig for; *waikari*, a ditch. Tahitian (drops *k*), *ari*, to scoop out earth with the hands. Fiji, *kari*, to scrape.
33. (B) and (M) *Kaso*, a spar; the rafter of a house; the rib of a ship. Sulu, *kasau*, a rafter. Kayan (Dayak), *kaso*, a rafter. Mal., *kasau*, a rafter.	Maori, *kaho*, a batten for the roof of a house. Samoan, *'aso*, the small rafters of a house. Marquesan, *kaho*, a cross-piece binding the rafters. Fiji, *kaso*, the cross-beams to which the deck of a canoe is fastened

Malay, &c. (B) — Bughis. (M) — Makassar.	Polynesian, &c.
34. (B) *Kai*, to clasp, to fasten with a clasp, to hook; *kaikai*, a hook on which to hang anything. (M) *Kai*, a hook; an ear-picker. Mal., *kail*, a fish-hook; *kai*, fish caught with a hook; *kayit*, a hook. Timor, *kail*, a hook; also *kawit*. Pelew Islands, *kairok*, a hook.	St. David's (Caroline Islands), *kai*, a fish-hook. British New Guinea, *kau*, a hook; also *auri*, a hook (cf. Maori, *aurei*, a pin for clasping the shoulder-mat). Maori, *whaka-kai*, an ornament in the ear; to hang an ornament in the ear. Tahitian, *faa-ai*, *id.* Paumotuan, *faka-kai*, *id.*
35. (B) and (M) *Kanuku*, a finger-nail. Mal., *kuku*, nail of finger, claw of animals; *kukur*, to scratch. Pampanga, *cucu*, a nail, claw. Dayak, *kuku*, finger-nails.	Maori, *maikuku*, a finger- or toe-nail; *kuku*, to scrape. Samoan, *mai'u'u*, a finger-nail. Rarotongan, *maikuku*, *id.* Marquesan, *maikuku*, *id.* Fijian, *kuku*, a nail of finger or toe.
36. (M) *Kassa*, strong. (B) Cf. *assa* and *kulassa*, strong. Mal., *sassa* and *kuwassa*, *id.* Sulu, *kuasa*, *id.*	Maori, *kaha*, strong. Samoan, cf. *'afa*, fit, proper; *'afa'afa*, strong, robust. Fijian, *uasa*, strong, powerful.
37. (M) *Kayu*, wood. (B) *Adju*, *id.* Mal., *kayu*, timber; a tree. Baju, *kayu*, a tree. Sunda and Dayak, *kayu*, a tree.	Maori, *rakau*, a tree. Tongan, *akau*, *id.* Marquesan, *akau*, *id.*; also *kaau*. Fijian, *kau*, a tree. (Melanesian), Api, *kau*, a tree; Efate, *kasu*, *id.*
38. (M) *Kana*, to swear; an oath; to abuse.	Maori, *kanga*, to curse. Hawaiian (drops *k*), *anaana*, a kind of sorcery used to procure the death of or a curse on any one. Paumotuan, *kaga*, to insult.
39. (M) *Kikiri*, a file. (B) *Karri*, *id.* Mal., *kikir*, *id.* Sunda and Java, *kihkir*, a file, rasp. [NOTE.—The Bughis is here probably on another root—allied to *kali*, to dig. (See *Kali*.)]	Samoan, *'ili*, a rasp, a file. Tongan, *kili*, a file, a saw. Futuna, *kili*, a rasp, a file. Motu, *iliili*, a rasp, file. (Probably this word is allied to *kili*, the skin, as a rasp made from shark's skin is often used.)
40. (B) and (M) *Ko*, thou or you. Mal., *Kau* and *kowe*, *id.* Java, *kowe*, thou Baliyon, *ko*, thee. Matu, *kaaw*, thee.	Maori, *koe*, thou. Marquesan, Mangaian, Mangarevan, Paumotuan, &c., *koe*, thou.
41. (B) and (M) *Katja*, glass. Mal., *kacha*, glass; a mirror. Java and Sunda, *kacha*, glass for glazing; a looking-glass.	Maori, cf. *ata*, a reflected image; *koata*, a spy-glass; *piata*, bright, clear; *puataata*, transparent; *whaka-ata*, a mirror, to look at one's reflection in a mirror or water. Samoan, *ata*, a shadow, a reflected image as in a photograph; *fa'a-ata*, to spy with a telescope. Hawaiian, *akaka* (for *katata* in ordinary Polynesian letters), to be clear, transparent as glass, lucid. Tongan, *ata*, to reflect as a mirror; *faka-ata*, a telescope.

Malay, &c. (B) — Bughis. (M) — Makassar.	Polynesian, &c.
42. (B) *Kao*, to take in the grip of the hand. Bima, cf. *kao*, to scratch.	Maori, *kao*, dried roots of young sweet-potatoes (*kumara*). They were obtained by thrusting the fingers into the base of the hillock in which the *kumara* were grown, and raking out the tubers. Tongan, cf. *kakao*, to bore or thrust with the finger. Mangarevan, *aka-kao-kao*, to take food out of one side of a pit without touching the other.
43. (M) *Kuli*, the skin or hide. (B) *Uli*, *id.* Sunda, *kulit*, *id.* Kayan (Dayak), *kul*, bark of trees. Baju, *kulit*, the skin. Dayak, *kulit* and *kurit*, *id.* (Mal., *gilit*, which seems nearer Polynesian, and means a skin, a roll, a volume, is said to be Arabic.)	Maori, Mangaian, Mangarevan, Paumotuan, all *kiri*, skin. Other Polynesian dialects have *kili* and *ili*, *id.*: Mortlock, *kili*, *id.* Melanesian: Futuna, *kiri*, *id.*; Ysabel, *guli*, *id.*; Rotuma, *uli*, *id.*; Fiji, *kuli*, *id.*; Malo, *uri*, *id.*
44. (B) *Lau*, the sea. Mal. and Java, *laut*, *id.* Battak, *lau*, water, river. Sunda, *laut*, the sea (but this word in Sunda (western Java) is said (?) to be Sanscrit from *lawana* and *uda*, salt water, and should properly be written *lawud*).	Hawaiian, *lau*, the sea, water, an expanse (obsolete); *laumake*, the abating of water, a drought. Maori, *raumati*, summer (*mati*, dry). Tahitian, *raumati*, to cease from raining. Efate, *lau*, the sea.
45. (B) *Lau-a-lau*, to go eastward. Cf. Dayak, *lau*, the sun.	Marquesan, *oumati* (see preceding word, *lau*), the sun; the east. Fijian, *lau*, the eastern group of islands. Bismarck Archipelago, *laur*, the east. British New Guinea, *walau*, the east.
46. (M) *Loli*, to roll: also *doli*. (B) *Lole*, to roll.	Hawaiian, *loli*, to turn over. Mangarevan, *rori*, to roll, to rock or toss about. Maori, cf. *pirori*, to roll; *turori*, to totter.
47. (M) *Lili*, to fear.	Maori, cf. *makariri*, to be cold; *riri*, angry. Tahitian, *maariri*, to shiver with cold; *horiri*, to be troubled by fear. Samoan, *lili'a*, affrighted. Mangarevan, *makariri*, to be cold; a shiver of fear. Hawaiian, *li*, trembling as from cold, shaking as with an ague-fit; *lia*, a shaking of fear. Futuna, *lili*, to be slightly agitated, as a liquid.
48. (B) and (M) *Lila*, the tongue. Mal. and Java, *lidah*, *id.* Kayan, *lidah*, to murmur. Malagasy, *lela*, the tongue. Cf. Bima, *lela*, a leaf blade.	Maori, *arero*, the tongue. Samoan and Hawaiian, *alelo*, *id.* Tongan, *elelo*, *id.* Sikayana, *aledo*, *id.* Rotuma, *alele*. St. David's (Carolines), *lel*, *id.*

Malay, &c. (B) — Bughis. (M) — Makassar.	Polynesian, &c.
49. (B) *Lino*, calm; cf. *malino*, solitary, lonely, quiet (said only of human beings). Bicol (Philippines), *malinao*, calm. Bima, *lino*, calm.	Maori and Rarotongan, *marino*, calm. Tongan, *melino*, peace. Paumotuan, *marino*, a calm sea. Motu, *maino*, peace.
50. (B) and (M) *Langi*, the sky. Mal., Sulu, Java, Sunda, Kayan, Dayak, and Tagal, all *langit*, the sky. Malagasy, *lanitra*, *id.*	Maori, Tongan, and all Polynesian dialects, *rangi*, *lagi*, and *rai*, the sky. (Note on this subject farther on.)
51. (M) *Lalang*, a row, a rank, a file.	Maori, *rarangi*, to form a row or rank. Hawaiian, *lalani*, a row (as of trees), a rank (as of soldiers). Paumotuan, *rarani*, a rank, a row; to range in rank.
52. (B) *Manu*, a hen (domestic fowl); *manumanu*, a bird, (2) a ghost. Kayan, *manok*, a bird. Kisa, *manu*, a bird. Magindano, *manok*, a hen. Sulu, *manuk*, a bird.	Maori, *manu*, a bird. Samoan, *manu*, *id.* Hawaiian, *manu*, birds. Mangaian, *manu*, a bird, a spirit.
53. (B) *Mai*, hither, here. (M) *Mae*, *id.* Sula, *mai*, to come. Gani, *mai*, to come. Cf. Mal. and Dayak, *mari*, to come.	Maori, *mai*, hither. Samoan, Tahitian, Hawaiian, &c., *mai*, a word denoting action towards the speaker. Yap (Carolines), *moi*, to come. (In New Zealand *moi* is a call for a dog to come.)
54. (B) *Maka*, causative prefix, as *maka-solang*, from *solang*, &c. Sulu, *mak* or *maka*, causative prefix. Tagal, *mag*, *id.*	Maori, *whaka*, causative prefix. Tongan, *faka*; Futuna, *faka*; Paumotuan, *faka*, *id.* Mota, *vag*, causative prefix.
55. (B) and (M) *Mata*, the eye. Mal., Java, Sunda, &c., *mata*, *id.*	Maori and all Polynesian, *mata*, the eye.
(B) and (M) *Mata*, raw, unripe, uncooked. Mal., *mantah*, *id.* Battak, *matah*, *id.*	Maori, Samoan, Mangaian, &c., *mata*, raw, unripe.
(M) *Mata*, a source, a spring. Sunda, *mata-chai*, a spring of water.	Maori, *matamata*, a source; *matapuna*, a spring. Tahitian, *mata*, the first beginning of anything.
(B) *Mata-djala*, the mesh of a net. Mal., *mata*, the mesh of a net.	Maori, Samoan, and Tongan, *mata*, the mesh of a net. Motu, *mata*, *id.*
(M) *Mata*, the point of a lance. Mal., *mata*, the blade of a weapon. Sunda, *mata*, the edge of a sword.	Maori, *mata*, the point or edge of a weapon. Samoan, *mata*, the point. Tahitian, *mata*, the edge. Futuna, *mata*, the point of a lance.
56. (B) and (M) *Mate*, dead. Battak, *mate*, dead. Mal. and Java *mati*, dead. Malagasy, *maty*, dead.	Maori and all Polynesian, *mate*, dead; to die. Fijian, *mate*, to die. New Britain, *mat*, dead.

Malay, &c. (B) — Bughis. (M) = Makassar.	Polynesian, &c.
57. (M) *Mara*, to form by alluvium.	Maori, *mara*, a cultivation; cf. *para*, sediment, mud. Samoan, *mala*, a new plantation; cf. *pala*, a muddy deposit in a swamp. Hawaiian, *mala*, a garden.
58. (B) *Mimi*, to suck, to slobber. (M) *Mimisi*, *id.*	Maori, *miti*, to lick, to lick up. Samoan, *miti*, to suck; *mimiti*, to suck a wound; *misi*, to make a kissing noise. Paumotuan, *mitimiti*, to lap, to lick up. Tahitian, *miti*, to lick; salt; salt-water sauce. Tongan, *mijikia*, to be sucked or drawn into.
59. (B) *Mula*, origin, beginning (said to be from Sanscrit *mula*). Mal., *mula*, source, orgin; *mulamula*, first.	Maori, *mua*, the front; former time. Samoan, *mua*, first. Tahitian, *mua*, first, before. Marquesan, *mua*, in front, before; the first.
60. (B) *Munri*, behind, after. (M) Cf. *kamudi*, a rudder. Java, *buri*, the stern. Mal., *buritan*, the after-part; the stern. Kayan, *mure*, a rudder. Dayak, *mudich*, a rudder. Sulu, *ha-buli*, behind, after.	Maori, *muri*, the rear, hind part, behind; after. Samoan, *muli*, the end, hind part. Rarotongan, *muri*, behind. Futuna, *muli*, after; to follow, &c
61. (M) *Nenge*, to languish. (B) Cf. *reke*, *id.*	Maori, *ngenge*, weary, tired; *konenge*, sinking, exhausted. Samoan, *gege*, to die (of animals); *gege-gege*, to appear as if dying (applied to the sun when obscured by clouds). Hawaiian, *ne* (for *nge*), to droop; to be sickly. Futuna, *gege*, to have a cold, a cough.
62. (B) *Ngingi*, the gums (of the teeth). (M) *Gigi*, the teeth, ivory. Mal., *gigi*, the teeth.	Maori, *ngi*, to laugh; *niho*, the teeth. Tongan, *gi*, to whimper; *gigi*, to whine.
63. (B) *Namo*, a gnat. (M) *Lamu*, *id.* Battak and Mal., *namuk*, the mosquito. Java, *lamuk*, *id.* Tagal, *lamok*, *id.* Dayak, *nyamok*, *id.*	Maori, *namu*, a sandfly. Samoan, *namu*, mosquito. Futuna, *namu*, *id.* Paumotuan, *namu*, *id.*
64. (B) *Nawa*, to think (cf. *manawanawa*, to think hard); *ininawa*, the heart, mind. (M) *Nawa*, to think; *anawanawa*, to think much.	Maori, cf. *manawa*, the heart as the seat of affection. Tahitian, *manava*, the belly, the interior man; *manavanava*, to think, to ponder. Mangaian, *manava*, the spirit. Paumotuan, *manava*, affected, touched; *manavanava*, to meditate.

Malay, &c. (B) = Bughis. (M) = Makassar.	Polynesian, &c.
65. (M) *Pana*, a bow. Sulu, *panah*, *id.* Mal., *panah*, *id.* (said to be from Sanscrit *bana*, an arrow; Malays calling the arrow *anak-panah*, "child of the bow"). Magindano, *pana*, an arrow. Dayak, *panah*, sometimes "bow," sometimes "arrow."	Maori, *whana*, to spring back like a bow. Marquesan, *pana*, a bow. Tahitian, *fana*, *id.* Hawaiian, *pana*, *id.* Rarotongan, *ana*, *id.* Samoan, *fana*, to shoot; *aufana*, a bow; *uafana*, a volley of arrows ("arrow-rain"?). Rotuma, *fan*, a bow. Aneityum, *nefana*, an arrow.
66. (B) *Papa*, a piece of bamboo split in two, a lath; *papang*, a board, plank. (M) *Papang*, a plank. Mal., Sulu, and Sunda, *papan*, a plank.	Maori, Tahitian, Samoan, Hawaiian, &c., *papa*, a board. Fijian, *papa*, a flat board.
67. (B) *Pari*, the sting-ray (fish). Mal., *ikan-pari*, *id.* Sulu, *isda-palit*, *id.* Bima, *fai*, *id.* (Note further on.)	Maori, *whai*, the sting-ray. Samoan and Tahitian, *fai*, *id.* Fijian, *vai*, *id.* The Caroline Islands—viz., Mortlock, *fai*, the sting-ray; Yap, cf. *pai-bok*, "tail of sting-ray"; Pingelap, *pai*, sting-ray.
68. (B) *Peka*, a cross-way; anything in the form of a hook. (M) *Pengka*, crossways. [NOTE.—If *pengka* is allied to Mal., *bengkok*, crooked, then Dayak dialects—viz., Bintulu, *bingkok*, crooked; Matu and Kanowit, *piko*, crooked—would infer connection between Maori, *piko*, crooked, and *peka*, crossways.]	Maori, *peka*, the branch of a tree or river; *ripeka*, a cross. Tahitian, *pea*, sticks laid crosswise. Hawaiian, *pea*, to make a cross with timbers. Marquesan, *peka*, a cross. Mangarevan, *peka*, a cross.
69. (B) *Pitu*, seven. Sulu, *pitu*, *id.* Tagal, *pito*, *id.* Java, *pitu*, *id.*	Maori, *whitu*, seven. Samoan, *fitu*, *id.* Tahitian, *hitu*, *id.*
70. (B) *Puloh*, ten. Mal. and Java, *puluh*, *id.* Battak, Lampong, and Dayak, *pulu*. Pampanga, *pulu*.	Maori, *ngahuru*, ten. Tongan, *hogofulu*, *id.* Samoan, *gafulu*, *id.* Nukuoro, *huru*, *id.* Marianne Islands, *ngafulu*, *id.*
71. (B) *Pokki*, dim, dark, not manifest; cf. *wanni*, night. (M) *Bangi*, evening. Java, *wengi* or *bengi*, *id.*	Maori, *pongipongi*, the time of dawn. Samoan, *popogi*, the dim morning light; to be dark, to be dizzy, to begin to be blind. Mangarevan, *poki*, dark, cloudy weather. Fiji, *bogi*, night. Melanesian—viz., Sesake, Api, and Lepers Islands—*bongi*, night.
72. (M) *Pile*, choice. Mal., *pilih*, to choose, select. Sunda, *pilih*, to pick, select. Formosa, *piri*, to choose.	Maori, *whiriwhiri*, to choose from a number, to select. Samoan, *fili*, to choose. Tongan, *fili*, *id.* Niue, *fifili*, to choose. Futuna, *fili*, to choose.
73. (B) *Rada*, a kind of tree with red flowers (*Erythrina dioica*).	Maori, *rata*, the name of a tree bearing bright-red flowers (*Metrosideros robusta* and *M. lucida*). Tahitian, *rata*, the Tahitian chestnut, with red blossoms.

Malay, &c. (B) = Bughis. (M) = Makassar.	Polynesian, &c.
74. (B) *Rallang*, to dry in the sun or by a fire. (M) *Rarang*, to dry, to heat; glow, flame.	Maori, *rangirangi*, to roast, to scorch, to dry by evaporation; *whaka-rangirangi*, to dry or warm before a fire. Samoan, *lagilagi*, to warm anything at a fire; *lalagi*, to broil.
75. (B) *Ratu*, a hundred. Mal., *ratus*, *id.* Champa, *ratu*, *id.* Java, *atus*, *id.* Sunda, *ratus*, *id.*	Maori, Rarotongan, Tahitian, &c., *rau*, a hundred. Samoan, Hawaiian, Tongan, *lau*, *id.* Matabello (New Guinea), *ratua*, *id.* Treasury Island (Solomons), *latu*, *id.* Marianne Islands, *gatus*, *id.*
76. (M) *Rumu*, moss. (B) *Lumu*, *id.* Sulu, *lumut*, *id.* Mal., *lumut*, *id.* Sunda, *lumut*, short moss; the sliminess on newly caught fish. Tagal, *lumut*, seaweed. Bicol and Panayan, *lumut*, seaweed.	Maori, *rimu*, moss, seaweed. Samoan, *limu*, *id.* Tahitian, *rimu*, moss, sponge. Hawaiian, *limu*, seaweed or sea-moss. Mota (Banks Islands), *lumuta*, moss. Carolines, *lum* and *lim*, seaweed. Nukuoro, *rimu*, seaweed.
77. (B) and (M) *Sau*, steam. Sulu, cf. *aso*, steam.	Maori, *hau*, dew, moisture. Samoan, *sau*, dew. Sausau, to sprinkle. Tongan, *hahau*, mist; *hauiia*, damp, wet with dew.
78. (B) *Sala*, fault, error. (M) *Sala*, crime, wrong. Sunda, *salah*, *id.* Mal., *salah*, *id.* Tagal, *sala*, *id.* Kisa, *hala*, *id.* Java, *hala*, base, mean. Kayan, *hala*, guilty. Malagasy, *hala*, hated, detested. *Halatra*, theft. Dayak, *salah*, to find fault with; wrong.	Maori, *hara*, to violate *tapu*; sin; to sin. Samoan, *sala*, wrong. Hawaiian, *hala*, a trespass, sin. Tongan, *hala*, to err. Fijian, *thala*, to err.
79. (B) *Sala*, to lack, to fail. (M) *Sala*, to divide, separate, stray away; *sara*, an atom. Sunda, *sala*, an interval, space between; by way of exception; nobody in particular. (Connected with last word.)	Maori, *hara*, the excess above a round number, matters of small importance; *tauhara*, an odd one. Samoan, *sala*, incorrect. Mangarevan, *tauhara*, units in counting after tens. Futuna, *sala*, to miss; without order or intention.
80. (M) *Sele*, a dagger, a *kris*.	Maori, *here*, a bird-spear. Samoan, *sele*, a bamboo knife; to cut, to shear. Tongan, *hele*, a knife. Fiji, *sele*, a strip of bamboo used as a knife. Niue, *helehele*, to cut (as grain).
81. (B) and (M) *Soba*, a friend, a companion. Sunda and Java, *sobat* (said to be from Arabic), *id.* Mal., *sahabat* or *sohbat*, *id.*	Maori, *hoa*, a friend, mate. Samoan, *soa*, a companion, friend. Tikopia (Fiji Islands), *soa*, friend. Futuna, *soa*, a friend, a couple, a pair.
82. (M) *Sulu*, a torch. (B) *Sulo*, *id.* Mal., *suluh*, *id.* Sunda, *suluh*, firewood (said to be from Sanscrit *sula*, a torch, a *chool*.)	Maori, *huru*, the reflection of fire, the glow of fire. Samoan, *sulu*, a torch. Tongan, cf. *tuhulu*, a torch. Motu, *huhuru*, a torch. New Georgia, *sulu*, flame. Efate, *ne-sulu*, a torch.

Malay, &c. (B) Bughis. (M) Makassar.	Polynesian, &c.
83. (B) and (M) *Susu*, a woman's breast. Mal., Java, and Battak, *susu, id.* (B) *Uwae-susu*, mother's milk.	Maori, *u*, the female breast. Tongan, *huhu*, the breasts; to suck. Samoan, *susu*, the breast. (Maori, *wai-u*, milk.)
84. (B) and (M) *Sumi*, moustachios. Mal. and Sunda, *kumis, id.* Battak, *gumis, id.* Tagal, *gumi, id.*	Maori, *kumikumi*, the beard. Tahitian, *umiumi*, the beard. Marquesan, *kumikumi, id.* Fijian, *kumi*, the chin or beard. Ponape and Kusaie, *kumikum.*
85. (B) *Tawa*, to bargain. (M) *Tawara, id.* Mal. and Battak, *tawar, id.* Matu (Dayak), *tawar*, to chaffer. Tagal, *tavar*, a bargain. Dayak, *tauar*, to beat down in price.	Samoan, *tau*, to buy or barter (cf. Maori, *tauanga*, a numbering, counting). Futuna, *faka-tau*, to barter, to buy or sell. Niue, *faka-tau*, to buy. Nala (New Guinea), *tavatava*, to buy; *tavana*, payment.
86. (B) and (M) *Tallu*, three. Java, *talu, id.* Sunda, *talu* and *tolu, id.* Malagasy, *telo, id.* Timur, *tolo, id.* Bisaya, *tulu, id.* Bima, *tolu, id.* Saparua, *toru, id.*	Polynesian everywhere, *toru* and *tolu*, three. Fijian, *tolu, id.* Matabello, *tolu, id.* Solomon Islands, *tolu, id.* Mota, *tol, id.*
87. (B) and (M) *Tai*, dirty, filthy. Java and Dayak, *tai, id.* Mal., *tai*, ordure, dung. Tagal, *tae, id.* Magindano, *tae*, dung. Sula, *tai, id.*	Samoan, *tae*, excrement. Maori, *tutae, id.* Tahitian, *tutae, id.* Tongan, *tae, id.* (The Melanesian *tai* or *tasi*, "dung," is said to be derived from *tai*, "sea," on account of a habit of the Natives in going to stool therein.)
88. (M) *Tali*, a cord, rope. Java and Mal., *tali, id.* Kayau, *tali*, a thread. Timor, *tali*, a rope.	Maori, *tari*, a method of plaiting an eight-strand cord; a noose for catching birds. Fijian, *tali*, to plait. Melanesian: Efate, *intali*, a rope; Maloese, *tale*, a rope; Ulia (Carolines), *tali*, a rope; Marono (New Georgia), *tali*, a fishing-line.
89. (B) and (M) *Taung*, a year. Battak, Sunda, and Java, *taun, id.* Mal., *taun* or *tahun, id.* Tagal, *taon, id.*	Maori, *tau*, a year. Tongan, *tau*, a year, a season. Rarotongan, *tau*, a season. New Britain, *taun*, a year.
90. (B) *Tara*, the natural spur of a cock; *tarang*, sharp. (M) *Tarang*, sharp. Mal., *taring, id.* Bima, *tara*, a thorn-prickle.	Maori, *tara*, a point (as of a spear), spines in the dorsal fin of a fish; *taratara*, a spine, a spike. Tahitian, *tara*, a cock's spur. Hawaiian, *kala*, a cock's spur.
91. (M) *Tappa*, to beat one another; *taba*, to pound, to strike. (B) *Tampa*, to beat. Mal., *tampar*, to strike. Java, *tabuk*, to slap. Sunda, *tabok*, to slap the face. Bicol, *tampal*, to slap.	Marquesan, *tapa*, cloth beaten from bark. Hawaiian, *kapa, id.* Maori, *tapa*, to pulverise soil; *tapahi*, to chop. Tongan, *tababa*, to beat a drum.

Malay, &c. (B) — Bughis. (M) — Makassar.	Polynesian, &c.
92. (M) and (B) *Takkang*, a staff, pole. (M) Cf. *tokong*, to push with a pole. Java, *teken*, *id.* Sunda, *tek-tek*, *id.* Tagal, *tungcod*, *id.* Sulu, *tongkud*, a prop; *tuku*, a pole. Mal., *tongkat*, a staff, walking-stick.	Maori, *toko*, a pole, walking-stick, rod. Polynesian generally, *toko* and *toko-toko*, a staff, a pole. Fiji, *doko*, a canoe-pole; *toko*, a prop.
93. (B) *Tang*, to plant. (M) *Tanang*, to plant. Mal. and Java, *tanam*, *id.* Battak, *tanom*, *id.* Basa-krama, *tanam*, to bury, to plant.	Maori, *tanu*, to bury, to plant. Samoan, *tanu*, to bury. Tahitian, *tanu*, to plant. Mangarevan, *tanu*, to plant, to bury, to inhume.
94. (B) *Teteng*, to take on the hand. Mal., *tatang*, to bear an object on the palm of the hand; *tangan*, the hand. Java, *tangan*, *id.* Baju, *tangan*, *id.* Sunda, *tangkap*, to catch, arrest. Magindano, *tago*, to keep.	Maori, *tango*, to handle; *tatango*, to snatch from another. Samoan, *tago*, to touch, to take hold of. Tongan, *tatago*, to seize. Paumotuan, *tago*, to catch. Murray Island, *tag*, the hand. Mota, *tago*, to touch with the hand.
95. (B) *Tjimu-tjimu*, the pecking of chickens, the point of the beak of a chicken. [NOTE.—The point of the *tjigi-tjigi* or clitoris is called *tjimu-tjimu*: this is cut off when girls are circumcised.]	Maori, *timo*, to peck as a bird, to strike with a pointed instrument; *timu*, a point, peak; *timutimu*, the clitoris.
96. (B) and (M) *Tja*, a mark, stamp (cf. *tatta*, to hew, hack; *taba*, to strike; and Makassar, *patta*, a signature). Java, *chachah*, to count (as in Maori, *tatau*, to count; Tahitian, *tatau*, to tattoo). Formosa, *tata*, a beater for corn.	Maori, *ta*, to beat, to print, to paint, to tattoo; a mark or sign. Samoan, *ta*, *id.* Tahitian, *ta*, to strike, to write; *tatatau*, a person who marks the skin. Tongan, *ta*, to beat, to tattoo. Mangarevan, *ta*, to write, writing, to tattoo.
97. (B) *Tiro*, to look from a high place, to stare at. (M) *Tiro*, to stare, to spy, to watch, to pry into. Bima, *tiro*, to look.	Maori, *tiro*, to look at; *tirotiro*, to investigate. Samoan, *tilotilo*, to peep, to spy. Mangaian, *tiro*, to look at.
98. (B) *Towa* and *matowa*, old. (M) *Towa*, old, a grandparent; *matowa*, the title of a chief. Mal., *tuwah*, old. Java, *tuwa*, *id.* Battak, *matuwa*, old, ripe, mature. Bima, *tuwa*, old; *dou-matuwa*, an old man.	Maori, *matua*, a parent, a master. Samoan, *matua*, mature; a parent. Tongan, *matua*, old people. Fijian, *matua*, ripe, mature.
99. (B) *Tore*, through. Mal., *tauriet*, or Java, *toret*, the Pentateuch—from the Arabic *taurit*(?). Malagasy, cf. *tory*, preached, proclaimed.	Maori, Tahitian, Rarotongan, Paumotuan, *ture*, a law, commandment (said to be from Hebrew). Samoan, *tulā-fono*, a law. (Alluded to farther on.)

Malay, &c. (B) = Bughis. (M) = Makassar.	Polynesian, &c.
100. (B) and (M) *Tjora*, lustre, brightness; to glisten. Java, *tjorong*, flame, to sparkle.	Maori, *tora*, to burn, to blaze; *toro*, to burn, blaze. Fijian, *todra* (used of the sun), to scorch, to be very hot.
101. (B) and (M) *Tunu*, to roast, to bake. Java, *tunu*, *id.* Battak, *tutung*, to roast. Bali, *tunu*, to burn. Mal., *tunu*, to burn, to consume with fire.	Maori, *tunu*, to broil, to burn. Samoan, *tunu*, to broil. Tahitian, *tunu*, to roast.
102. (B) *Ulang*, the moon; a month. (M) *Bulang*, *id.* Sunda, Battak, and Mal., *bulan*, *id.* Java, *wulan* and *bulan*, *id.* Kaili, *bula*, white. Bima, *bula*, white; *wura*, the moon, a month. Sikka, *bura*, white. Bisaya, *pulan*, white. Dayak, *purak* and *buda*, white; *burak*, white; *bulan*, moon.	Fijian, *vula*, the moon; *vulavula*, white. Duke of York Island, *pura*, white. Ysabel, *pura*, white. Samoan, *pula*, to shine. Tahitian, *pura*, a spark of fire. Maori, cf. *ura*, to glow; *mapura*, fire; *kapura*, fire.
103. (B) *Ulu*, the head; (2) the origin, the source of a river. (M) *Ulu*, the head. Mal., *ulu*, the head; the source of a river.	Maori, *uru*, the head, the upper end. Samoan, *ulu*, the head. Hawaiian, *ulu*, the bread-fruit tree. Paumotuan, *uru*, the head, &c.
104. (B) *Ura*, a vein, a sinew. (M) *Ura*, a vein. Mal., *urat*, a muscle, ligament, nerve. Ilocan, *urat*, a vein. Dayak, *urat* and *uat*, a muscle.	Maori, *uaua*, a sinew, a vein. Marquesan, *uaua*, a vein, artery. Fijian, *ua*, a vein, a muscle.
105. (B) *Urang*, a shrimp. Malagasy, *orana*, a lobster, crayfish (Malagasy, *o* for *u*).	Maori, *koura*, a crayfish; *kouraura*, a shrimp. Tahitian, *oura*, a shrimp. Samoan, *ula*, a crayfish. Ponape, *urana*, a lobster. Mota, *ura*, crayfish.
106 (B) *Utu*, a louse. (M) *Kutu*, a louse. Mal., Dayak, and Java, *kutu*, louse (Dayak, also *gutau*, louse).	Maori, Tongan, and Marquesan, *kutu*, a louse. Tahitian, *utu*, *id.* Melanesian: Whitsuntide Island, *gut*; Florida Island, *gutu*, &c., all meaning "louse," but being pronounced "*ngutu*" show connection with Polynesian *ngutu*, the mouth, the beak of a bird, &c.
107. (B) *Uwae*, water. Awaiya, *waeli*, *id.* Amblaw, *wai*, *id.* Salibabo, *wai*, *id.* Gani, *wayr*, *id.* Mal., *ayar*, *id.*	Maori, *wai*, water. Samoan, *vai*, fresh water. Hawaiian, *wai*, fresh water. Throughout Polynesia "water" is *wai* or *vai*.

Malay, &c., (B) = Bughis. (M) = Makassar.	Polynesian, &c.
108. (B) *Wanuwa*, land; (2) the sheath, as of a dagger (*kris*). (M) *Banowa*, land. Mal., *benua*, a region; *banuwa*, land, a country. Bisaya, *banua*, a village.	Maori, *whenua*, the earth, land; (2) the afterbirth or placenta of women. Samoan, *fanua*, the land. Tahitian, *fenua*, *id.* Tongan, *fonua*, *id.* Hawaiian, *honua*, *id.* Melanesian: Sesake, *vanua*; Aurora, *vanua*; Api, *venua*; &c.
109. (M) *Wangkang*, a Chinese junk. Sunda, *wangkang*, *id.* Dayak, *bangkong*, a boat with a single plank fastened into the dugout at the water-line. Tagal, *banca*, a canoe made from a single tree. Pampanga, *bangca*, a canoe. Bouton (an island south of Celebes), *bunka*, *id.* Massaratty (east side of Bouru), *waga*, *id.* Savu (an island west of Timur), *vaka*, *id.* Amblaw, *waa*, *id.*	Maori, *waka*, a canoe. All Polynesia, *vaka* or *vaa*, canoe. Brumer Islands, *waga*, *id.* Fiji, *wannga*, *id.* Waigiou (an island north-west of New Guinea), *waag*, a Malay ship, a *prauw*. Eddystone Island, *waka*, a ship. Banks Islands and New Georgia, *vaka*, a canoe.
110. (B) *Waru*, a shrub, the *Hibiscus tiliacens*, the bark of which is used for tying. (M) *Baru*, *id.* Java, *waru*, *id.* Mal., *baru*, *id.* Kisa, *warau*, *id.* Sunda, *waru-laut*, *Hibiscus tiliacens*. Bima, *wau*, *id.*	Samoan, *fau*, *Hibiscus tiliacens*; to tie together. Tahitian, *fau*, the hibiscus. Tongan, *fau*, *id.* Marquesan, *hau*, *id.* Fijian, *vau*, *id.*
111. (B) *Witung*, a star. (M) *Bintung*. Battak, *bintang*, *id.* Magindano, *bituun*, *id.* Ilocan, *bittuen*, *id.* Tagal, *bituin*, *id.* Pampanga, *batuin*, *id.* Menado, *bituy*, *id.*	Maori, *whetu*, a star. Samoan, *fetu*, *id.* Tongan and Futuna *fetuu*, *id.* Paumotuan, *hetu*, *id.* Melanesian: Aurora, *vitiu*, *id.*; Lepers Island, *visiu*, *id.*; Lord Howe's Island, *fitou*, *id.*; Solomon Islands, *bitobito*, *id.*; Marianne Islands, *putiun*, *id.*

Some of the words compared above need explanation, and others ask for consideration. Let us first turn to the curious connection of No. 67, *pari*, the sting-ray, with the New Zealand *whai*, a connection for which I am indebted to the never-failing acuteness of Mr. F. W. Christian, who, in his invaluable work on the Caroline Islands, called attention to the Micronesian values of the word. The fish known as the *whai* or *fai* in Polynesia is also known in Micronesia by this name, as at the Mortlocks, where it is *fai*. But the Pingelap and Yap form—viz., *pai*—is almost certainly connected with the Bughis *pari*, the sting-ray, and this even more certainly with the *ikan-pari*, the "fairy-fish" of the Malays. The sting-ray is a dreaded fish to waders with naked feet, and to find it euphemistically styled "the fairy-fish" and "Queen of the Sea-bottom" (in the Carolines) is a fact belonging to the same family as that of poor terrorised Natives in India styling the tiger "the Lord of Forests" when mentioning him—that is, for purposes of propitiation. However, to find the Persian word *pari* or *peri* (our English "fairy") extant in Maori for the fish generally known as "the stingaree" is surprising.

No. 99, *tore:* In many of the groups of Polynesia the word for "law" is *ture*. It is said to be a Hebrew word for the Law of Moses, and has been given to the Natives by the missionaries. I should be pleased to get some historical evidence for or confirmation of this belief. That the missionaries in New Zealand, Rarotonga, Tahiti, and the Paumotus —places thousands of miles apart—agreed with one consent to adopt a Hebrew word and coin it into Native dialects in preference to any other Native or European word seems unlikely. Of course, we must remember, however, that with a missionary the Bible comes first, and the "law" he considered as of most importance was the Mosaic law. Consequently there might have been a consensus of opinion even without personal communication on the subject. Why they should have hit upon that particular form of the word it is difficult to say, unless they were acting under instructions from a central authority at Home, and as they belonged to different Churches that was unlikely. The Hebrew word for "the Law" is *torah*, pronounced "*toura*," a sound which could be easily caught by the Natives. The missionaries seem to have preferred writing it as if pronounced without the Masoretic points, a curious freak. In the Malay Islands the case is quite different. There is not the slightest reason to doubt that the Javanese *toret*, the Malay *tauriet*, and the Burghis *tore* are Native words derived from the Arabic word for the Mosaic Law, because many of the island peoples are Mohammedan, and the languages are full of the creed-words of Islam. In Polynesia this is not so, although it would be of intense interest should it be so proven. Without direct historical proof that the word is modern and is a bastard form of Hebrew, it is quite permissible to doubt its Semitic origin. The Samoans have not either originally or by adoption received *tule* as the word for "law." Their word is *tulāfono*, "a law," wherein *fono* means a council, a legislative assembly. Is this *tulā* also intended as a form of the Hebrew *torah?* It appears rather to be a shortening used in composition for *tulaga*, "a standing-place" (on verb *tu*, "to stand"), since we have *tulāfale*, "a place on which a house stands" (*fale*, "a house"), *tulāumu*, "a place to build a cooking-house on" (*umu*, "an oven"), &c. Referring again to the Bughis form *tore*, it is curious that the

Malagasy should have a word *tory*, "proclaimed, preached." In Madagascar, however, the Natives do not use *u*, but substitute *o* therefor, so that *tory* may be *tury*, or it may have been of Mohammedan introduction into the great African island. In Mangareva the word *ture*, "the law," has formed compounds, such as *turevare*, "ignorant, incapable," *tureihemo*, "useless, incapable." This does not look as if *ture* was of modern introduction. It takes time before a word can sit down and feel itself at home in a strange language sufficiently to make compounds. If we compare Mangarevan *tureihemo*, "useless, incapable," with the Maori word *tureikura*, "folly, silliness," it will certainly be found that they have been formed in the same manner, and that *ture* was of no more modern introduction into New Zealand than into Mangareva. In Hawaii, where *k* takes the place of *t* in Maori, we have the word *kuleana* (*i.e.*, *tureango*), "a part, portion, or right in a thing; a right of property which pertains to an individual." This seems to carry the idea of "law," and that it is not an introduced word is insured by its being a derivative of *kule* (*i.e.*, *ture*), "to seize or take another's; to give one trouble in dispossessing another of his own." This latter would be considered by many as essentially lawyers' work, if not "law," and it is perhaps akin to the Dayak *tulih*, "to acquire, to obtain." I write this more in the hope of obtaining information, and in the hope of fixing whether *ture* is a Maori word or not, than with the notion of speaking authoritatively on the subject. The Polynesians already had the word *taura* for a priest or a prophet, so perhaps there was some ecclesiastical reason for not pressing that particular word.

Of No. 11, Bughis *baru*, "new," it may be considered interesting, because the word varies into *fau*, exactly as *baru*, "the hibiscus," does, without apparently any other connection and merely as a letter-change.

No. 43, *lau*, "the sea": Noticeable because the word has become almost obsolete in Polynesia in this sense.

No. 15, *boko*, "the after-part; the rear": The sense of this primitive root BAK appears to have been nearly lost in the Pacific. *Poko* and *upoko* have become "the head," but the Samoan form *ulupo'o*, "the skull," shows the meaning of the now rudimentary *u;* it is the surviving remnant of *ulu*, "the head." This is confirmed by the Hawaiian *panepoo*, "the back part of the head," *pane* being a pure Polynesian word for head. It is perhaps primitively allied to the Celtic *pen* or *ben*, "the head, the chief, the top of a hill." In the Rarotongan Bible the chapters are headed Pene I., II., &c., as we head ours Caput I., II., &c.

No. 20: There seems to be great irregularity in the words in several localities for "flower" and "fruit." The forms *pua*, *hua*, and *fua* for fruit would appear to be connected with Sanscrit *phua*, "fruit"; but the word for flower (if not a variant of the other, for they meet together) is almost certainly Indian. *Buha* is central-Indian (Santali) for "flower"; but other central- and southern-Indian words, *pu*, *pungar*, *bungna*, &c., resemble the Malay *bunga*, or Polynesian *pua*. The Kiranti (East Nepal) *bungwai*, "a flower," is very like the Maori *puawai*, "a flower."

No. 47, *lili*, "to fear": It is possible that the *maka* of *makariri* is the old causative, and that the word we now use as "cold" once meant "causing to shiver." (See *Maka*.)

No. 102, *ulang*, "the moon," is interesting. If the widely spread variants of Malay *bulan*, "the moon," originally meant "white," as both Malay and Polynesian seem to infer, then in this sense it is not confined to island peoples, but is an Asiatic word, for in Arrakan the Mru and Toung have *pula* for "moon." Similarly, No. 84, *sumi*, "moustachios," is to be found among the Sak of Arrakan as *kumi*, "hair." This varies among the Kachari of north-east Bengal into *kuman*, "hair," and the probability of this comparison is greatly heightened when we find that an adjacent tribe, the Garo, have as words for "hair" *kuman* and *houru*, the latter curiously resembling the Polynesian *huru* for "coarse hair."

No. 41, *katja*, "glass": This is not a strong case for comparison, but is valuable if there were other reasons to think the Maoris were once acquainted with glass. The prefixed *k* is always so easily dropped that there is here a possibility. The Maori *ata* or Hawaiian *akaka* (for *atata*), "to be clear, transparent as glass," closely resembles the Canarese (Indian) *achcha*, "clear, transparent." Many Polynesian words are like Canarese, but many of the latter are Sanscrit."

While referring to possible Asiatic connections, one of the most interesting comparisons is No. 50, *langi*, "the sky." In Nepal (Sunwar Tribe) the sky is *sarangi*, and among the Broken Tribes of Nepal (Darhi, Denwar Pahr, Chepang) it is *serag*, (Kuswar) *serang*, (Kusunda) *lagai*. So also in central India (Rajmahali) it is *sarange*. We might leave these as possibly chance coincidences were it not that they seem to merge into forms passing from *sarang* to *sarg*, and then to *swarga*, which is the Heaven of India in the Vedic Cosmogony of India, and as such has passed down to the Malay Islands with the Hindu religion.

In considering these similarities in sound and sense between Malay dialects and Polynesian, a few general remarks in conclusion may not be out of place.

1. Similarities may arise from one language being an offshoot of the other.

2. Languages may have extended in different directions from a common source.

3. The similarities may be mere coincidence.

4. The words may have been borrowed.

As to the first and second of these viz., whether one language is the offspring of the other, or whether both are descended from a common source further investigation is necessary before a decision can be arrived at. Coincidence is most unlikely; there are too many coincidences, because the resemblances brought forward in this paper are only a few of those easily to be presented. Probably the most interesting relationships are between words requiring more study for true comparison, and these when their pedigrees are traced will fully establish the comparative age of the dialects. Words in which I could long trace no connection, under the light of Malay have their position to each other defined. Thus I knew no bond between the Maori word *uira*, "lightning," and *rarapa*, "to flash," until the Malay forms like *kilap*, "lightning," showed that the *ra* in *uira* is properly *rapa*.

As to "borrowing," there is too great distance geographically for Maori and Malay to have borrowed in modern times. How much they interchanged when the Maoris passed through the Archipelago cannot be known, and it is not even known whether the Malays were at that time in possession of the Archipelago or not. We may rest certain that some of these words are not resembling those in the other language by chance. I will take a single word to illustrate this. That word is *mata*, the eye. Now, if the Celebes did not agree with Maori in this it would be singular, for *mata* in some of its forms covers the whole of Oceania and part of Asia; it is known in India, and is as good for either "eye" or "face" as far west as the Caspian Sea. But between the Celebes and Maori there is far more than this viz., the sub-meanings agree. We have:

MATA.

Celebes.	Polynesia.
1. The eye.	1. The eye.
2. The mesh of a net.	2. The mesh of a net.
3. Raw, ripe, uncooked.	3. Raw, unripe, uncooked.
4. The point of a lance.	4. The point of a lance.
5. The source, as of a river.	5. The source, as of a river.

If any one believes that all these meanings agree with each other by pure chance, he must have the organ of caution very highly developed. To me they appear to convey the fact that both the people of Celebes and of New Zealand are using the same word.

I have compiled a dictionary of Bima in Sumbawa from the works of Dutch collectors, and I should be glad if some scientific society would get it printed. It would establish one more link in the chain of evidence.

No. 2.—MAORI FOLK-LORE.

By Elsdon Best.

In this paper I propose to give some of the numerous items of folk and demon lore, &c., as collected by myself from the Tuhoe Tribe of Maoris of New Zealand. When studying such matters it is well to bear in mind the fact that the Maori mind is, and ever was, deeply imbued with animism and the spirit of personification. Hence we shall see that the Maori of yore endowed inanimate objects with certain dread powers, and also with the powers of locomotion and speech. Whether the Native mind accepted such myths as being absolutely true or not I cannot say, but it is certain that the Maoris repeat them in a most serious manner. One can quite imagine that they place belief in such things, or did so within the past generation, when one notes their belief in other matters equally as absurd, such as the alleged powers of their quack doctors, with their barbarous and ridiculous methods of treating disease.

We will first speak of certain mythical beings which are believed to dwell in rivers, lakes, and the ocean, and which are termed *taniwha*. This term was applied to mythical monsters which are said to have inhabited holes and pools in rivers and also certain lakes, while some few of them seem to have established themselves in caves. Many legends are retained by the Natives which describe the slaying of these monsters by the warriors of olden times. These *taniwha* are usually described as being a species of saurian.

One kind of these creatures was called a *tuoro* or *hare*. It lived underground, and was not seen in the upper world. These *tuoro* seem to have roamed about underground in the most careless manner by means of burrowing, in which manner they made huge subterranean passages, overthrowing trees and rocks which came in their way. Their bodies were sometimes seen in flooded rivers as they were being swept out to sea. *Te ana tuoro* (the Tuoro Cave) is a place-name at Te Whaiti. Tuoro is also a place-name in Rarotonga. A *tuoro* is said to have dwelt in a pond named Otara, on the summit of

Maungapohatu, a high range in this district. This monster is credited with having formed the valley in the Waikare Stream in times long past away. The term *hare* is sometimes applied by the Tuhoe Tribe to a man possessed of great muscular strength. In another pond on the summit of the same range dwells one Rongo-te-mauriuri, a *taniwha* of dread power, said to have been the offspring of one Taneatua, an old-time migrant to these shores, and to whom many strange deeds and strange offspring are credited. Many generations ago one Rongo-te-kauiti visited the above pond known as Wai-ngaro, and was pursued by the *taniwha*. The world of death was already open to receive him, when Rongo bethought him of the means by which *taniwha* and *tipua* (goblins) are subdued. Hastily plucking a lock of hair from his head, he cast the same into the troubled waters of red Wai-ngaro, repeating as he did so these words:—

> Uruuru o tauhou
> Mau e kai te manawa o o tipuna.

Instantly the monster retreated and the surging waters became calm. Rongo of the Ready Hand was saved.

A short distance from Wai-ngaro stands a huge column of rock called the Tara o Tu-te-maungaroa. This Tu-te-maungaroa was a man-eating monster which infested Kainga-roa, and attacked parties travelling to or from Taupo. It was eventually slain by one Uru-waewae, who flourished ten generations ago. This *taniwha* had destroyed many of the Tuwharetoa Tribe, hence the chief Mawake-hore gave his own daughter, Maunga-kohu, to Te Uru-waewae as a wife for that valiant warrior, which was meet and fitting reward.

Tau-kanihi was the name of a *taniwha* which appears to have made its headquarters in the lower Rangi-taiki River, while Ruarera, another such creature, occupied the Whakatane River. Another, known as Hine-paaka, lives in the Putere Lakes and Wai-kare-moana, and passes underground from one lake to another.

Te Kuri-nui-a-Moko was the name of a huge *taniwha* which lived in a cave near Wai-kare-moana, and levied heavy toll on passing travellers as a means of subsistence. So many were thus consumed that at last the various tribes collected in order to slay the monster. They effected their purpose by means of constructing a huge *taiki*, or wooden cage, into which they enticed the man-eater by means of a human bait, and then slew him.

Some of these *taniwha* are said to be ancestors of the Natives here, and became *taniwha* after death. Of this class of ancestral demons or monsters are Hine-ruarangi, Ngarangi-hangu, Hine-ngawari, and Te Tahi-o-te-rangi. This Hine-ruarangi was the daughter of Toi, the Wood-eater, a famed chief of the ancient people of New Zealand, and who flourished about twenty-five generations ago. After death Hine became a *tipua*. This name is applied to beings or inanimate things possessed of supernatural powers. Hine appears in the form of a *kawau* (cormorant), which is looked upon as an evil omen. When this bird is seen hovering over a village of the Whaiti Natives it is known that the tribe will either soon lose a chief by death, or that a defeat in battle is assured. In this manner Hine warned her descendants of the disasters which overtook the tribe on the red fields of Okiri and Te Ariki, and also of the death of Pare-uia, on account of whose death the waters of Whirinaki ran red, and the Children of Mahanga flowed like water down to Hades.

Ngarangi-hangu was a man who flourished about six generations ago. After death he became a *taniwha*, whose abode is the Rangi-taiki River at Rae-pohatu, near Te Houhi.

One of the most famous *taniwha* of this coast is the ubiquitous Ruamano, who seems to dwell, or have dwelt, in many different places. Ruamano is said to have been the offspring of Tutara-kauika (an emblematical term for whales), and is primarily an ocean *taniwha*, and those in peril on the sea would call upon him to aid them in their extremity. In the strange myth of Rua-kapana it was Ruamano that conveyed Pou-rangahua to the isles of Polynesia when that old-time chief went forth upon the Ocean of Kiwa in search of food for his child. Also it was Ruamano that guided the Takitumu canoe across the salt seas to New Zealand. After this, that useful demon took up his quarters in the Papuni Lake, but when the lake broke out some time about the middle of last century, then Ruamano made for the ocean again; but it is said that some of his teeth were found at Te Papuni. In connection with this I may state that some two or three years ago a survey party discovered fossil remains of a large cetacean at Te Papuni. It is possible that Natives may have seen some fossil teeth at that place and attributed them to their friend Ruamano.

Other famous *taniwha* were Tu-te-haumi, at Mataroa; Tu-kapua, at Ruawahia; Tarakura, who dwelt near Matata; Korako, at Te Reinga; and many others.

We will now describe some of those *tipua* that are not included in the term *taniwha*. The term *tipua*, of which *tupua* is a variant form, means "a goblin, a demon"; it is applied to certain birds, trees, stones, &c., which are possessed of strange, supernatural powers, baleful and otherwise. Scattered across these lands are many such trees and rocks, which appear to represent the spirits of the land, the demons evolved from the animistic ideas of the Maori mind. When a person in travelling comes to one of these *tipua* by the wayside, he proceeds to pluck a branchlet or a handful of weeds or grass, which he casts at the base of the rock or tree, repeating at the same time a brief invocation, such as that already given. This is to placate the spirits of the land, that they may not be angered and send bad weather to embarrass the travellers. This act is termed *uruuru whenua—i.e.*, an "entering of the land"—and it applies more especially to such persons as are traversing such lands for the first time. Marae-roa, a tawa-tree at Maunga-pohatu, is such a *tipua*. Te Pakura, on the Huiarau Range, is another. This is a totara-tree which has taken root upon a beech-tree, and there flourishes. Mohea, a *tipua* tree near Matairangi, is another such. Should a traveller when passing here ask, "What place is this?" then rain will at once set in. So it behoves one to be careful when travelling in this region. Another *tipua* was Tutaua, a log which, it is said, drifted about in Wai-kare-moana for generations, and had the pleasing habit of chanting weird songs as it drifted to and fro across the Rippling Sea. And, as these songs have been preserved, of course the legend must be a true one. Te Rapa-a-Hinewhati, a tree on the Huiarau Range, is another place where the *uruuru whenua* was performed. The guardian of this tree is a tieke bird (*Creadion carunculatus*). This singular custom obtained also in Samoa, as described by the Rev. J. B. Stair.

The following is one form of the brief invocation repeated by a stranger to the land at these *tipua*. Casting his offering at the base of the tree or rock, he repeats,—

> Tuhituhi o tauhou
> Mau e kai te manawa o tauhou
> Whakapiri ki tautohito.

When a travelling party was delayed by a fog or dense mist a curious act was performed at the time when the necessary *karakia* (invocation, incantation) was repeated, in order to cause the fog to disperse. The operator would pull up a stalk of fern (rarauhe), strip off the leaves, and stick it, top downwards, in the earth. He would then split the upper end, and insert in the cleft a small clod of earth. The origin of this peculiar act I am unable to explain.

Te Komata-o-te-rangi is a rock at Manga-o-Hou. It is a *tipua* of undoubted powers, inasmuch as should any person approach it heavy rain will at once set in. Another such *tipua* is a stone named Te Puku-o-Kirihika, which lies at Pu-kareao. This stone is gifted with the power of locomotion, for if any person shifts it away it will return itself to its former position. Another such is Opunga, a rock in the Waihui River, and which one Paia endowed with powers inimical to man by means of incantations. Tu-ki-te-wa, a stone near Tu-matawhero, is a place where the *uruuru whenua* was formerly performed.

On the lands known as Te Purenga are two *tipua* birds, known as Kau and Kahu. They are ruru (owls), and are extremely useful to the fowlers of those parts, for when persons go to those lands at the opening of the bird-taking season and those two owls appear before them, that is a sure sign of a plentiful season—birds, &c., will be numerous. Should they not so appear, then a "lean season" may be looked forward to.

In the Wairau district is a *tipua* lake which was formerly a famous place for bird-snaring, but a thoughtless act led to its being lost for ever to Maori. Being a *tipua*, naturally it was necessary to treat it with great respect, and a famed chief of old told his wife to be very careful and not pass before him or near the lake with cooked food. But that foolish woman did one day so pass before him carrying some cooked food, with the result that the demon lake concealed itself, and no man has ever since been able to find that pond or its prized bird-snaring trees. Now you can see what trouble a woman can cause.

It must not be supposed that these *tipua* trees and stones were actually worshipped, although they might be termed "fetishes." They were deemed to possess certain supernatural powers, and were treated with respect, if not dread, because of such powers. Hence they were placated after the manner Maori.

There is another series of strange legends anent certain beings, described as though they were human, but who had no knowledge of fire, and hence ate all their food in a raw state. They are said to inhabit far-away lands which have occasionally been reached by old-time voyagers. These beings wore no clothing and were very mischievous, hence they were termed *nanakia*. It is said that they sometimes seized and carried off women who were wandering in the forests. Some of these strange peoples are said to have lived in trees.

There are also said to be, or to have been, tribes of fairies or forest elves which lived on the high forest ranges. Sometimes their sleeping-places would be seen by hunters, but the forest folk would at once desert such home of theirs that had been visited by ordinary people of the common world, for these forest people are excessively *tapu*. They are known among Tuhoe as *heketoro*. The *turehu* are a similar people, who are of very fair complexion, hence *urukehu* (fair-skinned people with reddish hair) are often termed *turehu* by the Tuhoe Tribe. This fair type is very persistent, and has been so from ancient times. To illustrate this the Natives gave me genealogies of such families, showing how the type has sometimes missed a generation or two, but always to reappear later on. Another name for the forest folk or fairies is *patupaiarehe*, and these are credited with malevolent designs against the *genus homo*, inasmuch as they are said to enter sleeping-houses at night and destroy the people therein, which means that the Natives were ignorant of the effect of charcoal fires kindled on cold nights within their semi-subterranean and tightly closed sleeping-houses. It is said that these fairies were heard in misty weather talking, singing, and sounding their flutes away up on the mist-laden ranges. These *heketoro* are said to have formerly been numerous at Mapouriki, at Maungapohatu, at Te Turi-o-Haua, and at Oparoro and Te Pae whakataratara. "And we would hear the fairies singing in their forest homes, hear the voices of children — many children and of women, who ever sang plaintive songs and sounded their flutes and trumpets upon the forest ranges."

The *Kiri-whakapapa* are said to have been a strange but harmless tribe of bush people of Hawaiki or foreign lands. *Te Tini o te hakuturi* seems to be a sort of emblematical term for birds. This is the "tribe" that appears to have had the guardianship of forests in far Hawaiki, and is credited in Maori folk-lore with the gift of human speech and the power to use tools, as in the making of the canoe of Rata.

Old men say that in former times companies of spirits or demons, termed *tira maaka*, were sometimes seen passing along the high ranges or through space. To these were allied certain vaguely understood supernatural beings or spirits known as the Hordes of the Ocean, of Inland, of Outside, of Beyond, which beings were progenitors of human beings and of *taniwha*, demons. Away beyond these, in the very night of time, existed the Horde of Anu, of which no definite information is obtainable.

In the days of yore, when gods and heroes deigned to dwell upon earth, one Tairi-a-kohu,* a supernatural being, descended from the heavens, in order that she might bathe in the waters of this world. She was seen to descend, surrounded by mist, by one Uenuku, who, captivated by the rare charms of the Mist Maiden, sought to capture her. This he succeeded in doing, and so Tairi-a-kohu became the wife of Uenuku. But she only stayed with him during the night, and at break of day she departed every morning and ascended to the heavens, from which she again descended when the shades of night fell. And she told Uenuku that he must not on any account mention anything about her or show her to his people. Were he to do so, then she would leave him, never to return. But when their child was born and well grown, then Uenuku might inform his people as to who his wife was. So time

* "Tairi-a-kohu" means "suspended like mist," or fog. This being is said to be one and the same as Hine-pukohurangi, the personified form of mist and fog.

passed by, and at last the child was born, and was named Heheu-rangi. Then Uenuku his heart became dry with desire to exhibit his wife to his own people. So he carefully closed all apertures through which light might enter his dwelling, and the next morning he thus managed to detain his celestial wife until broad daylight. Then, when Tairi rose to return to the heavens, she found that daylight was upon the world, and that many people had collected outside the house in order to view her. Then was the Maid of the Mist dismayed, so stood she beneath the window of the house, clothed with nought save her own long hair, which covered her as a shawl. And so she sang a song of farewell and upbraiding to her husband Uenuku. Then she ascended to the heavens and left Uenuku disconsolate. And in after-days did Uenuku long to recover his celestial wife, even so he went forth and travelled over far lands in search of her for many years, until his days were numbered and he knew death. But Uenuku is not lost to the Maori people, for when you see a vivid rainbow of a certain aspect bestriding the heavens you may know that that is Uenuku, the wanderer.

Among the Taupo tribes obtains a legend of a flying ogre, known as the Ririo, which appears to have been in the habit of seizing people and carrying them off to the mountainous ranges of the district. It is said to have had its abode in the Kai-manawa Range. A certain ancestor, one Hau-kopeke by name, who had infringed the laws of *tapu* by partaking of sacred food prepared for the priests, and had thereby offended the gods, was seized by the Ririo and carried off to the abode of demons on the mountain. To cause the ogre to return the hapless one, the priests gathered at the sacred place and there remained for seven nights without food, but performing the rites of yore in order to rescue their tribesman from the demon. On the seventh day the ogre brought back the erring one and cast him down through the trees near his home, so that one side of our ancestor was paralysed ever after. Such is the story of Hau-kopeke.

Another class of folk-lore tales deals with the singular animistic myths relating to mountains, rivers, trees, &c. In ancient times the mountains grouped around Lake Taupo were much more numerous than they are now. It was Rangi, the Sky Parent, who married Mount Pihanga, a female, to Tongariro Mountain, and their offspring was the snow, hail, and driving sleet of those altitudes.

Te hoa tau te pupu e hu nei i Tongariro
Ka mahana i taku kiri
Na Rangi mai ano, nana i whakamoe
Ko Pihanga te wahine
Hai ua, hai hau, hai marangai
Ki te muri—e.

But in after-days dissensions arose among the happy family of Taupo anent these love affairs, hence Taranaki (Mount Egmont) migrated westwards to the sea-coast, where it now stands, while Maunga-pohatu, Kakaramea, Moutohora, and others went eastward. The two former seem to have been married previously and to have produced offspring viz., Mou-tohora (Whale Island), Tapanaua (a rock in the Tauranga Valley), Toka-tapu, Te Toka-a-Houmea (a rock by the roadside a mile from Whakatane), and others. The parents quarrelled over the route by which they should go. Kakaramea said, "Very well, we will separate; you and our offspring shall go eastward so soon as food is prepared for us." So they went their way, and Kakaramea got so far as Wai-o-tapu, where he now stands. But Maunga-pohatu got further; while Mou-tohora reached the sea, where he now stands, just off Whakatane. And Kakaramea in after-days yearned for his wife, who stood far away on the eastern sky-line, and so he lifted up his voice in a song of love for his absent spouse.

Strange indeed are the old time myths of the Maori regarding the origin of the universe, of the elements, and of man. Universal animism and personification obtains in these folk tales and myths of a primitive people. Man, the elements, trees, &c., are all descended from a common source, from a primal pair, the Sky Parent and the Earth Mother. Hence it may be understood how closely a Maori deems himself in contact with nature. He enters a forest and sees on every side, not senseless trees and plants as do we. He is amongst the Children of Tane; he placates the spirits of the woods by means of simple offerings; he performs a religious rite ere taking the life of one of the offspring of Tane-mahuta *i.e.*, before felling a tree. In searching for the *perei* as an article of food he is careful not to utter its name, or that useful tuber will disappear. As he goes to take birds from the snares he mentions not his errand to any one, lest the birds hear him, and make their escape. He not only looks upon all these things as sentient beings, but also as understanding human speech. He is a child of nature, uncultured and superstitious, but close, very close, to the heart of Mother Earth, from whom all things sprang in the days when the world was young.

No. 3.—SOME PERSONAL HABITS OR MANNERISMS OF THE POLYNESIANS.

By S. Percy Smith.

Every known race of mankind has customs peculiar to itself, and others that are the common property of many races. Many of these customs are handed down from generation to generation for untold ages, and become in time a distinguishing feature of such race by which we may recognise its members wherever we meet them. When such races separate by migration, branching off from the parent stock, the migrants carry with them the customs of their forefathers to far-distant lands, and impress upon their offspring the habits, the ideas, the feelings, and the speech of their ancestors. In this manner peculiarities of habit may often be found in races now separated by vast distances, the very presence of which leads us to conclude that a former connection existed between the various branches. Most savage races are extremely conservative in all that concerns their customs; contact with an outside and superior race alone induces changes more or less universal. Hence it follows that a great similarity in personal habit characterizes the branches of a race which have been separated from the parent stock for ages. Few races exhibit this conservatism in a greater degree than the Polynesian, or, it would be more accurate to say, did so. Contact with Europeans introduced to them manners and customs quite foreign to their ideas, inducing changes of such magnitude that in the course of a few generations their peculiar habits have in a large measure disappeared, whilst some few remain unchanged to this day.

It is with a view of preserving some of these racial peculiarities of habit that the following notes have been put together. In a short time these habits will have completely disappeared, and the descendants of the people themselves will know nothing of them, any more than do the Europeans now dwelling amongst them. By bringing into one view the peculiarities of personal habits of the Polynesians much may be learned as to the origin of the people themselves, for if we find the same habits common to other peoples it is a legitimate deduction that their forefathers had at some time—if not a common ancestry—certainly an intimate connection. The illustrations of these habits to follow are drawn more particularly from those of the Maori, or New Zealand branch of the Polynesian races, and it is to be hoped that those who are acquainted with other branches of the race will supplement what is here noted, and so make the record complete before the changes which are daily coming into play have obliterated the whole of them.

So far as the subject allows, the *personal* habits or mannerisms as distinguished from the racial customs will be dealt with; but it is obvious that the distinction cannot in all cases be clearly defined, any more than the meaning here attached to *personal* habit can be exactly explained. The notes themselves will best illustrate what is meant. It is quite possible to say, under certain given circumstances, what a European will do; it is equally possible to predict what a Polynesian will do under the same conditions. It does not at all follow that both races will do the same. Herein is contained what is intended to be expressed, for want of a better term, *personal habit.*

Europeans express pleasure at meeting their friends after a prolonged absence by a cheerful demeanour, hand-shaking, and amongst women by kissing. Polynesians, on the other hand, consider a sorrowful mien, the outpouring of tears, and contact of noses the correct behaviour. The contact of noses is usually termed "rubbing noses" by European writers. It is, however, nothing of the kind; there is no friction applied to the process. The salutation is sometimes performed by the two parties standing, but more generally by one sitting and the other standing. Hosts receive their guests sitting. Many a time have I been travelling with a company of Maoris when another party has come into view, advancing towards us. The custom was for one party to sit down to receive the others, who on meeting would salute their friends with the *hongi* or nose-pressure. The process is this: The head of each is inclined a little over the left shoulder, and the lower parts of the two noses are brought into contact, followed by repeated pressures, but no "rubbing" in the strict sense of the word. Usually a low-toned expression of feeling accompanies the *hongi,* more especially if the death of a near relative has occurred since the last meeting, when the name of the deceased was always mentioned. Usually the *hongi* lasts but a few seconds, but on the death of a relative the two operators often sit for half an hour or more with their noses in contact, and the whole time intoning a mournful dirge over the deceased relative, accompanied with copious tears.

Sitting down to receive guests is a mark of respect, exactly the opposite to European custom. On ordinary occasions the persons meeting said, "*Tena-koe*" ("That you"), or "*Tena-ra-ko-koe*" ("That indeed is you"), or "*Ko-koe-tena* ("Is that you?"); and I believe this latter to be the origin of the others. At parting, the one who leaves says to the other, "*E noho ra*" ("Stay here"); the other, "*Haere* *ra*" ("Go there); or sometimes the first says, "*Hei-konei ra*" ("At here then," which is equivalent to "Stay here"). The word *hongi*, under various forms, such as *ongi*, *honi*, *hoi*, *songi*, is common to all Polynesians, and is applied to the same mode of salutation. Its meaning is "to smell." Both men and women use the same form of nose-pressure, but only on meeting, never at parting. The only verbal form of salutation amongst the other islands of the Pacific which approaches that of the Maori that I have met with is that of Mangareva or Gambier Island. The Maoris of that island use the form "*Ko toe noti*." It is questionable if that is not really "*Ko koe ano oti*"; if so, it approaches the New Zealand Maori form "*Ko koe oti tera*" (Is that indeed you?"). The old original term of address in Rarotonga was "*Tena-koe*," superseded at the present day by "*Kia-ora ana*"; and it is said that the Tahitians formerly used the same words, now replaced by "*Ia ora na*," from whence the Rarotongan form is derived. It means, "May you be well!" This form is gradually being introduced into New Zealand, but as yet prevails to a small extent only.

SITTING.

The New Zealand Maori used no raised seats, though some other branches of the race did—at any rate, on State occasions. The ordinary position in sitting down to food was to squat on the heels, the hams touching them. This is called *noho titengi*, and it was their favourite position when engaged in most sorts of work, such as using the adze (*toki*), making nets (though sometimes the legs were stretched out in this latter case to allow of the net being firmly held by the toe), digging in the cultivations with sharp-pointed stick, or in mere repose during conversation, &c. The men, especially the younger ones, often sat cross-legged, which they managed with much more ease and grace than a European. This latter is the common position in most of the islands, and is used by both sexes. The women also very generally squat on their heels, but they have also a very common way of sitting, which I think is peculiar to the race, as I never heard it ascribed to another. When in repose and enjoying conversation—which they do very much—they kneel down on the ground, but with the legs placed on one side of the body, so that the hams rest on the ground; it is called *noho-whariki* in New Zealand, *faka-faite* in Tonga, *faite* in Tahiti and Futuna. They often sit this way when at work in their cultivations, weeding, or turning over the soil with a pointed stick. This mode of sitting is also common to some of the Micronesians, as I judge by one of Mr. Andrews's photographs of a group of Pleasant Island girls, in which several of them are sitting in the manner described (*noho whariki*).* In this and other positions of repose the women have a peculiar way of holding their hands, which I think is a racial trait also. It is a little difficult to describe, but if the tops of the thumbs and forefingers of both hands are brought all four together, whilst the hands rest on the leg, a fair idea of this posture will be obtained. It is also to be observed in the photograph of the Pleasant Island girls I have already alluded to.

ASSENT, WINKING, ETC.

The European gives assent to anything by nodding his head downwards. The Maori does exactly the opposite; he nods upwards, called *tungore*, at the same time quickly elevating and depressing his eyebrows. This means assent. Dissent is expressed by silence; one must, therefore, never by any chance take "silence for consent" with a Maori. On perpetrating a joke or on deceiving any one, if you are in the secret, but not the subject of the pleasantry, a Maori will wink at you with both eyes and eyebrows, accompanied with a slight nod downwards. A downward nod is generally intended as an invitation to sit one's-self down, usually accompanied by words expressing the same thing, and by patting the ground with the hand. The Maori had something similar to what we call "taking a guider," like Ingoldsby's monk, who "placed his thumb upon his nose and spread his fingers out." This operation was equivalent to the Maori way of putting the thumb between the first and second fingers, at the same time doubling the fist so that the thumb-top showed at the back of the hand. This means, "Don't you believe it," or "Do you see any green in my eye." The Maori term for this is *kohurehure*. The same idea is expressed by pulling down the lower eyelid with the finger.

GAIT, ETC.

A Maori walks with upright mien, the head set well back, and with considerable dignity of gait. On long journeys and if carrying a load he often shuffles along at an ambling gait, taking frequent rests. They can keep up this pace for very long journeys. They are not good walkers—a European will soon tire them out in the matter of distance; but in carrying a load on the back (*pikau*) the Maori (of old days) would surpass any European. They invariably turn the toes inwards, which is no doubt due to the narrow paths they were in the habit of using, for a race without tools with which to clear a road depends greatly on its feet for making a track, added to which the Maori always set fire to the scrub and fern to clear it off their tracks, which otherwise often would become

* The Pleasant-Islanders are, however, as much Polynesians as Micronesians.

so overgrown as to be barely perceptible. It is owing to this constant burning year after year that the forest in many places has gradually receded, often leaving in its place a barren soil, out of which the vegetable humus has been burnt and the soil thus destroyed. This is especially noticeable to the north of Auckland.

Old Maori women are habitually bent from carrying heavy loads on their backs, for it must be remembered they were the beasts of burden; the men's backs were too *tapu* in former times for them ever to carry any food. This, however, did not apply to slaves. A Maori woman's gait, to European eyes, is never a graceful one; when young she affects a peculiar movement of the hips, because it is the fashion and admired by the men. This is referred to as *hope-ngawhare*, or "pliant hips." It is difficult to describe, but consists in swinging the hips from side to side with each step, the hip-joint appearing to move almost out of its place each time—the back of the one leg being straightened at the same time. This causes—to us—a most unsightly waddling mode of progression, which was nevertheless highly admired by the old Maori.

In travelling, a party of Maoris always sat down to rest and admire the view at all open or high ridges the path might run over, for no one more admires a clear extensive view than the Maori, however much they may be incapable of appreciating the minor beauties of nature. To march single file was the invariable custom, necessitated by the narrowness of their tracks. On the approach to a settlement a halt was usually called to enable them to put on their best clothes, and to wait the arrival of stragglers. The chief personage then advanced in front of the rest, and led the way to the village.

So late as the year 1850 it was rare indeed to meet a Maori in some districts without his old Native arms in his hand, carried, I believe, more from custom than anything else. What has become of the enormous number of arms then in existence is puzzling, for to-day it is most difficult to see one.

The Maori always kneels in paddling his canoe, keeping his face towards the direction in which he is going. (In making water both sexes squat down on their heels.)

CARRYING LOADS, CHILDREN, ETC.

The method of carrying burdens at each end of a pole, like the Tahitians and some other Polynesians, was quite unknown to the Maori. Heavy articles were always carried strapped on the back (*pikau* or *waha*) like a knapsack, and they would carry enormous weights this way. The women especially were great adepts at this mode of carrying. Children were frequently so carried (*waha tamariki*), either by men or women. The child was caught by its two arms and slung round on to the back, where it puts its arms round its parent's neck, and then around it was thrown the mat, which, coming round to the front, was held there, keeping the child perfectly safe on the carrier's back in a warm and comfortable position.

Sometimes the little one was made to stride on its mother's hip with one of her arms round it (this was called *hiki*), and more rarely was carried in the arms in front (*kakapu*). Old women often carry a basket of potatoes, &c., on the hip, with one arm round it. After arriving at a certain age the mother's breasts became so elongated that she could feed her child whilst carrying it on her back. It was at one time no uncommon thing to see a Maori woman carry her young puppy or pig on her back just in the same manner as a child, and not infrequently they suckled them just like a child.

SWIMMING, ETC.

Like all Polynesians, Maoris are almost as much at home in the water as on land. They are strong swimmers, but do not take the water breast on as we do, but lie on one side, and with the left arm projected forward and then brought back to the body, whilst the right arm, starting at the same moment from the breast, is sent backwards to its full extent, the legs meantime being used much in the same manner as a dog swims. They swim rapidly and easily in this position; the women swim, if anything, better than the men. Children take to the water even before they can walk; indeed, I have known them to swim quite as soon as they could walk. They were excellent divers, too, both men and women, and in jumping in from a height always twisted the legs together and went in feet foremost. They could, however, dive head first, and that for great lengths, but never did so from a height. The women have an amusement in the water which consists in throwing the body upright as far out of the water as possible, and then placing the elbows against the sides, bringing the hollowed hands down on the surface of the water, making a great noise. This is called *posu* in Futuna, where the women have the same practice; in Maori it is *ta potu*.

SPEECHMAKING, ETC.

On the occasion of tribal gatherings to discuss the affairs of the tribe or other matters set speeches were made by the principal men, the audience all squatting around on the ground. The orator invariably held something in his hand to help his most expressive gesticulation—usually a spear, a club, or greenstone *mere*. He generally commenced by a few words of welcome to the strangers, then followed with a recitation from some old poem, in which was vaguely indicated the purport of his speech. As he warmed to his own words he would run forward for a few paces, ending in a jump, and then, frequently with much gesticulation and often simulated rage, pour forth a torrent of words until his ideas or breath failed him. He then walked quietly back to his starting-point with abstracted gaze, gathering fresh inspiration as he went. With an abrupt turn he again danced, rather than ran, along the short course, pouring forth torrents of eloquence, and again ended with a jump to give emphasis to his words. The audience meanwhile usually sits impassive, or sometimes gives utterance to its approval of the sentiments expressed by "*Korero! korero!*" ("Speak! speak!"). This speechmaking is termed *taki*. Many of the old men were most eloquent, and by their powerful words were able to sway large multitudes to their way of thinking. As a rule, the utmost decorum prevailed during these speechmakings, and rarely was the orator interrupted. Occasionally, however, I have seen another, who took extreme opposite views, get up and proceed to *taki* on his own account, in which case it frequently appeared from their gestures that they were on the point of braining one another. It was all taken in good part, however, and ended in nothing.

The Maoris' powers of narrative are of a very high order; no white man can, in my estimation, compare to their old men in this respect. Their splendid memories, expressive gesticulation, excessive attention to detail, and powers of description of events are all used with the greatest felicity. Nothing that I have ever heard equalled in interest some of the narrations of battles in which the narrators themselves had been actors. In their narrations the minutest event is recorded and nothing forgotten.

CONVERSATION, ETC.

As a rule, the Maori is of a joyous temperament, ardently loving conversation, especially if seasoned with a joke; nor were they particular as to the character of the joke many things which we call obscene were to them, men as well as women, topics of every-day occurrence. They had no occasion for false shame at the mention of things which to us, in mixed society, are *tapu*, for, living in a state of nature as they did, no improper ideas were engendered by mention of things and deeds which were openly talked of. Having no books, conversation naturally took their place. After the evening meal they gathered in their comfortable homes, or outside in the summer, and discussed with relish the proceedings of the day.

Any one arriving from a journey was expected to give the minutest details of all that had occurred since he left, which was listened to in rapt attention. No Maori could keep a secret long; it must out, and soon became the property of all, whatever its nature. Love of notoriety was a leading characteristic of the race; hence actions were often done to secure fame (*kawe ingoa*), and for no other reason. But of all the characteristics of the people, revenge was the ruling and strongest passion; it might slumber, but never died—even if the opportunity of gratifying the feeling did not occur in the lifetime of the injured party, his children avenged it on the first occasion.

Advances from one sex to another were more often than not made by the females, and their way of expressing it was by scratching the hand (*raraku* called *feta'u* in Samoa). As a rule, the girls were free to offer their forms to any one they pleased, without shame or reproof; but this was not the case in the chiefs' families, the daughters of which were sometimes as carefully guarded as amongst us. A chief's daughter would be called a *puhi* (a virgin), and it was counted as a transgression in a man even to touch the hem of her garment.

In old days both sexes usually wore the hair long, but the men gathered it up in a big lock on the top of the head, called a *tiki*: the women, however, frequently wore it hanging about their shoulders, but more often cut short. In mourning the hair was cut short, and sometimes in the most fantastic ways. I have seen the whole of one side of the head close-shaven, whilst on the other side the hair was long. I have also seen a man with a high ridge of *red* hair on the fore part of his head, while the hinder part was black and close-shaven. Red hair (*urukehu*) was not unknown, but was not common. I knew a family in Taranaki who—father and children—were all albinos (*korako*), a very ugly set, with white hair and eyelashes and pink eyes. The man was fully tattooed, the blue markings standing out in strong contrast on his white skin.

WHISTLING.

A Maori never whistles, the reason being that the gods spoke in a whistling tone when they communicated through the priests to the people. This, of course, was ventriloquism, in which the priest (or *tohunga*) was often an adept. It was thus an insult to the gods to imitate their voices. In boating excursions in former days I have often been reproved by my Maori companions when whistling for a wind, as sailors do; it was supposed to bring on a squall.

BECKONING.

When we beckon any one to approach us we do so by holding the hand up, fingers upwards, and drawing the hand towards the chest. All Polynesians do just the contrary; they hold the hand and fingers downwards, and thus beckon, drawing the hand towards the body. They also indicate the direction in which any person or thing may be by a quick elevation of the eyebrows and a slight turn of the head and eyes towards the direction required.

DRINKING.

All Polynesians when drinking from a stream, instead of scooping the water up in the hollow of the hand as we do, slightly bend the fingers and throw the water upwards to the mouth. This they do very neatly, whilst a novice generally succeeds only in wetting all his face. This, of course, was a Hebrew method of drinking.

MEASURING HEIGHTS.

The Polynesian measure of length is the *maro* or *whawhanga* the length of the outstretched arms from tip to tip of finger a fathom, in fact. But in describing the height of a child they adopt this curious method: For a very small child they hold the forearm upright, with the hand bent at right angles, the elbow touching the ground—if the describer is sitting; if standing, the other hand is placed on the elbow, to indicate the height.

A sign used by one person to many, signifying that they are to take no action, is to join the forefinger and thumb and place it on the side of the nose.

To denote the intention of a person to return, generally with a hostile intention, the hand is placed behind the back and the hand oscillated up and down—the back, of course, being turned toward the person for whom the sign is intended.

It was considered good manners to eructate after eating heartily—it was a sign that one appreciated the good things provided.

The Maori had no word expressing thanks—not that they are ungrateful, but it was not their custom to express their gratitude by words. On the other hand, the more ceremonious branches of the race Samoans, Tongans, Niueans—had a word signifying "Thank you"—*i.e.*, *Fakafetai*, *Fa'afetai*, *Oue*, *Oue tulou*, &c. But the Maoris do not belong to that branch, but to the eastern Polynesian, who are likewise without a word expressing thanks directly.

No. 4.—THE KUMBAINGGERI, ONE OF THE ABORIGINAL LANGUAGES OF NEW SOUTH WALES.

By R. H. Matthews.

Section G.
ECONOMIC SCIENCE AND AGRICULTURE.

Section G 1. Economic Science.

(No papers offered.)

Section G 2.—Agriculture.

VICE-PRESIDENTIAL ADDRESS.

By T. W. Kirk, F.L.S., Chief of the Divisions of Biology, Horticulture, and Publications, Department of Agriculture, Wellington.

(Delivered Thursday, 7th January, 1904.)

THE IMPORTANCE OF AGRICULTURE.

I regret the absence of our President, Professor J. D. Towar, Principal of the Roseworthy Agricultural College, South Australia, and the loss on this occasion of the services of so able a man. When informed of the proposed honour of the nomination as a Vice-President of this Section I was told that the post would be a mere sinecure, as a President and several other Vice-Presidents had also been appointed. Unfortunately, Mr. Gilruth, Mr. Lowrie, and Mr. Matthews are all absent, though the first-named will be present in a day or two. Misfortunes never come singly, and Professor Towar has, unfortunately, not been able to forward his address as President of this Section, and it was only with about five minutes' notice that I was informed that I must take his place. With no material available, and no time, it was hardly possible that this could be undertaken. There are, however, one or two points of importance which I desire to bring before you.

To the science dealt with by our Section all the delegates and members of the Congress now meeting in Dunedin owe their presence amongst us. Baron Von Liebig has stated, "There is no profession which can be compared in importance with that of agriculture, for to it belongs the production of food for men and animals. On it depends the welfare and development of the whole human race, the riches of the State, and all industry, manufacturing and commercial. There is no profession in which the application of correct principles is productive of more beneficial results or is of greater or more decided influence.''

As showing the importance of the industry dealt with, especially from a New Zealand point of view, I may quote certain figures which will give you an opportunity of realising the magnitude and importance of the subjects with which we have to deal in this Section. The figures for New Zealand are these: In 1880 the total exports from the colony were £6,102,000, and of this the agricultural and pastoral products amounted to £957,000. Ten years later—that is, in 1890—the total exports were £9,028,000, and the agricultural portion £1,028,000. In 1900 the total exports were £13,055,000, and the agricultural portion was £10,017,000. I regret I am not able to supply the figures for last year, as they are not yet available. It will be seen, however, that out of an export of thirteen millions the agricultural and pastoral pursuits supply ten millions, so that practically they are supplying considerably more than three-quarters of the total exports of the colony. This proves the preponderating influence of agriculture upon this country, and shows that the science with which we have to deal in this Section is of more economic importance to New Zealand than all the other industries put together. The Department of Agriculture was created in 1892, and I think the figures given warrant the belief that its influence has proved beneficial.

Of course, I am aware that there are other aspects beside the bread-and-butter view; but, as Liebig has shown, that is the most important, as without it the race would not live to study the other subjects. If the subject is so important and so much depends on agriculture, surely the possession of proper knowledge of its principles is imperative; and in order to gain this proper knowledge it is necessary that a complete agricultural education should be given to the youth of this country, and in order to gain this the system of instruction must be thoroughly efficient and practical. In 1897, and on various subsequent occasions, I drew attention to the necessity for this agricultural education. First, in the primary schools, especially in the rural ones, agriculture must be taught, all lessons as far as possible being illustrated by experiments, and a school garden should, if possible, be maintained, and the importance of, and reasons for, thorough tillage demonstrated; this garden being divided into a number of plots, in which the same plant or vegetable should be tested with varying quantities of manure and with various manures. This will show the children what manure is required by various plants in that locality, and in what the soil of the locality is deficient. Then come the secondary schools, where this course should be carried on to a larger extent, followed by schools of agriculture, including, of course, horticulture, for this colony is capable of taking a very prominent place in fruit-culture, and the export of fruit should ere many years be very considerable.

Probably one of the most important agencies in the development of agriculture and horticulture is the establishment of experimental stations, agricultural and horticultural, where, in addition to conducting experiments on crops, stock, &c., a number of cadets might be taken. The education obtained at such places would be invaluable. Where these cannot be maintained for want of capital, subsidised or co-operative experiments should certainly be undertaken: that is, where a settler is able and willing to undertake the conduct of experiments under the control of Government officers, the Government should arrange for the settler to find the land, which, of course, in such instances would not be a large area —anything from an acre to two or three acres. The Government would find the seed or plants and pay the settler for his labour, so that he would be out of pocket nothing but the rent of his land. Moreover, when the objects for which the experiment had been instituted were attained, the settler would come into possession of the trees and other improvements made at the expense of the country; but the country would have achieved its object, and the whole of the settlers in that neighbourhood would have received a most valuable object-lesson. These experimental stations in dairying districts should most emphatically have dairy schools attached to them.

I do not propose to make any lengthy remarks on the subject, but merely to remind you that if the State depends on agriculture, as is undoubtedly the case with us, she owes a great debt to agricultural science, for in this colony our prosperity is undoubtedly phenomenal. All agricultural States would be justified in spending much more money on agricultural education and experimental stations than they do at present, and the experience of the leading agricultural countries of the world has shown that such an investment is a remarkably paying one. It is a fact that those countries which spend most money in teaching agriculture, provided their efforts are judiciously guided, produce the best crops, highest-grade stock, and superior products generally, and consequently enjoy a greater amount of prosperity than those that pay less attention to the science and art of agriculture.

I am much obliged to you for the patience with which you have listened to the few remarks which, in the unavoidable absence of the President, I have been called upon to make on the spur of the moment.

No. 1.—SOME OBSERVATIONS ON POMOLOGY.

By W. C. Cato.

Fruit has now come to be recognised as one of the necessaries of life, and its culture is receiving greater attention at the hands of horticulturists in Europe and America than perhaps at any former period in the world's history. Scientific horticulture is now taught in schools and colleges by able professors, and we must adopt similar methods if we are to compete successfully with America and other fruit-growing countries in the matter of fruit-culture. Nova Scotia, with a limited population, has its School of Horticulture attached to the Wolfville University. "Horticulture, botany, and microscopic botany are taught by an able professor, F. C. Sears. The school consists of a class-room with a good collection of English, Canadian, and American books on horticulture, horticultural journals, about twelve good microscopes, and a collection of pressed wild plants. Beneath the class-room is a potting-shed or workshop, and adjoining a glass-house with economic and ornamental plants and flowers, in which grafting, budding, and propagating are taught. There is also a root-cellar, in which apple-stocks for root-grafting during winter are kept. Surrounding the school are ornamental grounds with a nursery of young fruit and other trees and plants close by. The horticultural course is at present confined mostly to the propagation of plants and to fruit-growing, dealing with wind-breaks, protection from frosts, setting out and planting, tillage, manuring, cover-crops, renovation of old orchards, grafting, budding, the life-history of fungi and insects, spraying, harvesting, and packing of the fruit, cold-storage, &c." (Mr. C. H. Hooper, M.R.A.C., F.S.I.)

Apart from the health aspect of the question, the commercial value to these colonies of the fruit industry should be very considerable when it is understood that England alone at present pays £10,000,000 yearly to foreign fruit-growers, and it is estimated that, unless the home industry increases, the foreign-fruit bill will, in a few years, reach £20,000,000. —(*World's Work.*)

The object of this paper is not to discuss the recognised methods of fruit-culture, which are exhaustively dealt with in our standard works on horticulture, but rather to indicate the lines upon which, it appears to me, expert investigation is needed in order that the best results may be obtained from such cultivation. In Tasmania many orchardists have been content to plant the best-known English and American varieties of fruit without regard to the suitability of climate or soil, which are factors far-reaching in their effect upon the character of the fruit, and, as far as is known, no system of cultivation can obviate materially unfavourable climatic conditions. The consequence has been in many cases failure to obtain the best results, although the most approved method of cultivation may have been adopted. The celebrated Newtown Pippin of America, so well and favourably known throughout Europe, where it is largely imported, and has realised fabulous prices, is a remarkable instance of the state of perfection which the apple may attain under good cultivation where climate and soil are favourable, whilst the same variety does not succeed elsewhere. Dr. Hogg says that, "even with the protection of a wall and grown in the most favourable situation, this apple does not possess that peculiarly rich aroma which characterizes the American-grown fruit." Some years ago Dr. Benjafield, of Tasmania, obtained from France the scions of about forty varieties of their choicest pears, but many of these proved to be practically worthless when grown in Tasmania. The Tasmanian climate and soil are well adapted to the production of all English fruits, whilst in Australia the American varieties appear to succeed better. The English Scarlet Nonpariel attains greater perfection in Tasmania than in England, and no apple has proved so profitable to Tasmanian growers as this one. Next in order of merit comes the New York, then the Sturmer Pippin and French Crab.

The character of the fruit may also be affected favourably or otherwise by the nature of the stock upon which it is grown. Dwarfing stocks, which have the effect of checking a too vigorous growth of wood, divert the energies of the tree towards the production of fruit, and of an improved quality, rather than wood. A writer in the *World's Work* for September last states that "a revolution is being wrought in British fruit-growing by the supersedure of the tall or standard by the dwarf. The miniature trees yield finer fruits, and consequently a far higher return than tall trees. The use of the dwarf tree is one of the chief features of the fruit-growing movement, and has been recognised by the leading men in the business as the basis of all profit."

In conclusion, I would urge the institution of experimental orchards, having a variety of soils and aspects, with a view of ascertaining the varieties of fruit which will succeed or be improved by existing climatic conditions, under the most approved methods of fruit-culture. This institution should be in charge of a horticultural expert, who should be able to give information generally in all branches of horticultural science.

No. 2.—CHEESE MATURED AT LOW TEMPERATURES.

By R. Crowe, Victorian Dairy Expert.

According to reports of experiments conducted in the United States and Canada up till last year, the results of maturing cheese at low temperatures were so promising as to warrant trials on a large scale to be undertaken.

Canada has earned a high reputation for quality of cheese, and supplies the great bulk of Britain's importation. Under the old system a considerable loss occurred through evaporation of moisture from cheese while ripening, and leakage of butter-fat, especially in the summer-time. The overheating and drying, whilst facilitating early curing, rendered the cheese less mellow in flavour, and gave waste in the shape of a thick rind. It was at once recognised that if beneficial results were secured in Canada, where the climate is colder and the air more humid than ours, no time should be lost in testing the method locally.

Generally speaking, the greatest fault noticeable in Victorian cheese is its dryness; it is mealy in texture, and does not break down on the palate as good cheese should. This is not to be wondered at when it is remembered that few of the farms where cheese is made have suitable insulated maturing-rooms. On hot days the temperature gets up to 80 deg., 90 deg., and even 100 deg. Fahr. sometimes, and on such occasions the shelves and floor are flooded with butter-fat that has run from the cheese, rendering it poorer, drier, and less palatable. Even the factories suffer in this direction in the height of summer; therefore it was concluded, even before a start was made, that in the new system there was promise of great things for the Victorian cheesemaker.

This time last year arrangements were made for a few cheeses to be placed in cool-stores; instructions were given to those makers who kindly consented to assist, asking them to forward half of the make from one vat of milk and keep the remainder to be treated in the usual manner, and weigh regularly at monthly intervals.

The first lot of two cheeses came from a farm on the 10th December, 1902, being taken out of press the day before, and weighed 76¼ lb. It was placed in a temperature of 32 deg. Fahr. and 75 per cent. humidity, and on the 9th July, seven months afterwards, the weight was 70 lb., showing a shrinkage of 8.15 per cent. The second set from the same maker arrived on the 17th December, 1902, weighing 69¼ lb., and on the 9th July weighed 63 lb., making a shrinkage of 8.6 per cent. The third set reached us on the 23rd December, weighing 75¼ lb., and on the 9th July weighed 70 lb., showing a reduction of 6.95 per cent. Nearly one-half of the total shrinkage occurred in transit and during the first month of storage. The weight of the duplicates on the farm totalled 219 lb. when made, and on the 9th July weighed 193½ lb., indicating a reduction of 25¾ lb., or 11.7 per cent. The average shrinkage in the cold-stored cheese was 8 per cent., so a saving in weight is shown of 3.7 per cent. in favour of the system. On making a comparison of quality at the end of a test there was a difference of opinion; the general conclusion, however, was that for current local consumption the cheese matured at the factory was the better lot, whilst for shipping that kept in cool-store was preferred, as it was less ripe and cleaner in flavour.

The second lot, for which incomplete data were kept by the maker, arrived on the 20th January, 1903, weighing 120½ lb. It was placed in a chamber at 40 deg. Fahr., with 60 per cent. humidity. On the 20th February the weight had decreased to 119 lb., on the 20th March to 117½ lb., and on the 20th April to 116 lb.—making a total shrinkage of 3.7 per cent. The weight of the duplicates kept at the factory were not recorded as arranged. As regards quality, the agents reported that that kept in cool-store was worth from ½d. to 1d. per pound more than those ripened at the factory.

The third lot was put into chamber and kept at 40 deg. Fahr. and 60 per cent. humidity. Two large cheeses arrived on the 15th January, 1903, weighing 82½ lb. On the 29th June, five months and a half afterwards, the weight was 78 lb., indicating a shrinkage of 5.4 per cent. The duplicates matured at the factory weighed 84¼ lb. when made, and on the 29th June 76½ lb., showing a reduction in weight of 9.1 per cent. From the same factory two small cheeses, weighing a total of 25 lb., were received on the 23rd January, and on the 29th June, five months and one week later, the weight was 22½ lb., which was equal to a shrinkage of 10 per cent. The duplicates at the factory weighed 25¼ lb. after taking from press, and on the 29th June 21½ lb., showing a shrinkage of 14.8 per cent. The difference in favour of the cheese ripened at the low temperature amounted to a saving in weight of 3.7 per cent. in the case of the large cheeses, and of 4.8 per cent. with the smaller ones. The general opinion as regards quality was in favour of the cheese ripened at the cool-stores, as it was cleaner in flavour and suitable for a wider range of customers than the duplicates matured at the factory.

The fourth experiment was also with factory-made cheese, which reached us on the 20th January, 1903; it consisted of four large and four small cheeses. The weight of the large cheeses was 161 lb. on arrival, and on the 30th June, five months and one week later, the weight was 152 lb., showing a shrinkage of 5.5 per cent. After it was received it was stored at a temperature of 40 deg. Fahr., with 60 per cent. humidity. The duplicates matured at the factory at from 60 deg. to 62 deg. Fahr. weighed 166½ lb. when made, and on the 30th June the weight was reduced to 151 lb., indicating a shrinkage of 9.3 per cent., or a saving of 3.8 per cent. in favour of cold-storage. The four small cheeses on arrival weighed 44 lb., and on the 30th June, five months and a week later, weighed 40¼ lb., showing a loss of 8.5 per cent. The four duplicates at the factory weighed 44 lb., and finally weighed 39 lb., showing a reduction in weight of 11.1 per cent., or a saving of 2.6 per cent. in favour of low-temperature ripening. The quality in this case, as with lot 3, was in favour of cheese ripened in cool-store.

The most comprehensive of the series of experiments was commenced with cheese made at the factory on the 26th February, 1903. It was taken out of press on the 27th, and nine large cheeses were received on the 6th March, just one week after date of making. Three of the cheeses were coated with paraffine-wax, three were wrapped in parchment-paper, and the remaining three were left in the ordinary way. Those were divided into three sets of three each, composed of one coated with wax, one covered with parchment, and one left plain; one set was placed at a temperature of 32 deg. Fahr. with 75 per cent. humidity, one set was kept at a temperature of 40 deg. with 60 per cent. humidity, and the third set at 50 deg. with 95 per cent. humidity. The six duplicates were treated in the factory in the ordinary way, and the maturing-room kept at a temperature of from 60 deg. to 62 deg. Fahr. The following tables give details of weights, &c.:—

Table A.—Cheese matured at the Government Cool-stores, kept at 32° Fahr., Humidity 75 per Cent.

Weight on arrival, 5th March, 128 lb. 9 oz.; weight 26th August, 125 lb. 8 oz.: loss per cent., 3·1.

—	No. of Cheese.	Weight.					Loss after Twenty-two Weeks in Cool-store.	Weight on 26th August.	Loss after Three Weeks out of Cool-store.
		5th March.	20th April.	13th May.	9th July.	5th August.			
		lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	Per Cent.	lb. oz.	Per Cent.
Coated with paraffine-wax..	1	43 10	43 8	43 8	43 4	43 0	1·4	43 0	..
Wrapped in parchment-paper	2	43 10	43 0	43 0	43 0	42 0	3·7	42 0	..
Plain	3	42 5	41 8	41 8	41 0	40 8	4·2	40 8	..
Total weight ..	..	129 9	128 0	128 0	127 4	125 8	3·1	125 8	..

Table B.—Cheese matured at the Government Cool-stores, kept at 40° Fahr., Humidity 60 per Cent.

Weight on arrival, 5th March, 135 lb. 13 oz.; weight 26th August, 131 lb.: loss per cent., 3·5.

—	No. of Cheese.	Weight. 5th March.	Weight. 20th April.	Weight. 13th May.	Weight. 9th July.	Weight. 5th August.	Loss after Twenty-two Weeks in Cool-store.	Weight on 26th August.	Loss after Three Weeks out of Cool-store.
		lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	Per Cent.	lb. oz.	Per Cent.
Plain	4	45 6	44 8	44 0	43 8	43 8	4·1	43 8	..
Wrapped in parchment-paper	5	45 6	44 8	44 8	44 0	43 8	4·1	43 8	..
Coated with paraffine-wax	6	45 1	44 8	44 8	44 0	44 0	2·3	44 0	..
Total weight ..	..	135 13	133 8	133 0	131 8	131 0	3·5	131 0	..

Table C.—Cheese matured at the Government Cool-stores, kept at 50° Fahr., Humidity 95 per Cent.

Weight on arrival, 5th March, 129 lb. 3 oz.; weight 26th August, 128 lb. 8 oz.: loss per cent., 0·53.

—	No. of Cheese.	Weight.					Loss after Twenty-two Weeks in Cool-store.	Weight on 26th August.	Loss after Three Weeks out of Cool-store.
		5th March.	20th April.	13th May.	9th July.	5th August			
		lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	Per Cent.	lb. oz.	Per Cent.
Wrapped in parchment-paper	7	44 0	44 0	44 0	44 0	44 0	..	43 8	1·1
Plain	8	42 0	41 8	41 8	42 0	42 0	..	41 8	1·1
Coated with paraffine-wax..	9	43 3	43 0	43 0	43 8	43 8	0·72	43 8	..
Total weight ..	..	129 3	128 8	128 8	129 8	129 8	0·24	128 8	0·77

Table D.—Cheese kept at a Temperature of 60° to 62° in the Cobrico Cheddar Company's Maturing-room.

Total weight when taken from press, 27th February, 1903, 264 lb.; weight 26th August, 243 lb.: loss per cent., 7·95.

Weight.							Total Loss.
27th February.	12th March.	4th April.	18th May.	15th June.	15th August.	26th August.	
lb. 264	lb. 260	lb. 255½	lb. 252½	lb. 248	lb. 244	lb. 243	Per Cent. 7·9

Table E.—Summary of Cheese matured at the Government Cool-stores.

Weight on arrival, 5th March, 394 lb. 9 oz.; weight 26th August, 385 lb.: total loss per cent., 2·4.

No. of Cheese.	Temperature at which stored.	Humidity.	Weight.					Loss in Twenty-two Weeks in Cool-store.	Weight on 26th August.	Loss after Three Weeks out of Cool-store.
			5th March.	20th April.	13th May.	9th July.	5th August.			
	°	Per Cent.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	Per Cent.	lb. oz.	Per Cent.
1, 2, and 3 ..	32	75	129 9	128 0	128 0	127 4	125 8	3·1	125 8	..
4, 5, and 6 ..	40	60	135 13	133 8	133 0	131 8	131 0	3·5	131 0	..
7, 8, and 9 ..	50	95	129 3	128 8	128 8	129 8	129 8	..	128 8	0·77
Total weight	..	..	394 9	390 0	389 8	388 4	386 0	2·1	385 0	0·26

Cheese matured at Cobrico Cheddar Company's Factory.

Weight when taken from press, 264 lb.; weight at present, 243 lb.: loss per cent., 7·95.

With Table A a loss of 3.1 per cent. occurred in five months; with Table B a loss of 3.5 per cent.; and with Table C, nothing whilst the cheese was in cold-store, but during three weeks afterwards the loss totalled 0.77 per cent. The total average shrinkage equalled 2.4 per cent., whilst the reduction in those kept and matured at the factory equalled 7.95 per cent., showing a saving in favour of the average cold-storage conditions of 5.55 per cent.

As regards quality, the cheese matured in the factory was more valuable for current local consumption, as it was more ripe and fuller in flavour. The cheese kept in the cool-store was milder in flavour and newer, and would therefore keep longer and develop into a cheese of very fine flavour.

THE INFLUENCE OF HUMIDITY IN RIPENING.

It will be noticed that the average shrinkage in the case of the cheese stored at 32 deg. was 3.1 per cent., that stored at 40 deg. 3.5 per cent., whilst that at 50 deg. showed no loss while in cool-store; therefore it would appear that some factor other than temperature influenced the reduction in weight. The humidity of the atmosphere in the chamber at the lowest temperature as indicated by the relative temperature shown by the dry- and wet-bulb thermometers was fairly constant at 75 per cent. The air was considerably drier in the lock where the cheese was kept at 40 deg., showing 60 per cent., whilst in the lock kept at 50 deg. the atmosphere was almost fully saturated. It will be seen, therefore, that the drier the air the greater the loss through evaporation, lower temperatures notwithstanding.

TREATMENT WITH PARAFFINE-WAX.

One of the third lot of two large cheese before referred to was on arrival coated with paraffine-wax, and the other left plain. They were both kept side by side in a temperature of 40 deg., with 60 per cent. humidity. The waxed cheese weighed 41⅓ lb., and at the end of five months and a half scaled 39½ lb., showing a loss of 4.8 per cent. The one left plain weighed 41 lb., and at the end of the period mentioned weighed 38½ lb., incurring a loss of 6 per cent. An advantage is shown in favour of the use of paraffine-wax in the shape of a gain of 1.2 per cent. In the case of Table A a saving in favour of paraffine-wax is shown of 2.55 per cent.; in the case of Table B, 8 per cent.; and with Table C, over 1 per cent. A peculiar result is shown in this table in the shape of a slight increase in weight instead of a reduction. On the 8th October four cheese were waxed, and weighed 33 lb., and the duplicates left unwaxed weighed 32½ lb. The cheese were kept at various temperatures, ranging up to 85 deg. occasionally, in a warehouse in Melbourne, and at the end of five weeks that coated with wax showed no reduction in weight, whilst that left plain had reduced by 1¼ lb., or a reduction in weight of 3¾ per cent. Another lot of four was waxed which weighed 46¼ lb., and stored with duplicates weighing 46¼ lb. also, in another warehouse in the city. The loss in this case amounted to ½ lb. in five weeks, as against 1¾ lb. in the case of the plain duplicates, showing a difference in favour of the use of the wax of a saving of 2.2 per cent.

CONCLUSIONS.

The average shrinkage of all the cheeses ripened at low temperatures at varying conditions, excluding those coated with paraffine-wax, was 5.83 per cent. The average reduction in weight of duplicates matured under ordinary conditions at the factories and farms was 9.77 per cent. The average saving in weight by keeping in cold-storage was 3.94 per cent.

The average shrinkage of cheese coated with paraffine-wax and kept under different conditions in cold-store was 2.02 per cent. The average reduction of plain duplicates kept in cold-store under similar conditions as the waxed cheese was 3.62 per cent. The saving credited to the use of wax-coating was 1.6 per cent.

The average shrinkage in five weeks of cheese coated with paraffine-wax and stored under ordinary conditions in warehouse was 0.03 per cent. The average reduction of duplicates was 3.81 per cent. The saving on account of the use of wax was 3.18 per cent.

These results, it will be observed, have been secured under impromptu conditions, as no chamber was specially prepared or fitted for this class of work and no expense incurred.

The experience enables me to state that in a cool-chamber suitably arranged and managed the shrinkage could easily be limited to less than 3 per cent., and a saving effected as compared with even the most up-to-date curing-rooms in the country at present of not less than 5 per cent. with the late spring and summer make of cheese. Already this season (30th November, 1903) the Department has received for maturing in cool-store over 30 tons of cheese, for which a charge of 3d. per 100 lb. is made for the first week, and 1½d. per week following. This is equal to about six months' free storage, as the value of the cheese saved will be sufficient to pay for that time; in addition, the cheesemaker is relieved of anxiety, labour, and expense in turning and attention for that period. More or less damage to quality is always incurred in connection with summer-made cheese.

The improvement in quality by cold-storage will bring about an increased local consumption and enable our cheese to secure more favour for export.

Paraffine-coating gives a shiny appearance which will be likely to meet with some prejudice at first, but its early and general use is certain both in the case of cheese treated at the place of manufacture and in cool-store. The cost of material and application is small, amounting to but a fraction of the benefit effected.

LATEST AMERICAN EXPERIENCE.

Since compiling the above data reports have been received from Canada and the United States further confirming the advantages of maturing cheese at low temperatures and coating with paraffine wax.

Mr. J. A. Ruddick, Chief of Dairy Division, Ottawa (late Dairy Commissioner of New Zealand), states that the cool curing of cheese is simply an attempt to create conditions, at all seasons, similar to those existing naturally when the very best results are obtained. On several occasions samples of cheese from the same batches, but cured at different temperatures, have been submitted to the Montreal buyers and other experts, and in every case they have pronounced the cool-cured cheese to be superior in quality to the ones cured at ordinary temperatures. The difference in value has been placed as high as 1 per cent. a pound.

Mr. R. M. Ballantyne, Montreal, in an address on "Cool Curing of Cheese" at the Convention of the Dairymen's Association of Western Ontario, held this year, states that the introduction of cool curing is the greatest advancement in the science of cheesemaking that has occurred within the past twenty years.

Professor Robertson, Commissioner of Agriculture, Ottawa, in commenting on Mr. Ballantyne's address, said he quite agreed that the cool curing of cheese was one of the greatest advances made in the business during the last twenty years. He added, "We had no less than 480 pairs of cheeses taken out of the same vats, 480 of them cured in a cool-room and 480 cured in the ordinary way, and never in one case were those cured in the ordinary way as good as those cured in the cool-room. They were made in thirty-seven different factories. There was not a single case where the cheeses cured in the ordinary way were as good as those cured in the cool-room, and there was less shrinkage in weight, and better texture and better flavour."

A bulletin was issued in July last by the New York Agricultural Experiment Station, in which particulars of experiments by F. H. Hall, L. L. van Slyke, G. A. Smith, and E. B. Hart, members of the staff, are given. In the popular edition the following appears: "The results of this experiment were so convincing that there has been no hesitation since in recommending to New York State cheesemakers and cheese-handlers the use of some form of cold-storage for ripening cheese. The cheeses in these tests, which were cured at 50 deg. Fahr. and lower temperatures, were markedly superior in quality to those cured in warmer rooms."

These tests, and others elsewhere made, were so striking that Major E. E. Alvord, Chief of the Dairy Division, Bureau of Animal Industry, United States Department of Agriculture, determined to repeat them, in part, on a commercial scale, so that the benefits of cold curing might be shown to makers throughout the whole of the United States. The cheese stored at 40 deg. Fahr. had an increased market value of more than 1 per cent. a pound over that stored at 60 deg. Fahr. By paraffining the cheese much of the loss in weight was prevented, especially at high temperatures, and the quality was improved in some instances, never lowered.

Briefly summarised, the advantages of curing cheese at low temperatures are the following:—

(1.) The loss of moisture is less at low temperatures, and therefore there is more cheese to sell.

(2.) The commercial quality of cheese cured at low temperatures is better, and this results in giving the cheese a higher market value.

(3.) Cheese can be held a long time at low temperatures without impairment of quality.

(4.) By utilising the combination of paraffining cheese and curing it at low temperatures the greatest economy can be effected.

No. 3.—NOTE ON A METHOD OF RENDERING INJECTIONS OF VIRULENT ANTHRAX BACILLI INNOCUOUS, AND CONSEQUENT PRODUCTION OF IMMUNITY.

By J. A. Gilruth, M.R.C.V.S.

Under ordinary natural conditions it may be taken for granted it rarely happens that the specific organism of any contagious disease is introduced into the animal economy in a state of purity.

Experimentally in the laboratory pure cultures are introduced, and rightly so. Yet, considering the absolute certainty that the specific organism of any particular disease must be accompanied, under the ordinary conditions applying in contagion, by other organisms, some being non-pathogenic, as in typhoid, tuberculosis, pneumonia, &c., and some being pathogenic, as in the case of diphtheria when that specific bacillus is accompanied by a streptococcus, it is surprising how few experiments have been made with mixed cultures. Yet in the two diseases with which I have experimented, using pure cultures of the pathogenic organism with pure cultures of others—some pathogenic and some not—the indication is strong that an extensive and interesting field of research in this direction is awaiting exploitation, and that the deductions therefrom may be of no small value.

BUBONIC PLAGUE.

Three years ago, when engaged in the study of bubonic plague in New Zealand, I ascertained that a culture of *B. pestis* of small virulence to the rat and the guinea-pig could have its virulence exalted very considerably by the addition of a pure culture of a streptococcus, or a diphtheria bacillus, even although these latter cultures possessed little pathogenic power, and that even non-virulent cultures of the plague bacillus could be rendered pathogenic by the same means.

In one case I added to the *B. pestis* of small virulence a culture of a streptococcus isolated some days previously from a pharyngeal false membrane, and death resulted in four days with the typical *post-mortem* appearances of bubonic plague. In another case a culture which had lost all virulence was mixed with a five-days-old culture of a recently isolated diphtheria bacillus, and death of plague resulted in three days with typical *post-mortem* appearances. In still another case a culture which normally required ten days to kill a guinea-pig was mixed with a virulent culture of diphtheria bacilli, with the result that death of plague supervened in forty-eight hours. The cultures from this last experiment, when inoculated in the usual way into another guinea-pig, showed that the virulence had so increased that the bacillus was fatal in six days. In all those cases the *Bacillus pestis* alone was found in the spleen and in the bubo above the seat of inoculation. In the first two cases bacilli were found in the spleen in enormous numbers, but in the last they were comparatively few in number, which was accounted for by the rapid course of the disease.

A similar increase of virulence is known to result from the mixing of weakened bacilli of black-leg with other organisms, such as *B. prodigiosus*.

ANTHRAX.

Remarkable as the results of mixing cultures of plague bacilli and other organisms were, they did not lead me to expect the startling results, in an entirely opposite direction, achieved when similar experiments were conducted with virulent anthrax bacilli. Naturally these were not undertaken with the endeavour to increase the virulence of *B. anthracis*, which, unlike plague and many other bacilli, do not lose that property as a consequence of cultivation on artificial media at blood-temperature. The experiments which I propose to detail to you were conducted because of the observation of peculiar symptoms exhibited by a guinea-pig after inoculation with a small quantity of blood from an animal dead of anthrax, this blood having been accidentally contaminated by another organism during collection.

As is well known, a guinea-pig or rabbit inoculated with even a small quantity of a pure culture of anthrax bacilli succumbs within from twenty-four to forty-eight hours, and then with comparatively no premonitory symptoms, while no evidence of inflammatory action is exhibited at the seat of inoculation. In this case, however, there was intense inflammation around the region of inoculation for the first two days, which nevertheless produced practically no general disturbance and rapidly disappeared almost entirely. On the fifth day after inoculation the animal was, so far as could be observed, in the best of health, yet on the morning of the sixth day (exactly 140 hours after inoculation) death occurred.

Post-mortem examination disclosed a typical anthrax condition with subcutaneous gelatinous œdema and enlarged spleen, while microscopical examination demonstrated enormous numbers of *B. anthracis* in the blood, spleen, and other organs. That it had lost none of its virulence was proved by further tests on rabbits and guinea-pigs after isolation from this guinea-pig.

It is interesting to note that a pure culture of the *B. anthracis* had been separated from the original sample of blood the day following the inoculation of the guinea-pig, and that another guinea-pig inoculated subcutaneously with a small quantity of the pure culture by means of the needle succumbed in thirty hours, or three days before the one first inoculated. Further, two days after inoculation the fluid of the intense swelling at the seat of inoculation of the first animal proved to contain only the accidental bacillus, so far as could be demonstrated by microscopical and by cultural methods, proving that the development of the anthrax bacilli was at least being inhibited as a result, indirectly, at all events, of the other's presence.

These observations have led me to undertake different experiments with various species of organisms, and besides the bacillus *x* I have used the streptococcus pyogenes of different origins, Gærtner's bacillus (*B. enteritidis*), and *Bacillus coli*, the two last being subcultures many generations distant from cultures originally secured by Dr. Makgill, of Auckland, from the London Hospital.

As regards the short non-pathogenic bacillus with which I first experimented, and which I designated "bacillus *x*," the following are its characteristics, shortly described: Short, varying from almost a coccus to about the length of *B. typhosus*. Non-motile. Does not stain by Gram's method. Grows readily in gelatine, forming in two days a definite growth with irregular edges, and a faint-bluish tint. On agar it forms a thick creamy growth in eighteen to twenty-four hours at 37 deg. C. It does not grow on potato, does not coagulate milk, and forms gradually a thick scum on the surface of broth, which it renders very cloudy.

In considering these experiments it should be remembered that in equal quantities of broth cultures of such organisms as *B. enteritidis* (Gærtner), *B. coli*, bacillus *x*, the streptococcus, and *B. anthracis* there are many more organisms per cubic centimetre in the first three than in the last two, so that in this paper I must be understood to deal with quantities of liquid, not numbers of organisms.

Following are details of the various experiments carried out:—

EXPERIMENTS WITH BACILLUS X.

I. Guinea-pig 1, inoculated with two drops of blood (secured in pipette from a cow dead of anthrax in the field) which contained numbers of *B. anthracis* and bacilli *x*, the latter predominating.

In twenty-four hours the region around the seat of inoculation, the scrotum, and the perineum were swollen and inflamed. This inflammation increased considerably during the succeeding thirty-six hours, after which recovery was very rapid. The animal's appetite remained unimpaired. During the second day a small quantity of the œdema from the swelling was examined under the microscope, and was found to contain numbers of the bacillus x, many within leucocytes. No *B. anthracis* could be demonstrated even by cultural methods. By the fourth day the guinea-pig had apparently quite recovered. One hundred and forty hours after inoculation the animal died practically with no premonitory symptoms.

Post-mortem *Examination.*—At seat of inoculation under skin small hard swelling with caseous centre. Spleen, double normal size and pulpy. Other organs apparently normal.

Microscopical Examination.—The nodule in the groin showed chiefly bacillus x. The spleen and blood throughout all the tissues contained enormous numbers of *B. anthracis*, and no bacilli x could be recovered therefrom by cultural means, while tubes of media inoculated with the caseous material only developed bacillus x.

II. Guinea-pig 2, inoculated by platinum needle with small quantity of agar culture of bacillus x into pocket made under skin of thigh. Only a slight swelling was developed at the seat of inoculation, which reached its maximum in two days and rapidly disappeared. Thirteen days later this animal was inoculated with 0.05 c.c. broth culture of *B. anthracis*, and death of anthrax resulted within thirty-six hours.

III. Guinea-pig 3, inoculated by needle as before, a small quantity of agar cultures of both *B. anthracis* and bacillus x being used. Result: Beyond the development at the seat of inoculation of a slight swelling, which rapidly disappeared, no bad effects ensued.

Second Inoculation.—Thirteen days later 0.05 c.c. pure broth culture of *B. anthracis*, death resulting from anthrax within thirty-six hours.

IV. Rabbit 1, inoculated with 0.05 c.c. *B. anthracis* and 0.05 c.c. bacillus x.

With the exception of the usual slight swelling at the groin, the animal remained for some time to all intents normal. Death resulted of typical anthrax in four days and a half.

Microscopical examination demonstrated no bacilli x, but numbers of *B. anthracis*.

V. Rabbit 2, inoculated with 0.05 c.c. *B. anthracis* and 0.05 c.c. bacillus x. Result: Usual slight swelling, but otherwise remained normal.

Animal reinoculated eight days afterwards with 0.05 c.c. *B. anthracis* alone. Result: Death of typical anthrax within thirty-six hours.

VI. Rabbit 3, inoculated with 0.05 c.c. *B. anthracis* and 0.1 c.c. bacillus *x*.

Animal remained normal, with exception of local slight swelling.

VII. Rabbit 4, inoculated with 0.1 c.c. *B. anthracis* and 0.2 c.c. bacillus *x*. Result: Usual slight local change, otherwise animal remained normal.

Reinoculated nineteen days later with 0.05 c.c. *B. anthracis* and 0.05 c.c. bacillus *x*. Result: Remained normal.

Again inoculated eight days later with 0.05 c.c. *B. anthracis* alone. Result: Death of typical anthrax occurred on the morning of the third day.

[Note.—The third inoculation was controlled by inoculating another rabbit (5) with 0.5 c.c. *B. anthracis*. Result: Death within thirty-six hours. It would therefore seem that rabbit 4 had gained some power of resistance.]

VIII. Rabbit 6, inoculated with 0.05 c.c. two-days-old broth culture of *B. anthracis* and 0.1 c.c. bacillus *x*.

Twenty-four hours later the animal was killed for examination. There was a very small area of congestion at the seat of inoculation, in which a number of bacilli *x* could be demonstrated, but no *B. anthracis*. Media inoculated with a quantity of spleen-tissue and of blood remained sterile.

EXPERIMENTS WITH BACILLUS COLI.

I. Rabbit 7 (young animal), inoculated with 0.05 c.c. *B. anthracis* and 0.1 c.c. *B. coli communis*.

Result: Death occurred in thirty-six hours.

Post-mortem Examination.—At seat of inoculation much swelling and hæmorrhage, with separation of the muscles by sanious œdema. The joints, particularly the carpal and tarsal, were affected with arthritis. There was considerable subcutaneous œdema, from which both the *B. coli* and *B. anthracis* could be isolated. The spleen was found to contain both anthrax and coli bacilli in numbers.

II. Rabbit 8, inoculated with 0.1 c.c. *B. anthracis* and 0.2 c.c. *B. coli*.

Some inflammation and œdema developed at the seat of inoculation, but no changes occurred similar to the previous case. Death, however, occurred on the morning of the fifth day, *post-mortem* examination revealing a typical anthrax condition.

III. Rabbit 9, inoculated with 0.1 c.c. *B. anthracis* and 0.3 c.c. *B. coli*.

A slight swelling developed at the seat of inoculation by the second day, the animal otherwise remaining apparently normal. A small quantity of œdema was taken by needle from the swelling forty-eight hours after inoculation, but no organisms could be demonstrated. Death occurred on the morning of the fifth day.

Post-mortem showed a considerable hæmorrhagic area where the second puncture had been made, but no œdema. The spleen was enlarged and pulpy. The blood and spleen contained numbers of anthrax bacilli, but no *B. coli* could be demonstrated.

IV. Rabbit 10, inoculated with 0.25 c.c. *B. coli*, broth culture.

Result: Beyond a very slight swelling and redness, which developed during the first forty-eight hours at the seat of inoculation, the animal remained normal.

EXPERIMENTS WITH STREPTOCOCCUS.

I. Rabbit 11, inoculated with 0.05 c.c. *B. anthracis* and 0.05 c.c. streptococcus (isolated from diphtheritic throat).

Slight inflammation developed at the seat of inoculation. Otherwise the animal remained normal till found dead on the morning of the sixth day.

Post-mortem examination disclosed a small collection of pus at the seat of inoculation, while there was also a purulent nodule in the precrural lymphatic gland. The spleen was enlarged and typical of anthrax. Microscopical examination of the pus in the thigh showed numbers of streptococci and a few *B. anthracis*. The nodule in the gland showed numerous *B. anthracis* as well as streptococci. The spleen and blood showed only *B. anthracis*, in enormous numbers.

II. Rabbit 12, inoculated with 0.1 c.c. *B. anthracis* and 0.2 c.c. streptococcus, isolated from subcutaneous pus in a human being.

After twenty-four hours slight swelling and redness developed at seat of inoculation. In two days a small abscess was present, though the animal remained normal meanwhile. On the third day the condition was about the same, the animal being apparently in good health. On the fourth day the rabbit died.

Post-mortem.—A quantity of thick, sticky pus was found at the seat of inoculation; spleen enlarged and pulpy, and blood very tarry. The pus under the microscope showed only streptococci. The blood contained a number of cocci in pairs and a few anthrax bacilli, the cocci preponderating very considerably. The spleen showed a number of *B. anthracis*, but comparatively few, and a few cocci. Evidently death was due to mixed infection.

[Note.—A guinea-pig inoculated subcutaneously by needle with a quantity of agar growth of this streptococcus after first isolation from the man remained normal, and developed no abscess or other evidence of illness. Also, a rabbit was inoculated with 0.25 c.c. of a two-days-old broth subculture and remained healthy.]

III. Rabbit 13, inoculated with 0.2 c.c. streptococcus and 1 c.c. *B. anthracis*.

Killed and examined twenty-four hours later. At the seat of inoculation a small area of whitish adhesive pus, with congestion of surrounding tissue.

Smears showed numerous cocci in pus, some within cells, but no *B. anthracis* could be demonstrated. Spleen showed a few cocci in pairs, but no *B. anthracis*.

Media inoculated developed a good growth of streptococci from pus and one or two colonies of streptococci from the spleen, but no colonies of *B. anthracis*.

EXPERIMENTS WITH BACILLUS ENTERITIDIS (GÆRTNER).

I. Rabbit 14, inoculated with 0.1 c.c. *B. anthracis* and 0.2 c.c. *B. enteritidis*. Result: Animal remained normal without even a local disturbance.

Second Inoculation.—Nineteen days later inoculated with 0.25 c.c. *B. anthracis* and 0.5 c.c. *B. enteritidis*. Result: Animal remained normal.

Third Inoculation.—Fifteen days later inoculated with 0.5 c.c. *B. anthracis* and 1 c.c. *B. enteritidis*. Result: Animal remained normal.

Fourth Inoculation.—Eighteen days later inoculated with 1 c.c. *B. anthracis* and 2 c.c. *B. enteritidis*. Result: Animal remained normal.

Fifth Inoculation.—Fourteen days later inoculated with 0.05 c.c. *B. anthracis* alone. Result: Animal remained normal.

Sixth Inoculation.—Fifteen days later inoculated with 0.1 c.c. *B. anthracis* alone. Result: Animal remained normal.

Seventh Inoculation.—Fourteen days later inoculated with 0.25 c.c. *B. anthracis* alone. Result: Animal remained normal.

Eighth Inoculation.—Eighteen days later inoculated again with 0.25 c.c. *B. anthracis* alone. Result: Animal remained normal.

II. Rabbit 15, inoculated in right ear with 0.05 c.c. *B. anthracis* and 0.2 c.c. *B. enteritidis*. Result: No swelling occurred, and animal remained normal.

Second Inoculation.—Inoculated in thigh twenty days later with 0.5 c.c. *B. anthracis* and 1 c.c. *B. enteritidis*. Result: Animal remained normal.

Third Inoculation.—Inoculated twelve days later with 0.05 c.c. *B. anthracis* alone. Result: Animal remained normal.

Fourth Inoculation.—Inoculated fifteen days later with 0.1 c.c. *B. anthracis* alone. Result: Animal remained normal.

III. RABBIT 16, inoculated with 0.5 c.c. *B. anthracis* and 1 c.c. *B. enteritidis*. Result: Animal remained normal.

Reinoculated seven days later with 0.05 c.c. *B. anthracis* alone. Result: Death occurred from typical anthrax, but not till fifty-six hours elapsed.

This indicates that the first dose had conferred some resistant power. It is also probable that had the second inoculation been delayed a week greater resistance might have been developed.

IV. SHEEP 1, inoculated with 0.05 c.c. *B. anthracis* and 0.1 c.c. *B. enteritidis*.

Animal showed no ill effects and remained apparently normal till eighth day, when death occurred, *post-mortem* showing a typical anthrax condition. As the animal was shorn owing to hot weather during the experiment, and afterwards the weather changed to bitterly cold, it is possible this may have had some effect.

V. SHEEP 2, inoculated with 0.1 c.c. *B. anthracis* and 0.2 c.c. *B. enteritidis*. Result: Animal remained normal.

Second Inoculation.—Inoculated eleven days later with 0.5 c.c. *B. anthracis* and 1 c.c. *B. enteritidis*. Result: Animal remained normal.

Third Inoculation.—Inoculated fifteen days later with 1 c.c. *B. anthracis* and 2 c.c. *B. enteritidis*. Result: Animal remained normal.

VI. RABBIT 17, inoculated in one thigh with 0.25 c.c. *B. enteritidis*, and in other thigh with 0.05 c.c. *B. anthracis*.

Result: Death within thirty-six hours of typical anthrax. Where *B. enteritidis* was injected there was no evidence of any lesion.

It should be noted that during the foregoing experiments broth cultures twenty-four hours old were always employed unless when otherwise specified, and that in order to test the virulence of the anthrax-cultures used the majority of the experiments were controlled by injecting guinea-pigs or rabbits subcutaneously with doses of pure anthrax bacilli, varying from 0.005 c.c. to 0.05 c.c., and that in these animals death invariably resulted within thirty-six hours.

I consider, therefore, that from the results obtained by mixing the *Bacillus anthracis* with a "foreign" bacillus the following conclusions can be drawn:—

1. Guinea-pigs, rabbits, sheep, and probably other animals can completely resist the inoculation of large doses of virulent anthrax bacilli, provided these organisms are mixed with certain other organisms in certain proportions, the latter being in themselves non-pathogenic.

2. If complete resistance is not exhibited, death is generally delayed very considerably when the organism mixed with

the anthrax bacilli is possessed of some pathogenic properties, or if a local reaction occurs.

3. The anthrax bacillus must be mixed with the other (foreign) micro-organism, for if they be injected under different parts of the skin no resistance results.

4. An animal which has suffered with absolute impunity the injection of a large dose of anthrax bacilli when mixed with a foreign organism may succumb later to a much smaller dose of pure anthrax-culture, although generally some resistance is evidenced.

5. In spite of this, however, it will be seen, as in the case of two rabbits which received repeated doses of both anthrax and Gærtner bacilli in increasing quantities, that immunity may be conferred against very large doses of pure anthrax bacilli.

6. And if this phenomenon be further investigated it may possibly afford a surer and more satisfactory method of conferring immunity against anthrax, and possibly against other diseases, than the methods now in vogue.

How comes it that the system can repel the invasion of such a number of virulent anthrax bacilli simply because they are accompanied by organisms which to all intents have no pathological significance?

In order to approach this question satisfactorily one must consider the different effects of the introduction of the *B. anthracis* into the human and the lower animal.

As is well known, the introduction of the *B. anthracis* into the human system through an abrasion of the skin produces an intense local reaction known clinically as "malignant pustule." In other words, a fierce battle takes place between certain of the white blood-cells—which crowd in enormous numbers to the spot—and the invading bacilli. In this battle many of the individuals on both sides perish, but, as a result of this opposition, cutaneous inoculation with anthrax bacilli in man, provided surgical treatment is available in time and the initial dose of the bacilli has not been too great, is rarely attended with fatal results.

Inoculation with the anthrax bacillus in the lower animal, however, is followed by no such warfare. As a rule, twenty-four hours even after inoculation the seat presents a normal appearance, there being no inflammatory changes evident. Death, as is well known, is almost appalling in its suddenness. Frequently I have observed experimental animals half an hour before death in apparent perfect health. Often, even on *post-mortem* examination, there is no lesion to be observed near the seat of inoculation, though generally there is a greater or less amount of clear œdematous fluid in the vicinity. The notable point in regard to this œdema is that it is almost totally devoid of the white blood-corpuscles, particularly those which have been proved to have a bactericidal action.

My experiments prove that when the anthrax bacillus is mixed with an organism that alone would cause a local congestion or inflammation, the latter does not lose this property, and that consequently the protective cells are brought to the spot. In the resultant fight both the "foreign" organism and the anthrax-germ are attacked by the phagocytes, and although the anthrax-germ ultimately prevails it is only after the lapse of a much greater time than occurs under ordinary experimental conditions. In the other cases, where practically no swelling or congestion occurs and where the virulence of the anthrax bacilli is most completely baffled (such as in rabbit No. 16, which on first inoculation received subcutaneously with impunity 0.5 c.c. of the *Bacillus anthracis*). the circumstances are more difficult perhaps of explanation. This is a point that in itself would require to be the subject of extended investigation. As was seen in the case of the rabbit inoculated with streptococci and anthrax bacilli, and the rabbit inoculated with bacillus x and anthrax bacillus, both being killed twenty-four hours later, bacteriological examination failed to demonstrate the anthrax bacillus either at the seat of inoculation or elsewhere, though the foreign organisms could be demonstrated. It seems probable that the x bacillus and Gærtner's bacillus, possessing no pathogenic power alone, being an easy prey to the phagocytes, and having no harmful effect upon these cells, were rapidly conquered soon after inoculation, and along with them the anthrax bacilli before they had time to multiply. But these points will repay much more attention than I have had time or opportunity to bestow upon them as yet. Any tentative effort to form a conclusion from theory alone is undoubtedly complicated by the apparently opposite results achieved by mixing a weak plague bacillus with a foreign bacillus, for there it would seem the phagocytes are handicapped by having to fight a mixed infection.

The comparative rarity with which animals are affected with anthrax, even when grazing continuously on lands badly infected with anthrax-germs, has been the subject of frequent remark. The experiments which I detail in this paper, however, offer a satisfactory reason. No doubt in districts where anthrax is indigenous the bacillus frequently gains entrance to the system, but, as must be the case under most circumstances, being accompanied by numbers of other organisms of a benign nature, no deleterious results ensue unless either the dose of anthrax bacilli be very great or the dose of the foreign bacilli be very small.

In conclusion, I must crave your pardon for the incompleteness of these experiments. Naturally, instead of publishing them in their present state, I should have preferred waiting till much more work had been accomplished; but careful consideration of the large field opened up forced the conclusion that the work was not for one, but for many investigators with greater opportunities than I possess. It is therefore not without a full knowledge of the shortcomings of this paper that I lay it before you, but with a hope that my few observations may be confirmed and greatly extended.

Table showing Inoculations of First Animals rendered immune.

Inoculations.	Dose of Anthrax Bacilli.	Dose of *B. enteritidis.*	Result.
	RABBIT 14.		
	C.c.	C.c.	
1.	0·10	0·20	Negative.
2. 19 days later	0·25	0·50	"
3. 15 "	0·50	1·00	"
4. 18 "	1·00	2·00	"
5. 14 "	0·05	None	"
6. 15 "	0·10	"	"
7. 14 "	0·25	"	"
8. 18 "	0·25	"	"
	RABBIT 15.		
1.	0·05	0·2	Negative.
2. 20 days later	0·5	1·00	"
3. 12 "	0·05	None	"
4. 15 "	0·1	"	"

The variation in the number of days allowed to elapse between each inoculation was due solely to my frequent absences from headquarters. It was intended to allow about fourteen days to intervene between two inoculations.

At the conclusion of the reading of this paper Mr. Gilruth made the following demonstration:—

Two rabbits which had been previously immunised by the method given in the paper were inoculated with a pure culture of anthrax alone, in the following doses: Rabbit No. 1, a quarter of a cubic centimetre; rabbit No. 2, a tenth of a cubic centimetre. Two other rabbits not immunised were inoculated in the following manner: Rabbit No. 3, a tenth of a cubic centimetre of a pure culture of anthrax, mixed with a fifth of a cubic centimetre of a non-pathogenic organism; rabbit No. 4, a twentieth of a cubic centimetre of pure anthrax-culture alone, as a control.

This demonstration was completed at a meeting which took place on Wednesday, the 13th January, forty-eight hours after the inoculations were made. It was then seen that rabbits Nos. 1, 2, and 3 had remained perfectly normal, while the control, No. 4, had been dead some sixteen hours.

Mr. Gilruth made a *post-mortem* examination of the control, which showed that it had died of typical anthrax. A microscopical examination of the blood was made, and the presence of the *Bacillus anthracis* demonstrated.

No. 4. BOVINE TUBERCULOSIS: SOME SUGGESTIONS REGARDING STATE METHODS OF CONTROL.

By C J. Reakes, M.R.C.V.S.

The prevalence of tuberculosis among cattle in the Australasian Colonies is a matter deserving far more attention than it at present receives either from the State or from stock-owners, the disease being widely distributed and annually causing a heavy monetary loss, both in direct mortality and in depreciation of value of affected animals. But beyond the financial aspect of the position is the even greater question of the danger to human health involved by the existence of the disease, more especially among milking-cows. I do not propose here to go minutely into the question raised by Dr. Koch as to the non-identity of the bovine with the human bacillus of tuberculosis. In the absence of opportunities for carrying out any experimental work in this direction I am not in a position to put forward any new facts, and can only base my opinion on the evidence at present available.

This has led me to the conclusion that Koch's theory is, to say the least, non-proven, and this opinion has been greatly strengthened by the experiments carried out by Professor Arloing, of the Lyons Veterinary College, the results of which have recently been published. These are summed by him as follows:—

(1.) Human tuberculosis can be readily inoculated into the ox, and sometimes by certain ways of inoculation it causes the lesions characteristic of bovine tuberculosis.

(2.) The human bacillus is not always of the same virulence, and a given bacillus does not manifest the same degree of activity on herbivorous animals of different species.

(3.) In some cases the human bacillus is as virulent as a bacillus of bovine origin; in others, on the contrary, its virulence is so much weakened as to appear null, particularly if used on bovine subjects.

(4.) Human bacilli of attenuated virulence always cause, at least in the lung after intravenous injections, lesions visible to the microscope, which sometimes tend to rapid fibrous transformation.

(5.) It is therefore impossible to give an opinion on the failure of an inoculation without a microscopic study of the lung and of the principal parenchymatous viscera.

(6.) The variability of the virulence of the bacillus accounts for the apparently negative results which led Koch and Schütz to believe in duality.

(7.) The identity of human and bovine tuberculosis ought to be maintained, and the prophylactic measures which result from it ought also to be maintained, notably with regard to the use of milk.

(Journal Comp. Path. and Ther., Vol. xvi., pt. 2.)

Also, a very definite expression of opinion was given at the International Congress in Hygiene and Demography held at Brussels in September last. This Congress, by a vote of twenty-five to five, affirmed the existence of the danger of the transmission of bovine tuberculosis to man. As regards experimental work in the direction of the communicability of bovine tuberculosis to the human subject, the natural sentimental difficulties in the way have prevented anything of value being done. There are certainly cases on record where accidental direct inoculation from the bovine to the human subject has produced the disease, and others where strong circumstantial evidence exists of the conveyance of infection by other means, as inhalation or ingestion. There can be no doubt, provided one admits the accuracy of the records, as to the cases of direct inoculation; but, as regards those based only on circumstantial evidence, they are, as always under the circumstances, open to argument. However, it must be admitted that the balance of probabilities is strongly opposed to Koch's dictum.

It is a matter for regret that experimental work cannot be carried out in the direction of settling definitely and beyond cavil the question of the transmittibility of bovine tuberculosis to human beings. It has been before suggested that those unfortunate individuals who commit offences which cause them to be sentenced to the death penalty should be given the alternative of submitting themselves for experimental inoculation with bovine tuberculosis under State supervision, and I personally am strongly in favour of the adoption of this course.

However, in the light of present-day knowledge, one must assume the danger of infection being conveyed from the bovine to the human animal, and hence it becomes the bounden duty of every State Government to do its best to deal with the disease, and, as far as is possible, reduce the number of its victims. Under present conditions it is impossible to stamp it out, but much can be done to minimise its ravages. I am strongly of opinion that there is still a field of investigation open in connection with the life-history of the tubercle bacillus outside the laboratory, and money voted by any State Government in these colonies for the purpose of assisting scientific work in this direction would be well spent. Indeed, such investigation is an absolute necessity if the disease is ever to be dealt with effectively.

It is a generally accepted idea that direct sunshine under all circumstances exercises a powerful germicidal action upon the bacillus. Yet certain experiences in this colony lead one to think that it can retain its virulence for a prolonged period outside the animal body, or else, as has been before suggested, is capable of leading a saprophytic existence. A case in point, recorded by Mr. Gilruth, occurred on a station on the east coast of the South Island, situated in a district where the rainfall is very light and bright sunny weather predominates. A large herd of purebred cattle were running on the property, and tuberculosis had been prevalent among them for many years. At the request of the owners a number of young cattle were subjected to the tuberculin test, all the reacting or doubtful animals being at once isolated. The healthy ones remaining were removed to a large paddock in which no stock of any kind had been running for six months. This paddock was situated on dry limestone country, and, though well grassed, the growth was not dense or thick, and good opportunity was thus afforded for the exercise of whatever germicidal influence the sun's rays were capable of exerting. Yet when these animals were again tested, thirteen months afterwards, nine out of seventeen of them gave a decided reaction. The evidence of them having contracted the infection from the pasture is very strong, seeing that no other cattle had been in touch with them meanwhile. Evidence of a like nature, although less exact, is afforded by my frequent experiences of finding station cattle, which have never been under a roof of any kind from the day of their birth onwards, and have spent their lives in ranging over large areas of naturally well-drained, healthy, sunny country, extensively affected with tuberculosis.

In this connection the experience in Queensland of Mr. A. W. Barnes, M.R.C.V.S. (now in the service of the New Zealand Government), is very interesting. In an article published in No. 886 of the *Veterinarian* (October, 1901), he, in referring to tuberculosis in Queensland, after describing the extremely dry, hot, and sunny climate prevailing in the central and western districts of that colony, proceeds to state, "The cattle operated upon at the meat-works come from all parts of central Queensland. All cattle in central Queensland are entirely unhoused and only yarded to brand and castrate, and then in many instances are not even seen again until mustering takes place, when they are travelled to a market. My records show that without exception there is not a cattle run or station which supplied the meat-works with stock during my eight years of veterinary supervision which did not send a percentage of tuberculous cattle, and I conclude that in all probability there is not a cattle-station in Queensland entirely free from this disease. Cattle arriving at the meat-works from inland stations have always been fat cattle or cattle in fair condition, bought for freezing purposes, and consequently representing the pick of the cattle on the run. As shown by the report of the Chief Inspector of Stock, the Meat Inspectors in Queensland (six of them being members of the R.C.V.S.) all report having condemned from 2½ to 9 per cent. of cattle for tuberculosis, but these records do not by any means represent the true percentage of tuberculosis existing in the colony. It is the custom on the cattle-runs to shoot all 'wasters,' or cattle showing indications of the disease, and no doubt many die unseen on the runs. Even the record of the meat-works cannot be relied upon as indicating the number of tuberculous cattle slaughtered. Cattle showing slight tuberculous lesions are not condemned or recorded; and it must be admitted that, when 350 to 400 head of cattle are slaughtered daily, slight tuberculous lesions of the viscera frequently pass unnoticed by the Inspector, who has not time to make a searching examination of the viscera of each animal slaughtered. On the stations and cattle-runs on the coast country tuberculosis is still more prevalent. I have frequently condemned from 15 to 20 per cent., and I remember one instance of condemning ninety animals out of a mob of 120 sent from a station notorious for tuberculous cattle. As before mentioned, cattle in Queensland are never housed in any part of the year, and are seldom brought into actual contact with each other, the runs being very large. . . . The number of cattle with tuberculosis of the pharyngeal and abdominal glands and liver, but not in any other part of the body, seems to indicate that the bacilli find a suitable medium for their growth upon vegetable or other matter.

But, in spite of the difficulties in the way, it is the duty of the State to exert its utmost endeavours to protect the community from the danger to human health and the loss of capital value involved by the existence of this disease among its herds, and it is a question for consideration whether the measures at present adopted in the Australasian Colonies are adequate or satisfactory. The conditions prevailing here as regards the attitude of the people towards any measures entailing Government supervision and control are very different from those in the older European communities. Still greater is the difference of the conditions under which cattle live and are handled; hence the methods to be utilised must, in order to be successful, be adapted to the habits and practices of colonial stockowners.

First, and very important, is the need for obtaining the confidence and co-operation of stockowners. A great help in bringing this about is gained by instilling into their minds an intelligent appreciation of the nature and gravity of the disease, and the monetary loss involved by its widespread existence and its unrestricted dissemination. Much good can be done in this direction by lectures and demonstrations in convenient centres in country districts carried out by thoroughly competent officers who are able to combine a complete knowledge of the subject with the capability of placing the facts before their audience in an exact yet easily understandable form. A useful adjunct to this is the distribution of leaflets or booklets written in plain and easily understood language. In this every endeavour should be made to emphasize the fact that the object of the measures enforced is not to harass the stockowner, but really to benefit him, and thereby the community generally. In order that this position may be more thoroughly realised, it is desirable that the State should pay some compensation to owners of animals condemned for tuberculosis. This compensation should, however, be based strictly upon the actual market value of the animal at the time of condemnation, and not, as the ingenuous New Zealand farmer sometimes thinks should be the case (when he is personally interested), upon its value when healthy. In this colony compensation is at present paid upon the basis of one-half the fair market value of the animal, and this I consider is just and reasonable. If stockowners can be induced to co-operate, a great step forward is gained, and good results may be expected. Without their co-operation little good will result.

An additional advantage to be derived from the dissemination of elementary knowledge of diseases among stockowners and the arousing of an intelligent interest in the matter on their part would lie in the benefit which would accrue to the scientific investigator in being able to obtain from them useful data and general information obtained from the intelligent observation of animals living under ordinary conditions. This would be of special value in the further systematic study of the life-history of the tubercle bacillus.

The legislative measures required for conferring the necessary powers upon the officers intrusted with the work should be comprehensive and thorough, yet at the same time practical, and the direct responsibility for their administration should be placed in the hands of a veterinarian possessing advanced scientific knowledge and administrative ability, combined with a thorough practical knowledge of colonial pastoral conditions.

Tuberculosis is an extremely difficult disease to deal with from a clinical point of view, and only a man possessing the necessary complete knowledge of the disease can successfully direct the work of subordinates engaged in inspection duty in connection with it; and to saddle a layman with the responsibility is obviously unfair both to him and to the community, seeing that he is, owing to his lack of technical knowledge and practical experience of disease, incapable of efficiently directing the work of the officers under his control, and the results are of far less value than those which would accrue under more efficient direction.

Another important point is that the subordinate Inspectors engaged in the work should be thoroughly competent, well-educated men, who have undergone a course of training in anatomy, physiology, and the pathology of this and other animal diseases, and have, under examination, demonstrated the efficiency of their knowledge. With good, well-trained men such as these, good results may be anticipated, whereas, if the practice, unfortunately too prevalent in the colonies, be followed of appointing men to these positions who lack these essential qualifications, little good work will be done. The average farmer possesses quite enough common-sense to realise whether an Inspector is competent or not, and, although, being by law compelled to do so, he may accept the verdict of a man in whom he has no confidence, yet he is left with a sense of injury, and of animus against the methods and aims of the Government. On the other hand, a tactful competent officer will not only be able to impress the farmer with the necessity and value of the work of disease-eradication, but will convert him into a helper towards the desired end.

As regards the *modus operandi* of inspection, this should be systematic and thorough. Each subordinate Inspector should be given charge of a defined sub-district sufficiently circumscribed to enable him to efficiently fulfil his inspection duties. The sub-districts should in turn be grouped into a number of larger districts, each of these being placed under the control of a Veterinary Officer possessed of administrative ability, sound professional knowledge, and common-sense, to whom the Sub-Inspectors should be directly responsible.

These Veterinary Officers in turn should be responsible to a Chief Veterinarian, who should be the administrative head of a Department of Animal Health.

The duties of the Sub-Inspectors should consist solely of the inspection of stock with a view to dealing properly with cases of tuberculosis or other contagious disease, and advising and thereby assisting stockowners on matters connected with the general welfare of live-stock. Herds should be inspected at as frequent intervals as is possible, especial attention being paid to dairy cows. The tuberculin test should be utilised as a means of deciding all suspicious cases which do not present sufficiently definite clinical symptoms to warrant condemnation.

To apply this test wholesale is, I consider, an economical mistake, at any rate, as regards the small farmer. Once an animal reacts the Government must do something with it. Yet a considerable proportion of reacting cattle will be found so slightly affected that to slaughter them right away is nothing less than an unwarrantable waste of good material. Where an owner can conveniently arrange to isolate all reacting animals, this waste is greatly obviated, as the animals can be fatted for beef purposes, and, when fit, slaughtered and dressed under the supervision of a Government Inspector; or, if valuable for breeding purposes, be isolated and so utilised, they meanwhile undergoing periodical examination. But the greater number of small dairy-farmers cannot afford the necessary grazing-accommodation for isolation purposes, and it is here that the greatest difficulty arises. At the same time, those farmers who make a business of breeding purebred stock for sale as such should be advised and encouraged to get their herds clean by means of the general application of the test, and endeavour to keep them clean afterwards. But in all other cases (except where the owner desires the test and is able and willing to do what is required afterwards) the inspection should be conducted on the lines of as careful a clinical examination of each individual beast as is possible under prevailing conditions, the application of the tuberculin test to all doubtful cases, and the immediate slaughter of all those found affected. Wherever possible, these condemned cattle should be conveyed to a freezing-works, or other place where the necessary plant is available, and slaughtered there under Government inspection, in order that their carcases may be utilised to the best advantage, either by conversion into manure, or, in the case of animals showing only local chronic lesions, for human food, in the form of canned meat, &c.

If this method of inspection could be properly carried out it should in time show a good result, as it would clear out all those animals in which the disease has reached so advanced a stage as to render them capable of spreading infection, seeing that most cattle in this condition will exhibit clinical symptoms. Inspectors in making their examinations should always make a point of carefully examining the udders of milking cows, for, in addition to the question of human health, there can be no doubt that the ingestion of infected milk by calves is one of the chief means by which the disease is perpetuated. Every cow the condition of whose udder raises any suspicion should be tested. The compulsory pasteurisation of all separated milk before removal from dairy factories or creameries is an extremely important and necessary measure, and if enforced it would, I am satisfied, lessen the number of affected animals in a very marked degree.

I have in my mind two pig farms in this colony in which the pigs' principal diet is separated milk from dairy factories. For years past a considerable percentage of the pigs reared on these farms have been found to be tubercular when slaughtered. In both cases they are kept under good conditions as regards housing, &c., and I have no doubt in my own mind that the milk they receive is the means by which many become infected, more especially as in the majority of cases the location of the lesions indicates infection by ingestion. If pigs contract the disease in this way, calves, which in dairying districts here are principally reared on separated milk, will do so also.

A useful aid in dealing with the disease is derived from a system of inspection by qualified Government officers of meat killed for human consumption. When affected cattle are observed it can generally be ascertained from what farm or station they were purchased, and if it be noted that from certain properties diseased animals are frequently sent the District Inspector can be notified; he can carefully examine the stock on the place, and advise and assist the owner in endeavouring to get rid of the trouble.

The administration of a legislative measure embodying all these suggestions would naturally involve a considerable expenditure, but this, I submit, would be fully warranted by the necessity for effectively dealing with this serious disease, and by saving both in human health and in animal values which would result. It would be quite reasonable that the necessary funds should be obtained by the imposition of a tax on cattle. A very small sum per head would produce a considerable annual income.

In conclusion, I would submit that the following provisions are necessary in any legislative measures framed with the object of effectively dealing with bovine tuberculosis:

(1.) Compulsory notification of all cases of ascertained or suspected tuberculosis.

(2.) Compulsory notification of all cases of disease of the udder in cows.

(3.) Compulsory pasteurisation of all separated milk before its removal from dairy factories or creameries.

(4.) The payment of some compensation for stock destroyed, on the basis of its market value at the time of condemnation; full market value to be paid for animals wrongly condemned and found free from the disease when slaughtered.

(5.) The registration and licensing (provided they are in a satisfactory condition) of all dairy premises.

(6.) The appointment of thoroughly competent Inspectors (who must pass a satisfactory examination before being admitted to the position), with full powers to enter upon premises and to deal as required with condemned stock.

(7.) The infliction of a penalty (with a high possible maximum) for failure to notify, or for allowing obviously diseased animals to go off the owner's premises.

(8.) The inspection by competent officers, at the time of slaughter, of all meat killed for human consumption in the larger centres of population or for export.

I am persuaded that the proper carrying-out of these provisions would quickly bring about a vastly improved condition of affairs. Necessary factors in this improvement would be the efficiency of the administrative head of the Department intrusted with the working of the law, and the capability of the Inspectors, combined with the cordial cooperation of stockowners.

At present in Australasia, so far as I can judge from my personal knowledge, the authorities have, in regard to this question, got into a somewhat shallow groove, and appear inclined to allow matters to drift on as they are instead of making a systematically determined attack upon the disease and endeavouring to get it at least under control. The admitted difficulties in the way should only be a stimulus to sustained effort, and if only this effort could be made and maintained I am confident that an immense improvement upon present conditions would ensue.

No. 5. THE TOXIC EFFECTS OF THE INGESTION OF *SENECIO JACOBÆA*.

By J. A. Gilruth, M.R.C.V.S.

Senecio jacobæa, commonly known as "ragwort," although one of the commonest weeds of Great Britain and certain parts of Europe, has not hitherto been credited with any toxic or pathogenic property. At all events, such a property has never been attributed to it by scientific men, although it is recorded by Professor Williams that to the ingestion of this weed in the beginning of the last century a large outbreak of a disease called "stomach staggers" in horses in Wales was popularly attributed.

The fact that Culpeper, writing over two hundred years ago, mentions that the plant was known in certain localities as the "staggerwort" and the "stammerwort" (the two words being synonymous) is significant as showing that centuries ago the more observant of the populace had noted a definite connection between a certain disease in horses and cattle and the presence of ragwort on the land. This apparently has been lost sight of during the age of scientific investigation, and I can find no inquiry that seems to have been made even to ascertain why such a definite and suggestive name as "staggerwort" had ever been applied to such a common weed. Even Culpeper, beyond stating this as one of its common names, makes no further comment, and attempts no explanation of the origin of the term. Yet that the *Senecio jacobæa* had been formerly credited with certain toxic properties (and, as we shall see later, correctly so) may be taken for granted, the name being sufficient evidence of the fact.

But it is not to Great Britain we must go to see the very close association between the presence of the weed and the occurrence of a disease. In Novia Scotia, Canada, the weed has been known in the Pictou district for about fifty years, the seed having probably been imported in ballast from Europe. There the weed, since its first appearance, has spread over a large tract of country. About ten years after its importation a peculiar disease of cattle described as "stomach staggers" made its appearance, and in time became a great scourge to the farming industry of the district. The opinion of the majority of farmers in the affected area has always been that the disease was caused by eating ragwort, which was so prevalent as to be almost constantly present to a greater or less extent in the hay so largely used for winter feeding of stock.

Naturally the existence of such a disease amongst the cattle has led to a number of investigations. Drs. Osler and Wyatt Johnson have made a number of observations, chiefly as to the nature of the pathological lesions found *post mortem* in animals dead of so-called "stomach staggers," and it would appear that years ago Dr. McEachran, of the Department of Agriculture, conducted some experiments during which animals were fed on dried ragwort, with negative results, but a complete report of these experiments I have been unable to secure, and I cannot ascertain that any *post-mortem* examination of the animals that were so fed was made.

During recent years the investigation of the "Pictou cattle-disease," as it is called in Canada, has been in the hands of Dr. J. G. Adami, Professor of Pathology at the Montreal University, from whom I have recently received his latest report to the Minister for Agriculture. Evidently misled by the apparent failure of the early feeding experiments, he has followed other lines of investigation, but states, "It is, to say the least, interesting that in Nova Scotia the popular view has been to attribute Pictou cattle-disease to the existence of the ragwort. For myself, I continue to be doubtful as to whether any such relationship does exist, although believing in the existence of some primary cause not necessarily microbic. I should be glad to find that the irritation caused by the ragwort was of this nature. Nevertheless, the negative results of the experiments conducted under this Department years ago by Dr. William McEachran (when animals were fed for long periods upon dried ragwort) would strongly tend to negative this supposition." In Dr. Adami's conclusions as to the cause of the disease at the time of the issue of his last report, he favoured strongly the theory that the disease, so far as the lesions were concerned, was caused by certain bacilli and their toxines.

In this colony, New Zealand, also, ragwort is a very prevalent noxious weed, more particularly in that district in Southland of which Winton is the centre. Curiously enough, a disease affecting horses and cattle known as "stomach staggers," corresponding in almost every detail with the symptoms described of the same-named disease in Great Britain, and exactly the same, both symptomatically and pathologically, as the "Pictou cattle-disease" of Nova Scotia, has been known in that district for nearly twenty years. During that period the weed has extended throughout a great portion of Southland, and as the plant has spread so has the disease.

Here also a feeding-experiment was made by one of the officers of the Department of Agriculture, but the record shows that the amount of ragwort given was far too small, while no *post-mortem* examination was made. However, that experiment, combined with the fact that both horses and cattle generally display a distinct aversion to the weed, while sheep can apparently live on it with impunity, diverted investigation from that plant for a considerable period, even although several farmers and others were of opinion that ragwort was the cause of the disease. Yet, after having exhausted all possible lines of experiment in an endeavour to induce the disease known as "stomach staggers," or in New Zealand known as "Winton disease," the occurrence of the disease in a large herd of breeding-cows in the Auckland District (the mortality being so great in the one herd as to form what could be termed an "outbreak," during which 10 per cent. of the animals succumbed in three months), combined with the great prevalence of ragwort on the property, again forcibly directed my attention to that weed.

Accordingly a number of experiments were conducted, during which animals were fed with the plant both dried and green, the result being the production of the characteristic symptoms of the disease in cattle and in horses, followed by death, when *post-mortem* examination revealed the characteristic pathological changes.

PATHOLOGY.

The chief organ of the body affected by the ingestion of ragwort is the liver, and, although the stomach may occasionally be found to present pathological changes, my observations lead to the conclusion that they are secondary to those of the liver, and probably dependent thereupon.

Pathological Changes in the Liver and other Organs.

Depending upon the amount of poison absorbed into the system and the length of time during which it is absorbed, the pathological condition of the liver consists of an inflammation, varying from acute and subacute to chronic, of Glisson's capsule chiefly. In the more chronic cases there is observed an intense increase of fibrous tissue, chiefly interlobular and capsular. This tissue may consist of very broad bands, which, although more pronounced in the interlobular region, send processes into the lobules between the liver-cells, isolating them in groups and even singly. In all instances this is accompanied by (1) extravasations of blood throughout the organ, but more particularly in the intralobular tissue, where the hepatic cells are frequently separated by areas of blood-extravasation; (2) distension of the intralobular veins, probably by contraction further on of the larger veins; (3) coalescence and the formation of hepatic giant cells (chiefly in the horse); and, (4) particularly in the horse, by the deposit of a brownish-yellow pigment in the liver-cells. As these chronic conditions are the most frequently encountered *post mortem*, they are rightly considered first.

In the very early stages there is naturally little formation of new fibrous tissue. The chief characteristic is intense portal and hepatic congestion, with an accumulation, particularly in the interlobular tissue, of new connective-tissue cells, some of which are laying down delicate fibrillæ throughout the tissue, and already the tendency to distortion and coalescence of several of the liver-cells can be observed.

In the subacute cases a condition which partakes of each of the above phases prevails that is, there is intense capillary congestion, there is considerable deposit of new fibrous tissue (not so much confined to the interlobular region, however, as in the chronic cases), and a large accumulation of new connective-tissue cells, both inter- and intra-lobular.

In the two last conditions, when a liver-section is examined under the microscope, the most notable feature is the almost complete absence of any definite arrangement of the liver-cells. Individual lobules are indistinguishable, and the hepatic cells have often a distorted appearance. Fatty degeneration may be observed in certain cases.

In some instances I have observed the formation in the interlobular new tissue of new bile-ducts or fragments of them, and this phenomenon is difficult to account for, unless it may be that the separation of liver-cells from each other by the blood, and the excessive supply of nutrient material, induces proliferation of some, with the tendency of the new cells to arrange themselves in a tubular fashion. In the chronic condition angeiomatous spaces filled with blood are formed, and very frequently these contain a few true liver-cells. That these liver-cells detached from the main tissue may be carried into the circulation we have demonstrated by observing them, in one instance, in the distended blood-vessels of the kidneys.

The brain and the kidney at death are usually congested, the capillaries being frequently distended to many times their normal diameter, and occasionally areas of blood-extravasation are present, due to rupture of the smaller vessels. In the brain of one horse, which exhibited marked cerebral symptoms before death, the peripheral capillaries of the cerebrum were extremely engorged, and here and there areas of extravasation could be observed on section. Also, in the kidney there is acute catarrh of the urinary tubules, while the urine contains enormous numbers of desquamated epithelial cells and epithelial casts.

Ulcerations of the mucous membrane of the stomach of the horse and abomasum of cattle are occasionally found, and are difficult to account for. They are almost entirely confined to the mucosa. They are not constant, and to them the symptoms exhibited before death cannot be in any way attributed, for they may be found completely healed, only a faint cicatrix remaining. It may be they are caused by the intense œdema of the submucosa interfering with the circulation of certain areas.

The foregoing description of the macroscopical and microscopical appearances of the affected organs is a summary of observations made on a large number of cases which have occurred under ordinary conditions, and these have been confirmed by all the experiments which we have been able to conduct so far.

EXPERIMENTS.

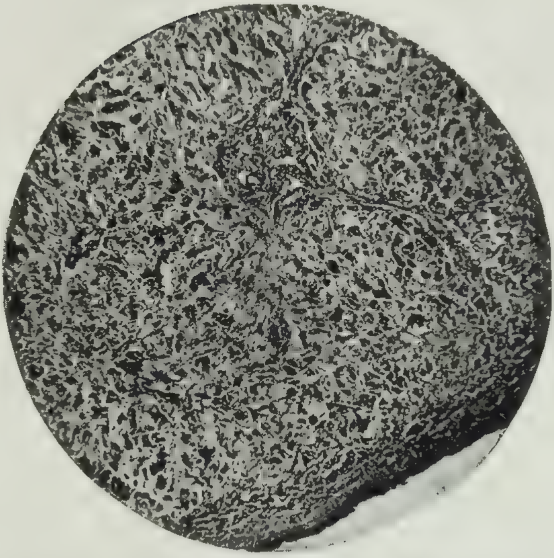
The *first experiment* consisted of feeding two well-grown six-months-old calves which had never been within a hundred miles of any affected animals, and had previously had no opportunity of eating ragwort. The plant was cut when in flower and carefully sun-dried. It was then passed through a chaffcutter, and a mixture of leaves and stems was fed to each calf. The daily ration consisted of cut ragwort, 6 lb.; bran, 2 lb.; and chaffed oaten sheaves, 2 lb. Both animals ate this ration greedily, and seemed to thrive thereon until the eighteenth day, when Mr. D. Ross, Stock Inspector, who had the animals under observation, noticed that they were dull and sleepy-looking, and he turned them into a paddock containing turnips and young oats.

The first calf died twenty-eight days after the experiment commenced and ten days after feeding on ragwort ceased. For three days before death it was reported to be in a state of "semi-madness," and for the last two days dark-coloured liquid fæces were continually passed. The second calf died two days later, or twelve days after feeding on ragwort ceased. Similar symptoms were observed *ante mortem*, though not so acute as were exhibited by the first calf. The livers of both were apparently diseased, and specimens were forwarded for my examination.

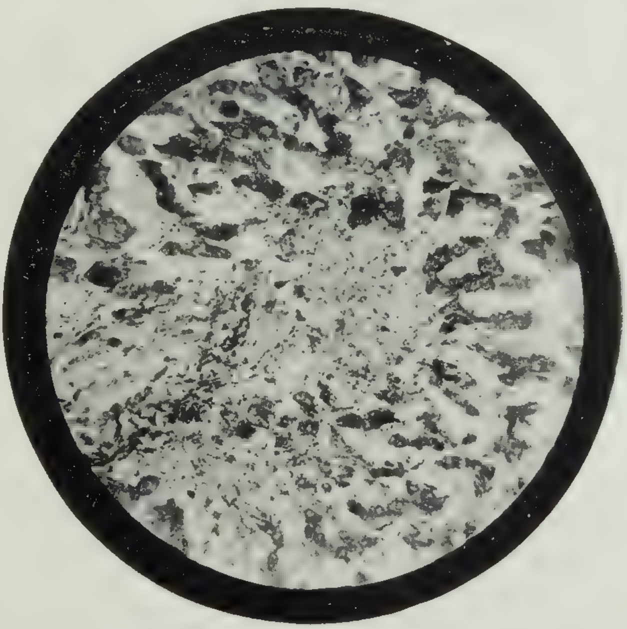
When sections were prepared and examined under the microscope, the following were found to be the changes in the organs: (1.) Acute congestion of the portal capillaries; (2) increase of the fibrous tissue around the branches of the portal vein, including the intralobular capillaries; (3) thickening of the capsule, with fibrous trabeculæ passing into the interlobular tissue; and (4) disarrangement of the liver-cells, atrophy of some and coalescence of others, with alteration of the general contour.

Second Experiment.

It having been demonstrated that serious and important inflammatory changes in the liver of bovines were produced as the result of the ingestion of ragwort cut and dried when



Liver of Calf (First Experiment), showing New Fibrous Tissue, Thickening of Capsule, &c.



Liver of Cow (Third Experiment), showing New Growth of Fibrous Tissue separating Liver-cells.

in flower, an experiment was arranged in order to determine whether the active agent in the production of the hepatitis was still to be found in the naturally dead or withered plant. For this, a large quantity of the withered plant (which had already seeded and was completely dead) was secured and cut into chaff. Two cows and a horse were fed daily on this material mixed with other fodder. One cow received of the plant finely cut 1 lb., the other 2 lb., and the horse ¾ lb. per day, and the feeding was continued for three months. The cows ate the material greedily, but the horse seemed to have a considerable aversion to the fodder throughout. At the end of three months the cow which had received the largest quantity was killed for examination. The animal was in excellent condition, and had never shown any evidence of indisposition. On *post-mortem* examination no evidence of disease could be detected, and, so far as the liver was concerned, this was confirmed by microscopical examination.

Third Experiment.

This was undertaken to test the effect of the ingestion of the plant in the green state grown under natural conditions. For this purpose a property-owner kindly fenced in 5 acres of land very badly affected with the weed, and which had been previously well eaten down by sheep. The growth of ragwort was extraordinary, and, in fact, with the exception of a few patches of native bush, it monopolized the enclosure.

The stock placed in the paddock, none of which had previously been on ragwort-infested country, were—(1) black steer, three years old; (2) red-and-white cow, which had calved just previous to being put in the paddock; (3) light-roan steer, two years old; (4) black three-year-old light horse.

Unfortunately, the land was situated a very considerable distance from any habitation, so the animals could not be closely observed. They were all in fair condition when placed on the pasture, and in this state they remained for two months, after which they gradually became poorer. The cattle exhibited little desire to eat much ragwort, and seemed to prefer the foliage of the bush. The horse, on the contrary, kept feeding among the growing weed and seemed to thrive for some time.

Three months after being placed on the pasture the black steer was found dead, death having occurred some days previous to the discovery of the body. Consequently *post-mortem* examination was unsatisfactory. Microscopical examination of the liver, however, in spite of the advanced stage of putrefaction, showed that the capsule was distinctly thickened, and there was evidently a decided increase of interlobular connective tissue, a chronic inflammation of the liver having become established.

The cow died on the 4th May, about four months after being placed in the paddock. *Post-mortem* examination showed the characteristic lesions of hepatic cirrhosis, the liver being smaller than normal, hard, and the capsule adherent. Patches of sero-gelatinous exudation were found subcutaneously and throughout the mesenteries and omenta. The abdominal and pericardial cavities contained a quantity of yellowish serous fluid. Microscopical examination showed that the liver in this case was very definitely cirrhotic. There was congestion of the bile capillaries, an enormous increase in the interlobular tissue, which was invading the spaces between the liver-cells, causing their degeneration and atrophy, with distortion, thickening of the capsule, and considerable general venous congestion.

The roan bullock was killed five months after being placed in the paddock. The *post-mortem* examination showed practically a normal condition throughout. The rumen contained no trace of ragwort, but was filled solely, so far as could be observed, with leaves from the native trees, on which it had evidently been subsisting. The liver, when examined under the microscope, proved to be absolutely normal.

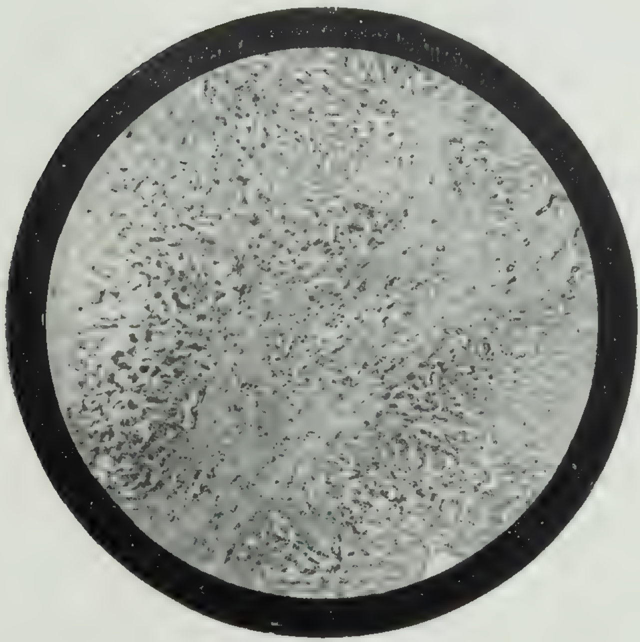
The horse remained to all appearances normal for nearly four months, but on the 2nd June he was observed to be dull and languid. On the next visit of Mr. J. Lyons, Government Veterinarian, who had the animals under observation, he was found dead. The following is Mr. Lyons's report of the *post-mortem* appearances: "All the tissues of the body were extremely yellow. Even the muscles were tinged yellow. Sero-gelatinous patches were found all over the body. On opening the stomach and anterior portion of the small bowels they were found to contain a large quantity of sero-purulent matter, nothing else being found therein. The villous mucous membrane of the stomach, also the mucous membrane of the anterior portion of the small bowels, were greatly thickened—in some places it reached over ½ in. in thickness—and was separated from the muscular tissue by a thick gelatinous serum. The abdominal cavity and pericardial sac were filled with blood-stained serum. The liver was small and pale in colour, much harder than normal, cut with a gritty feel, and the cut surfaces in places were of a bright-yellow colour." Microscopical examination of the liver demonstrated a condition of advanced inter- and intra-lobular cirrhosis. The capsule was thickened. There was congestion of the intralobular capillaries, areas of extravasation, and distension of the smaller veins throughout the organ.

Fourth Experiment.

This was conducted at my laboratory in Wellington. The subject was an aged light horse in good health. The material

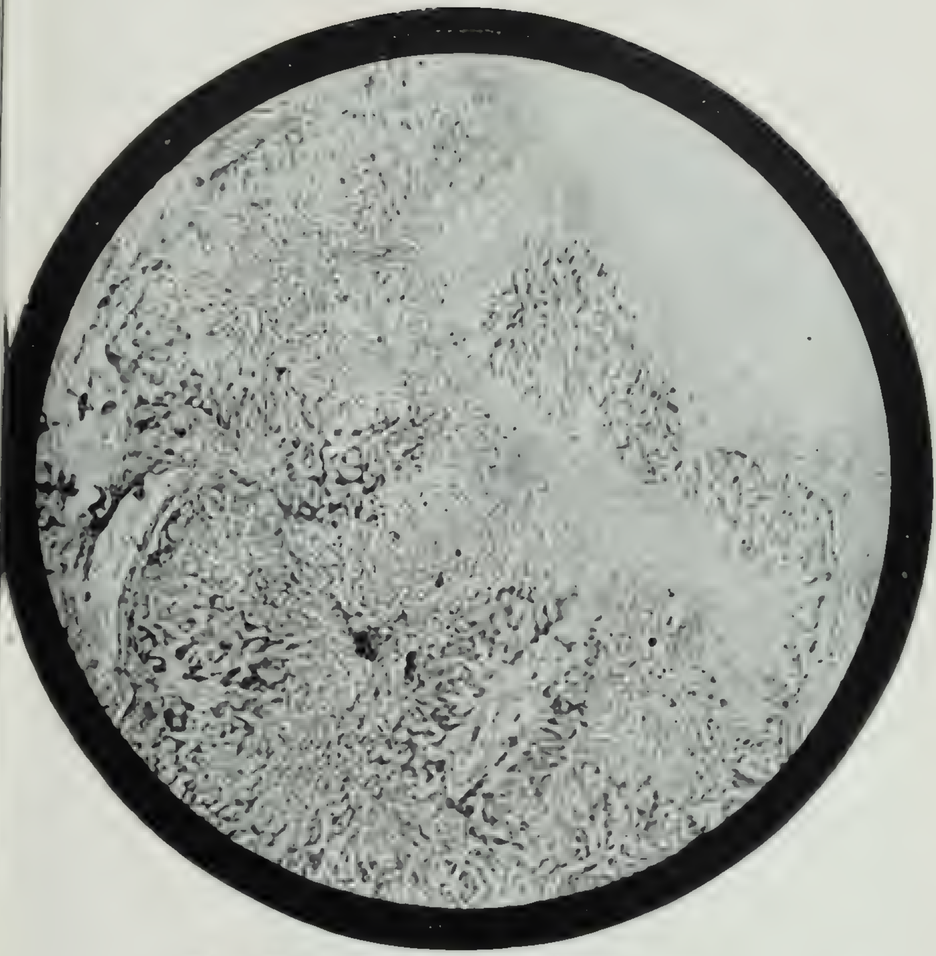
Hepatic Cirrhosis.

Normal Liver of Cow. x 50

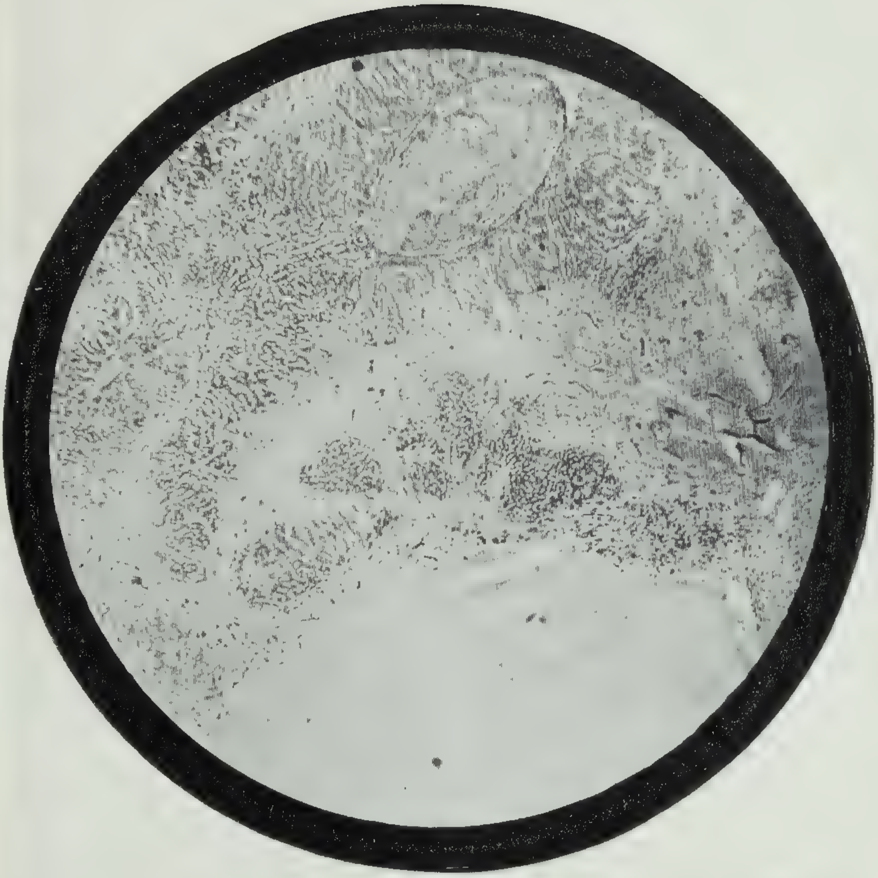


Liver of Typical Bovine Case. x 50

Hepatic Cirrhosis



Liver of Cow, showing New Fibrous Tissue. 145



Liver of a Cow, showing Dense Growth of Interlobular Fibrous Tissue. × 40.

Liver of Steer, showing Dense Intralobular Growth of Fibrous Tissue. [illegible]

used for feeding was ragwort cut in flower and sun-dried. So far as possible the strong stems were removed, leaving the branches, leaves, and flower-heads, which were cut into chaff. The animal was fed well in the ordinary way, and ragwort was added to the food in quantities never exceeding 1 lb. daily. Feeding with ragwort commenced on the 1st July, and was continued till the 22nd September, or for twelve weeks, during which period the animal consumed about 93 lb. of dried ragwort, less a few pounds of the harder stems, which remained in the manger.

On the 28th July disinclination for food was exhibited, and the ragwort ration was reduced from 1 lb. to ½ lb. per day. On the 18th August premonitory symptoms of disease were exhibited, the movements were languid, and the appetite was slightly depraved. On the 15th September slight want of muscular co-ordination was evinced, but it was not till the 22nd September that really definite symptoms of the disease were exhibited. From this date till the morning of the 25th, when the animal died, all the characteristic symptoms of the disease were presented, and during the whole of the 24th the general appearance and gait of the animal was that of alcoholic intoxication.

The *post-mortem* appearances were fairly characteristic. The liver was smaller than normal, dense and firm in consistency. On section, to the naked eye the appearance was that of a nutmeg liver.

Microscopical examination of sections of the liver showed the following condition: Capsule not markedly altered, though here and there slightly thickened. While on macroscopical examination the capsule was apparently non-adherent, stripping readily, yet under the microscope it is seen to be attached to the liver-structure by fine fibrillæ, which pass inwards, splitting up the lobules and separating the liver-cells. The general structure of the liver-tissue is completely altered. The liver-cells are separated from each other, either completely or into groups, by a loose fibrous tissue of varying density, with which there are a considerable number of new connective-tissue cells. The spaces of this new loose fibrous tissue are filled with blood, which forms an especially dense irregular zone in the majority of the lobules around the intra-lobular veins, which are distinctly distended. Many of the liver-cells have disappeared, numbers are atrophied, groups show distinct fatty degeneration, and here and there two or more are coalescing. Numbers of the blood-vessels contain large epithelial cells, which are evidently liver-cells being carried away in the blood-stream.

Other Animals.

Two sheep have been fed for prolonged periods on ragwort collected at the same time and on the same land as that used in the fourth experiment on the horse.

A yearling ram received 1 lb. per day for 120 days, and a full-grown ewe received 130 lb. during a period of 175 days, the weed being mixed with other food. On this ration both animals did well, and presented no symptoms of illness. When slaughtered and examined *post mortem* the livers were to the naked eye apparently normal, and when examined under the microscope no increase of fibrous tissue could be demonstrated.

I have had also an opportunity of examining the livers of sheep which had been grazing on paddocks badly infected by ragwort, and beyond a considerable fatty infiltration of the liver-cells there was no pathological change.

A rabbit which received 2 oz. daily for 150 days seemed to relish the food, and remained in perfect health. When killed at the end of this period and examined *post mortem* the liver was found to be apparently normal, which was confirmed by subsequent microscopical examination.

SYMPTOMATOLOGY.

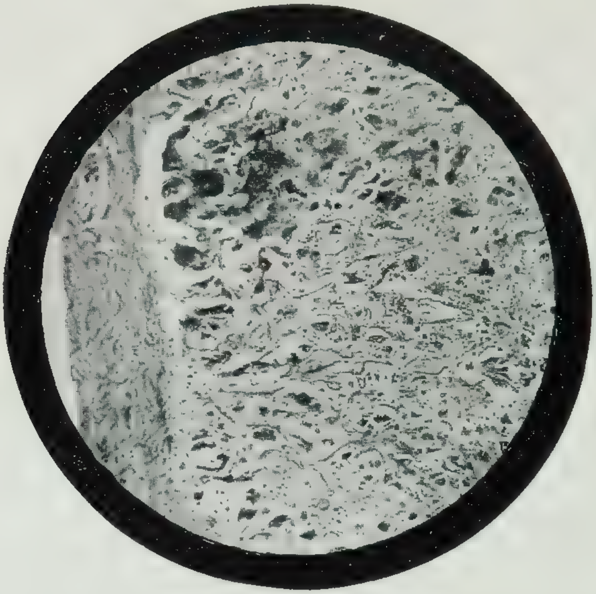
The foregoing experiments therefore satisfactorily prove that the ingestion of the *Senecio jacobæa*, at least before seeding, results in a slow chronic inflammation of the liver in horses and cattle, although as yet the definite toxic principle has not been isolated. That the symptoms exhibited by animals for some days before death are, however, caused directly by the action of the toxic principle is not so certain; indeed, the evidence indicates strongly that the ragwort poison itself does not produce the symptoms manifested in the disease. The striking point about the exhibition of symptoms is that (unless treatment is administered) the termination is always fatal.

There is no constant relation between the extent of the liver-disease and the time when symptoms are exhibited. Death may result when the liver is in the comparatively early stage of the disease, or it may not result until the liver-substance is to a very great extent displaced by very dense new fibrous tissue and the organ is as hard as leather. Finally, animals may develop the symptoms months after there has been any possibility of ragwort being ingested, while impaction of the stomach, which readily occurs owing to the depraved appetite, constantly results in an aggravation of the symptoms. The fact seems to be that the disease of the liver may induce at any time a derangement of the processes of digestion resulting in a species of auto-intoxication by the toxins formed.

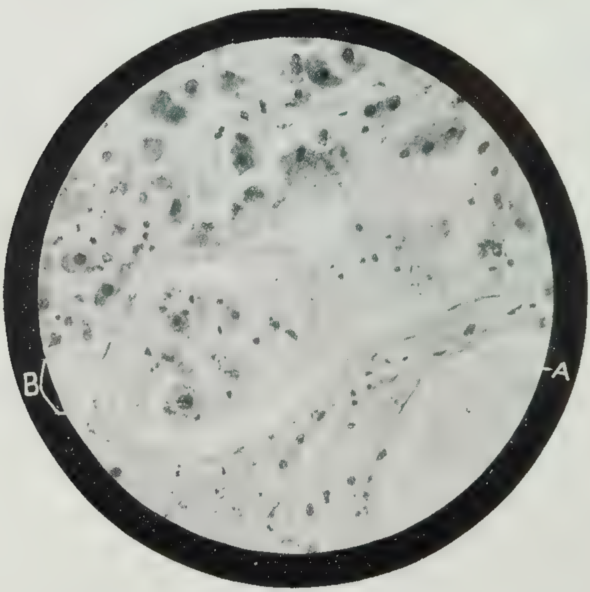
That the symptoms exhibited are those of a form of intoxication the following description leaves no doubt:—

HEPATIC CIRRHOSIS.

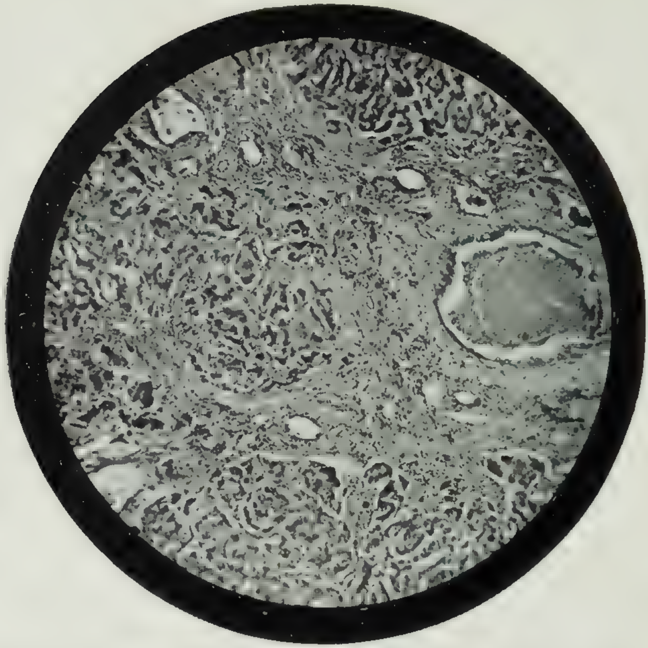
Liver of a Horse, showing Interlobular Cirrhosis and Intense Intralobular Venous Congestion. x 200



Liver of Horse (Third Experiment), showing Fibrous Tissue passing inwards from Capsule and separating Liver-cells. x 75



Liver, showing Angeiomatus Space — (A) with Liver-cells, (B) lying free amongst Blood-corpuscles. x 250



Liver of Horse, showing Dense Inter- and Intra-lobular Growth of Fibrous Tissue. x 50

Liver, showing Early Stage of Cirrhosis, from a Cow, which exhibited no Symptoms prior to being killed. x 50

Symptoms in Horses.

The most noticeable symptoms are a weak, staggering, swaying gait, when standing a tendency to stamp with one or both hind feet, twitching of the muscles, an amaurotic condition of the pupils, yellowness (which may be very pronounced) of the visible mucous membranes, a clammy condition of the mouth, constipation, irregular and generally weak intermittent pulse, a depraved appetite, and a normal temperature. The earliest noticeable symptom is drowsiness, with general dullness. There is nearly always a depraved appetite exhibited from the earliest stages, manifested by the eating of any rubbish, such as leaves, stable-soiled straw, weeds, &c., which may be convenient. Gradually inability to completely co-ordinate the muscles asserts itself, and even when standing still, in advanced stages, there seems to be continuous endeavour to keep from falling, and a patient may be frequently discovered leaning with the head against the end of the stall or a loose-box. Soon afterwards the animal exhibits symptoms of what can only be likened to drunkenness. With eyes staring, and staggering, swaying gait, the patient lurches forward with no evident consciousness of direction. As a rule, he wanders in a more or less direct line, which he will adhere to unless forcibly turned. I personally observed a patient which burst open the end of a not very strong loose-box in which he had been confined, entered a paddock by breaking down the fence, and finally reached the river, into which he floundered and swam to the other bank, where he was found, the bank being too steep for him to climb. A frenzied condition may ensue, when the animal exhibits all the symptoms of madness, rushing hither and thither, head held high, and bruising the body heedlessly against any obstacle. Soon, however, the patient falls and is unable to rise. Later, unconsciousness occurs, and beyond a spasmodic movement of the head and limbs no attempt is made to improve the condition. Complete coma results, and death rapidly supervenes

An almost constant and characteristic symptom is the dark colour of the urine and its offensive smell. Constipation, or at least an extreme sluggishness of the bowels, is also characteristic, as is the impotency of ordinary purgatives, even in large doses, to procure relief.

Mr. Paterson, M.R.C.V.S., who has had special opportunities of studying cases, on several occasions has observed stomatitis, with slight ulceration, in the horse, but such a condition is not always present. He has also called my attention to the following very frequent symptom: The animal may be standing in a paddock or stable, dull and sleepy, when suddenly he seems to think he is hungry, and makes a grab at grass or straw, or other food within his reach. With this he will fill his mouth, and then stand and stare, as if he had forgotten how to chew. He may remain in this attitude for a considerable time, and on attempting to take another mouthful the first drops out.

A definite peculiarity in all cases is the intense aggravation of the symptoms which constantly and rapidly follows overloading of the stomach, a habit which all horses suffering from the disease are prone to, and one that has to be most carefully guarded against when medicinal treatment is being applied.

Symptoms in Cattle.

Unfortunately, cows not being so valuable as horses, we have not had the same opportunity of studying the symptoms exhibited, our attention being only directed to the cases when in the later stages. In dairy cows the first notable symptom is diminution of the milk-supply. Mr. Paterson has called attention to the fact that one of the earliest symptoms observed in dairy cows in milk is the presence of a peculiar odour about the animal's skin, which can be rendered more definite by slight friction. If the skin be rubbed by the hand, this peculiar odour clings to it for some hours afterwards. The same odour can be detected in the milk, particularly if rubbed between the hands. The milk has a peculiarly acrid flavour, which renders it absolutely useless for butter-making. He reports that it is a common occurrence for farmers' wives to observe that this abnormal flavour was the first peculiarity they noticed with a cow sick of this disease.

There is rapid emaciation, a voracious appetite, or a total absence of any desire for food. Jaundice is more or less pronounced. Ascites is frequently observed while the animal is alive. There is a similar want of co-ordination of the muscles, but this is not so constant as in the horse, and there is always chronic diarrhœa of a most persistent type accompanying the rapid emaciation previously noted.

Feeding-cattle, and cows kept for purely breeding purposes, do not exhibit quite the same symptoms. Diarrhœa is not nearly so acute, ascites is not so evident, and, whereas in the dairy cow symptoms may be exhibited for even ten days or a fortnight, in these cows death occurs in from two to five days, the animal being in a visible state of excitement almost bordering on frenzy throughout, and it may charge even a man on horseback. That the milk is changed seems evident from the fact that in breeding-cows with calf at foot the first symptom noted is the cow bellowing for the calf, which pays no attention, and, indeed, is generally not to be seen—evidence that for some days previously a proper supply of milk has not been available.

In dairy cattle Mr. Paterson has observed in many cases that the patient exhibits complete oblivion to all surroundings. The animal persists in lying, and no effort succeeds in disturbing her. "I have bawled into their ears, switched them with a cane, and even twisted their tails, but they never seemed to mind in the least. They looked as if they did not know I was there."

In conclusion, I do not wish it to be inferred that I consider all the work relating to this interesting subject has been overtaken. There is much to be accomplished, for, as a matter of fact, we have only been able to indicate the route of investigation. The most instructive part is that what now seems to have been so obvious was overlooked by so many investigators. Perhaps in this age of microbes we are a little too prone to search for the infinitely small and remote, imagining that those causes which appear obvious cannot be operative simply because of that fact.

To you I must personally apologize for the length of time I have occupied, and also for much of this paper being extracts taken bodily from my report to the Government on this disease, its nature, cause, treatment, &c., a copy of which can be secured on application by any member of the Association who may desire to ascertain fuller details.

SECTION H.

ARCHITECTURE AND ENGINEERING.

PRESIDENTIAL ADDRESS.

By H. DEANE, M.A., M.Inst.C.E., &c.

(Delivered Thursday, 7th January, 1904.)

DAY LABOUR ON GOVERNMENT WORKS.

WHEN looking round for the subject of an address my first thought was to offer an account of the more important of the special methods adopted in engineering practice in Australia, as distinguished from those used generally all over the world. That in Australia some peculiarities of practice have been developed and inventions of great value introduced must be acknowledged—for example, the locking-bar method of making the pipes first used for the Coolgardie water-supply, and since this elsewhere. The Australian climatic and geological conditions sometimes necessitate special modifications of methods, and then local genius comes to the front and supplies what is wanted.

I found, however, considerable difficulty in collecting the information that I required, and had I everything to hand I doubt if in the short period of an hour real justice could be done to so extensive a subject. Instead of this, I have selected one upon which a great deal of heated controversy has arisen, and which in view of the existing tendency to State socialism is worthy of deep thought and consideration—namely, the direct employment of labour on Government works without the intervention of a contractor, which is in New South Wales commonly called the "day-labour system."

Many years ago it would have been thought almost madness for any Government to undertake the direct employment of its own labour on a large scale. It used to be supposed that the only safe way of getting work carried out was through a contractor, and that he only was competent to make the necessary arrangements; that he only could get value out of the workmen for wages paid; and that, at any rate, if a contract were let the limit of cost could be determined. It used to be considered that the Government official was a man whose whole knowledge was theoretical; that he could exercise no efficient control over the workmen employed by him, and could get no more out of the latter than the so-called "Government stroke." On the other hand, the contractor was looked upon as a man possessing almost unbounded practical common-sense and judgment, beside whom engineers and others who had to design and lay out works were mere children. It could easily be seen that contractors were often making enormous fortunes, from which it could be judged how much money could be saved if good managers and honest workmen could be secured and those profits had not to be paid; but no Minister would have dared to risk his reputation in ordering that such works be carried out by day labour, and perhaps he did not care to oppose the very strong prejudice of the community and the pressure of vested interests.

I think it may be fairly considered that, although the day-labour system is viewed with the greatest disfavour by many, there is not now the same prejudice against it. The adoption of the day-labour system has been a great education to Government engineers, and they have now, even if they had not before, an intimate acquaintance with the value of work, and thus know now, what was frequently suspected during the progress of contracts, that the contractor was often less of a genius than a lucky blunderer, who by virtue not of brains, but of high prices, sometimes reaped enormous profits, and often added to these by a deliberate system of scamping when the inspector's back was turned.

Do not let it be imagined that I thus wish to stigmatize the body of contractors as a whole. I know many men of intellect and business capacity, who also would scorn to commit a shady transaction; but it must be admitted that the contractor of the old style was, as a rule, rough and ready in his methods: he was a man who prided himself in being called a "practical man," and he provided just as much in quantity or quality as by dint of efficient inspection he was compelled to do. The modern contractor is, on the average, better trained, and, indeed, circumstances require that he should be so, as prices are now cut much finer. Commend me, however, to the scientifically trained man, who combines knowledge with sound judgment.

The desire to introduce the day-labour system on a large scale into the works of the Australian States seems to have arisen about ten or twelve years ago. Day labour for relief-works is, of course, a very old practice, but on anything like an extensive scale it is of much more recent origin. I have not had the opportunity of making an exhaustive inquiry into the history of the subject, but I have been informed by Mr. M. Kernot, Acting Engineer-in-Chief of the Victorian Railways, that in 1892 the Minister for Railways, Mr. Wheeler, ordered the introduction of what was called the "butty-gang system" for the carrying-out of railway-works. Mr. Kernot, in a pamphlet on the subject, explains that the butty-gang principle combines piecework and petty contracts with day labour, thus practically coinciding with what is in New South Wales called the "day-labour system," which also includes small contracts and piecework. In one case the piecework predominates; in the other the paying of wages is the ruling feature. In either case, however, the work is done under the direct supervision of the Government engineer, and the services of the contractor are dispensed with. To show to what extent the system has been followed in Victoria, it was pointed out by Mr. Kernot that in Victoria when the before-mentioned pamphlet was written (year 1900) a total length of over five hundred miles of railway had been carried out, costing from £1,250 to £10,000 per mile, and Mr. Kernot says that "I can fairly claim to have executed the work quicker, cheaper, and better than under the old system of large contracts."

My predecessor in office for the meeting of 1898, Mr. A. Moncrieff, Engineer-in-Chief of South Australia, gave some interesting particulars of what had been done in that State in carrying out work without the intervention of the large contractor. He then described the system under which over three hundred miles of railway and waterworks and other works had been successfully carried out.

In the case of New South Wales it was first in 1896 that the then Minister for Works, the Hon. J. H. Young, expressed a desire that railway-works should be carried out by day labour, and asked me if I would undertake it. My reply was that I would do so; I was certain that the system would prove a success if I were accorded a free hand in engaging and managing men and in the purchase of materials. These stipulations were conceded at the time, and instructions were given to commence operations. Since then, during Mr. Young's term of office and that of the present Minister for Works, the Hon. E. W. O'Sullivan, 531 miles of railway have been completed without the intervention of contractors and handed over for traffic, and 169 miles more are in process of construction, besides that great and impoortant work the Central Station in Sydney, on which a sum of £180,000, exclusive of compensation for land, has already been spent. The same freedom of action which I stipulated for is not now accorded. When the late Mr. Eddy, Chief Commissioner for Railways, took office in 1888 I was intrusted with the laying-out of a large number of duplication and deviation works. These were carried out by contract, but since that time additional works of the same nature have been put in hand and carried to a successful issue by the Railway Commissioner's own staff. In New South Wales other branches of the Public

Works Department have also carried out work on the same system.

Mr. Pagan, Chief Engineer, Queensland, informs me that he has successfully carried out railway-works by day labour, and Mr. Palmer, Enginer-in-Chief at Perth, has kindly furnished me with reports describing the satisfactory execution of works of various descriptions, including railways, harbour-works, and a large weir.

The only condemnatory voice in Australia has been that of Mr. Davidson, Inspector-General in Melbourne, who finds that the so-called "Government stroke" could not be eradicated from the works attempted by him.

In New Zealand, as I am given to understand by Mr. Hales, Engineer-in-Chief, in Wellington, much work has been done under the "co-operation principle," which seems to correspond with the "butty-gang" method of Victoria. The system having been established so firmly and over so wide a field, it does not seem likely that for certain classes of work the contract system will be reverted to; and it meets the approval of the labour leaders, who are now a power in the land.

The influence of the Labour party seems every year to be extending, and provided that influence can be wisely and honourably applied, and not improperly used, there is no reason why the continuation of the day-work system, or even its still wider extension, should be viewed with apprehension. The abolition of the contractor is of distinct advantage to the working-man, for under the day-labour system he undoubtedly gets more consideration and better treatment than under the most humane of contractors, whose motive is gain, and who take pains to arrange the work that the men can be kept continuously occupied. I am, of course, advocating the interests of no one class to the exclusion of those of others, but am dealing with the question as affecting the welfare of the community as a whole; but if it so happens that that object can be reached under conditions which suit the interests of that particular class, so much the better.

I have heard the day-labour system condemned in New South Wales by many as tending to State socialism, by which I suppose is meant a system under which the State would take charge of all industry and all work. I confess I do not see the analogy, and to apply an objectionable name is no argument. If the direct employment of day labour leads to State socialism, we must have already proceeded some distance along the track, as the railways and a good many other State properties are managed on the day-labour principle, but we do not seem to be any the worse for it. In these cases the contract system could not well be applied. Although it is true we have heard of the maintenance of lines being let to a contractor, the wisdom of doing so is exceedingly doubtful.

The subject of my address has, so far as I am aware, rarely, if ever, been exhaustively and dispassionately treated. Except in a few departmental reports, which, unfortunately, do not have the circulation they deserve, little has been done to present the matter clearly before the public mind. The portion of Mr. Moncrieff's address referred to, and Mr. Kernot's short account of the butty-gang system in Victoria, are the best I have seen. There have also been special inquiries and investigations by Select Committees of Parliament in New South Wales on special aspects of the question. In New South Wales recently the Public Service Board has been conducting an investigation, dealing with a particular case where great abuses had crept in. Unfortunately, inquiry was not made into the subject as a whole. The Board's report on the subject condemns the use of political pressure, and not day labour as a whole. On the other hand, many abusive letters have frequently appeared in the Press, some written by contractors, who consider themselves cheated of their legitimate trade; some by cranks and critical-minded persons, who believe that everything that a Government does is wrong, who deny business capacity to departmental officers, and a willingness to do a fair day's work to the men employed. Such writers always assume that the so-called "Government stroke" cannot be got rid of, and that improper influence pervades everything in fact, they misrepresent things generally.

I do not know whether in New Zealand the mind of the public has been made up with regard to the question, although, as hinted before, the system has come to stay. In Australia, at any rate, it is still treated with distrust; and, as this is a meeting where matters are dealt with from an Australasian point of view, the opportunity is offered for a calm and judicial consideration of the subject, where the advantages and disadvantages of the system can fairly be set forth and a decision reached as to the circumstances under which it can be relied on, and where, on the other hand, the contract system is preferable. (For obvious reasons I shall be very guarded in particularising instances, and shall studiously avoid making personal references.)

When speaking of the "day-labour system" on Government works, it is necessary that we should understand what is meant by the term used. The expression is, of course, it will be seen, not quite correct, as it covers work paid for in other ways than as wages. Like the expression "butty-gang system" used in Victoria, and "co-operation system" in

New Zealand, it is employed in contradistinction to the large-contract system. Although the bulk of the work is actually performed by wages-men, the adoption of small contracts and piecework on the same job are by no means excluded. The great point is that the Government dispenses with the services of the middleman or contractor, with his managing and executive staff, and deals direct with the men through the agency of their own official staff. The Government places itself in the position of the contractor, purchases plant, tools, and materials necessary for carrying out the work, and arranges for the payment of the labour required either by day labour, piecework, or small contracts.

One of the first conditions for successfully carrying out work is that the right sort of men should be engaged to supervise and take charge, men who have the requisite knowledge and the right force of character to command the workmen, for without these it would be ridiculous to make the attempt. The superseded contractor who writes to the papers persists in asserting that the Government engineers are only men of theory, and without practical experience. There is nothing like sticking to a statement and repeating it constantly if the public are to be impressed, especially if it is untrue. The falsity of the assertion has, however, been amply proved in all the Australasian States. Perhaps the result might have seemed a little problematical when the attempt was first made to carry out day-labour works, but the officers who had been supervising contracts were for the most part men capable of observing and assimilating knowledge, and, having watched the contractor in his methods and carefully noted costs, they became fitted to undertake the management of works themselves, and perhaps to go one better than the contractor. Amongst the engineers of each State there are many who have actually enjoyed the advantage during some part of their career of being employed by contractors, and so have early gained experience in the business of construction. Even without this special experience a large proportion of the staff have proved themselves quite competent to take positions in the management of men and work, and have shown that they possess all the proper energy, grit, and habits of forethought necessary to enable them to take over the responsibility of managing works. There are, of course, some officers who, otherwise very capable, are not suited to these positions, because they have not the right sort of capacity. Such men should not be placed in charge if the work is to be carried out in an economical manner. Thus it may be concluded that there is no difficulty in finding the right men to take charge. As to the rest of the staff required, no special selection is necessary; the duties of the junior assistant involve no greater responsibility than under the contract system, and, except that they may be expected sometimes to work longer hours, the kind of work they are called upon to do is precisely the same. As to the next in rank, inspectors and gangers, they have to be taken on under any circumstances, and the same men are equally available for employment by the Government as by contractors.

As far as provision of a competent staff, therefore, is concerned, the ability of the Government to undertake works without the aid of the contractor should not be called into question. As to securing quality of work there should be no difficulty, and the question has, so far as I know, never been raised. The engineer who designs and specifies knows exactly what he wants, and the executive engineer has been accustomed to see that the contractor carries out his work according to specification. There is no reason, therefore, why work should not be carried out by Government officers in every respect in a proper manner, and the chances are that under the day labour system the engineer in charge will get better quality, as he will not be met with resistance to orders or by any desire to scamp the work. The work might possibly be more costly, but, at any rate, it can be well and faithfully executed; it can be absolutely relied on, and no risk of breakdown as the consequence of bad work is to be feared.

Need, however, the work be more costly? That is the question to be considered. Now, in carrying out work through the management of its own officers the Government enjoys many advantages as compared with letting by contract. First of all there is the saving of staff. Under the contract system there is a double staff required—that of the contractor and that of the Government. The contractor, when he puts in his prices, has to allow for the expense of keeping up his staff, and when reckoning up the total cost of the work the salaries of the Government staff must be charged as well. Under the day labour system only one set of officers is wanted, for those who are placed to check the contractor now take charge of the work. There may be a little more assistance required in the way of timekeepers and clerks to keep accounts, but, for all that, there is a considerable saving. Secondly, the contractor has to be provided with working capital, out of which he purchases plant, tools, &c., and he also has to find a sum of money to deposit with the Government as security for carrying out the contract. If he does not possess the requisite amount of money to meet these objects he has to borrow at a high rate of interest, and if he is the happy possessor of so much capital interest must be charged, as he has to withdraw the required funds from other investments. All these expenses he has to provide for; the prices in his tender have to cover them, and the country has to pay proportionately for them. In carrying out work by day labour the Government is not hampered by these considerations, and the expense is to a very large extent saved. Thirdly, the contractor fixes his prices so as to cover heavy risks and penalties, and to afford him an opportunity of making a profit, and in the past this has often been a very large one. These costs are saved to the country under the day-labour system. Again, during the progress of a contract there may be delays by the Government in providing certain materials, such as rails, bridgework, &c., or it may be found necessary to suspend operations, deviate from the original design, or add materially to the work. The contractor may also have differences with the supervising engineer as to quantity and quality of work or material that has been or is to be supplied. In some or all of these cases the contractor prefers claims for pecuniary compensation, and if he and the engineer cannot come to terms the matter may have to be settled by law or arbitration, which means considerable expense, even when the award to the claimant is *nil*. It is well known that at the fairest of tribunals the contractor generally gets the advantage, and then there are heavy costs to pay. Such are the uncertainties of law and arbitration that the result sometimes goes very heavily against the Government, and so to avoid these contingencies the contractor who threatens litigation is very often offered terms of settlement which are, to say the least, very favourable to him.

All this additional expenditure is saved under the day-labour system, as alterations and modifications can be arranged for without materially adding to the proportionate expense. There is another advantage which in my experience has proved to be of a material value. The departmental officer, provided, of course, that he has been properly selected to take charge of the work, is a better-trained man than the ordinary contractor, while at the same time he possesses practical knowledge and judgment. He can therefore often exercise much intelligence and ingenuity in the carrying-out of work. When an officer of this stamp is supervising a contract these talents represent no money value to the Government, and should he be able to make a labour-saving suggestion the contractor, if he adopts it, reaps the benefit. Not so, however, under the day-labour system, where the gain is reaped by the country. I could point to examples to illustrate my contention. There is also another way in which it seems to me the day-labour system may score, and that is in securing the earlier commencement and consequently the earlier completion of the work. If the work is of a remunerative nature, the advantage of finishing early can easily be calculated in pounds, shillings, and pence. In the opposite case there are still indirect advantages which must not be overlooked. When a work has to be let by contract all details must be ready, final surveys completed, all formalities gone through as to acquisition of land, all plans worked out and specifications completed before tenders can be invited, as no satisfactory contract would be possible unless all conditions were accurately settled beforehand. Then, time has to elapse before tenders come in; still more is required for consideration of tenders and selection of the most suitable, for preparation of acceptance and signing of contract, and then the contractor has to make his final arrangements for commencement of work. Under the day-labour system, if only a portion of the land is available and only some of the plans ready, some work, such as foundations, for instance, can be put in hand, and while this preliminary work is proceeding all necessary formalities can be attended to and the rest of the plans prepared by the time they are wanted. In this way the final completion must be much accelerated.

The catalogue of pecuniary advantages to be derived from the adoption of the day-labour system here comes to an end. There are also drawbacks to be considered, which may or may not be of importance according as the rulers of the situation are pleased to act. These drawbacks are chiefly of two kinds—political pressure directed towards the appointment and retention of men, and what is often characterized as "red tape."

It cannot be too clearly understood that political pressure is not an essential part of the system. Works can be carried on without its baneful presence, and some Ministers have absolutely refused to interfere in any way with the authority of the officers charged with the work. It is needless to say that when the officers have a free hand and full discretionary power the work can be carried out much more economically and satisfactorily. The men as a body are really none the better off when this influence is exercised; the better class of workmen at least want no backing-up before they get recognition, or influence to keep them in position, but it is the idle, incompetent, and indifferent men who gain by it, and they should not be on the work at all, for they are not worth the minimum wage, and if employed they spoil and discourage others and tend to bring all down to their low average of work. When political pressure is rife the day-labour system suffers, and it would be a good thing if the working-man properly recognised the fact that it brings the whole system into discredit, so that it loses the confidence of the public. Good workmen should protest against its being exercised, as it brings into unfair competition with them the lazy and indifferent.

The question of the adoption of the minimum wage is one that hardly affects the comparison between the "day-labour" and "large-contract" systems, so long as the engineer in charge has a free hand in engaging and discharging men. The contractor, who is equally compelled under his bond to pay certain rates of wages, will, of course, take care that he gets the best value for them that is to say, that he engages only the competent and energetic and rejects the indifferent and the lazy. On Government works these wages should only be paid for the same standard of work, and the official in charge should have equal opportunities with the contractor of selection and rejection, as is only right in the interests of the whole community and in the true interests of the labouring-class itself. The minimum-wage principle is disastrous in its effects if it is applied in such a way that it has to be paid to the man below the standard, to the weak man, the lazy man, or the man who in advancing years perhaps cannot duly perform his portion of work. It is unjust that the latter, if he is still forced to work for his living, should have to enter into competition with the able-bodied, and it ought to be allowable for the engineer to employ such men at wages-rates in accordance with their ability. Of course, political pressure might be exerted and such men put on at the minimum wage, but such a practice must ultimately have a bad result, as the best men would lose their incentive to work, and the quantity and quality of their work would degenerate. There are not wanting proofs that this result has taken place. There are many kinds of work which are specially suited to the weaker members of the community, such as side-ditching, odd jobs at stone-breaking, &c. Stone-breaking on a large scale should, of course, be performed by machinery.

Cases are reported where men have been discharged by the foreman and afterwards sent back to him by the Minister with orders to reinstate them. Nothing can be more unfortunate for the continuance of the system, and it is absolutely opposed to the public interest. No officer can get a good day's work out of a man if the latter believes that he cannot be put off, however lax he is. Common-sense suggests that complaints should not be taken up by the Minister unless they have been previously dealt with by the officers in charge up to the Engineer-in-Chief, and then should not be listened to unless there is a genuine case of injustice, the probability of which occurring is extremely small. In some States the officers in charge of work are not interfered with, and consequently most satisfactory results are obtained. In our case, on country jobs, work is fairly free from political pressure. This is also the case under the Railway Commissioners of New South Wales; but recent inquiries by the Public Service Board in Sydney show that political interference has been exerted to quite a serious extent in some cases. The reply of a certain Minister of one of the States when he was waited upon by some delegates of one of the sub-departments is well worthy of note, and it were wise to follow his example in other cases. He is reported to have said that "he received the deputation chiefly for the purpose of getting the men to understand that he wanted all this kind of thing to end. He would not interfere with the Superintendent. An institution was often made ineffective and unprofitable because the head was continually interfered with, sometimes for political or personal reasons outside the business. When he entered office he decided, so far as he could effect the matter, that there should be no political or personal influence exercised by a Minister or any one else. This was best for the men, and certainly best for the country. If he interfered with the Superintendent he would not be able to hold him responsible. If a manager was to be held responsible, he must be the boss. There was not to be a Court of Appeal on matters of detail to the Minister, but only when he had reason to believe that there was gross partiality would he feel called upon to interfere." The recent inquiry by the Public Service Board in Sydney, already referred to, shows that the strongest and unwisest of political influence was at that time exerted in one of the Government institutions; that men were put on, and advances of wages forced without substantial grounds, so that between unduly high pay in some cases, granting of an excessive number of holidays with full pay and of other privileges, and the consequent weakening of control, the condition of things was about as bad as it could be. These are not my conclusions; they are those of the Public Service Board, and it is open to every one to read and judge for himself. It is an immense pity that the cause of "labour" should be damaged by such practices. Although done with the best intentions, it is a case when the working-man can fairly cry out, "Save me from my friends." What the working-man requires is justice—high pay if he can get it, but fairly, and for good work—otherwise the community is being imposed upon; in fact, cheated.

As to "red tape" I shall say very little. In a Government Department there must necessarily be more in the way of checks and formalities than a contractor would think of imposing on his employees. It would not pay a contractor to introduce into his business all the elaborate machinery that a Government office requires. A few irregularities or indiscretions on the part of his employees would not concern him very much, if the profits came out all right, although, of course, if he found any one abusing his confidence and taking advantage of him he would clear him out pretty quickly; but in Government business safeguards are necessary, and all transactions have to be followed up and checked in an elaborate manner. Public opinion demands it. A good many things are done, however, that need not be done; in the case of appointment of gangers in New South Wales a quite ridiculous amount of writing has had to be gone through, and approvals obtained from three months to three months, so that if the papers of each individual were printed after he had been employed some time it would make up a small pamphlet. These formalities were supposed to be necessary in order to conform with the Public Service Act, than which in some respects a more absurd piece of legislation was never invented. An amendment of the Public Service Act recently passed alters the method somewhat, but it remains to be seen whether some other drawback does not make its appearance. In the Railway Commissioners' Department such absurdities are not enforced, and the work is just as well controlled as in the Public Works Department, and the Auditor-General is satisfied. In the other States things seem to be managed much better, as there is no harassing legislation to contend with.

As regards purchase of materials, the contractor is at a great advantage over the State Department. If he can pay ready money he can buy in the cheapest market, and the departmental rules of tendering do not bind him, so that he is free to bargain, &c. The Government, as a rule, cannot pay ready money; ordering must be done according to fixed methods, involving a great deal of complicated machinery, and vouchers are sometimes very considerably delayed before the money is available—in some cases, from one cause or another, weeks have elapsed before payment for an article has been made; and it is not surprising, therefore, that the Government cannot purchase at as low a figure as the contractor. Perhaps sufficient attention is not devoted by those framing regulations to simplification of method; the desire to simplify is, of course, there, but unfortunately the steps taken have in some cases led to complication. I have inquired into the methods adopted under different Departments and States, and there is a great deal of variation in the amount of work done to secure the same end, and it is not always the most complicated organization which provides the best safeguards.

The true test of a system is in its pecuniary results. If work cannot be carried out as cheaply as, or more cheaply than, under the large-contract system, it is better to adhere to the latter. In order, therefore, to arrive at a decision as to which method to employ, facts are wanted. I am informed by many of the engineers who have adopted the day-labour system that they are quite satisfied with it. Mr. Pagan, Chief Engineer of the Queensland Railways, assures me that his results are good, and this he attributes to his having had accorded to him a completely free hand. Mr. Fraser, Engineer-in-Chief for Existing Lines, New South Wales, says, "The conditions with us are more favourable to economical working, that is, there is no restriction as to the employment of men, who are retained only so long as they give satisfactory service, and are immediately dispensed with if they show an inclination either to shirk work or display any lack of capacity to perform this in a satisfactory way; and I hold strongly to the opinion that while these conditions obtain—that is, that the engineer in charge of the work has as complete control over his staff as a contractor has—that work should necessarily be carried out very much more cheaply than would be the case under contract." I need not say that Mr. Fraser's opinions are based on a comparison of costs of work under the two systems. Mr. Moncrieff, Engineer-in-Chief of Adelaide, South Australia, in his address already referred to, shows that the cost of the works carried out by him have come out well under the estimate. Mr. Kernot, Acting Engineer-in-Chief of the Victorian Railways, has in his pamphlet above referred to, entitled "Railway-construction under the Butty-gang System" (which is, as I have explained, really the same as that I have called the "day-labour system"), summarised the results, and he finds that there is an actual average reduction of cost of 37 per cent. My experience is similar to that of Mr. Kernot, and the saving of cost is quite equal to his when all circumstances are taken into consideration. Taking earthworks as an example, and making special reference to the cost of side-cutting, I find that under the contract system we never paid less than 1s. 3d. per cubic yard, while generally 1s. 6d. per cubic yard has been the schedule rate, and sometimes it has been much higher. I find that on day-labour works, by adopting improved methods, we have, in precisely similar country, carried out for a fraction under 5d. per cubic yard what was paid for under the contract system at 1s. 3d., and that the average cost, taking all unfavourable circumstances of thick timber and wet ground into consideration, has been 10½d., as compared with 1s. 6d. paid to contractors. In making a comparison between cost of other classes of work, such as timber-work, it must be borne in mind that we are comparing the day-labour conditions now with the conditions under which contracts were carried out some years ago, when prices of material were lower generally. The minimum wages-rates have been raised all round in consequence of the action taken by the present Minister for Works, and costs as regards labour have risen on the average from 12 to 15 per cent. Higher prices are now paid for sleepers, the Minister having in many cases taken upon himself the fixing of the prices and distinctly countenanced in others an advancement of established rates. Were the large-contract system to be reverted to the prices would not be lowered. It is most probable that supply of sleepers would be excluded from the main contract, and would still be obtained direct from the men, so the prices would not be affected. With regard to bridge-work, which is let in small contracts, the contractor could not get the work done more cheaply himself, and in his charge to the Government he would have to add a percentage to cover cost of staff and his own profit.

It has sometimes been said that only work of a low order can be carried out advantageously by the Government without the aid of the contractor, but this statement is not borne out by the facts. All kinds of work have been carried out under this system. I have instanced side-cutting; I need not say that earthworks generally can be executed equally well; timber bridge-work I have mentioned; concrete-work has been turned out from 10s. to 15s. per cubic yard less than what is paid to a contractor to do it for us; while permanent-way and ballasting are much better carried out when performed by Government gangs, and equally satisfactorily as regards cost. It has this advantage: that rates of progress can be fixed to suit circumstances, such as rate of supply of materials and existence of obstructions caused by unfinished work ahead; and thus heavy claims for compensation are avoided, which the wily contractor delights to put in and base on assumed ill usage. Recently I have found it much cheaper to undertake the erection of steel bridges by day labour, the result being that this work has been executed for from £4 10s. to £5 per ton, including all cost of plant and staging, as against £10 per ton paid previously to contractors. Work such as timber bridge-work and fencing are best carried out by means of small contracts, the Government undertaking to supply the material. Station buildings are better, in my opinion, let by contract, as they combine a variety of work, to carry out which the man whose business is building and contracting has special experience. I have found, however, much advantage in obtaining timber and materials for trucking-yards and then letting the labour by contract.

With regard to the construction of large public buildings of brick and stone and of elaborate design, such as the Fischer Library and the Prince Alfred Hospital wing, there are great varieties of trades, and an intimate knowledge of them all is required to arrange for details and to guide the work to a successful issue, and I am sure that under such circumstances the contract system is in general the safest. At the same time, seeing that the most modest-minded contractor would include in his price a profit of 10 or 20 per cent., the Government officers would have a considerable margin to go upon, and I think that if one had that absolutely free hand that one ought to have a great work like the Central Station could be carried out at a less cost than if a contractor were employed, and the country would possess the assurance of having all good work and no scamping.

My experience in New South Wales being chiefly with railways, I have dealt with works of this character. In Western Australia it has been observed that some railways have been carried out under the contract system at prices which it would be impossible to compete with under the day labour system, the reason, however, being not that the work itself had cost so little, but that the contractor in tendering was bidding to get the profits which he knew would accrue to him from working the traffic on the line during construction. In New South Wales several large jobs have been carried out under the Government architect, but owing to the peculiarities of the circumstances and excessive political influence they cannot be pronounced successful.

With regard to actual manufacturing under the day labour system, there are examples which seem to show its advantage in some cases. Mr. Moncrieff finds that in the manufacturing of pipes, &c., directly by the Government there is a very large saving. On the other hand, Mr. Hales tells me that in New Zealand the same success has not been achieved, but this relates principally to the manufacture of steel bridges. An example of manufacturing by day labour is presented in the railway workshops of the different States, where necessarily a large portion of work done, such as making of articles for renewals and repairs, must be effected under the day labour principle. Of course, in many cases opportunity is given for letting work in small contracts or piecework, and in some cases the supply of castings and rolled steel and iron have been let by contract to firms outside the shops.

I will now proceed to sum up my ideas upon this subject. Works of a general character not presenting special difficulties where experience of a rare and exceptional character is called for can be advantageously carried out by the Government without the intervention of a contractor, on account of the saving that will be made on the following items: Cost of staff; contractor's profit and risks charged for; no provision of working capital, plant, &c.; no provision of security; no costs of lawsuits or arbitration; saving in time, and consequent saving in money, as works can be begun as soon as some part of the surveys and drawings are ready, it being clear that in the case of a contract everything must be ready so that the contract may be defined; better working conditions can be offered to the men. The possible drawbacks to the system are political influence, and harassing departmental regulations, or "red tape."

Whatever may be the motives leading the Government to adopt this system—whether a contemplated saving, avoidance of lawsuits, or an improvement in the position of the working-man by removing him from a hard taskmaster—it should be remembered that the Government is throwing an enormous amount of extra work on its staff requiring very close attention, and involving a great deal of anxiety and an immense amount of overtime. For this the Government should pay fair rates, from top to bottom of the service. The rates that are paid very often by the Government for these responsible services a contractor would be ashamed to offer. The action is very much of the nature of "sweating."

To make works a complete success the following conditions are necessary: That competent officers should be employed, and no others. That competent gangers should be engaged or put off as required by the responsible head, or by the officer in charge with his approval. That good workmen labourers and artisans should be taken on and put off as required by the officer in charge, or by the ganger with his approval, and their continuation on the job should be subject to good conduct or duration of the work. That no appeals from men should be listened to by the Minister unless a prior complaint has been presented to the officer in charge, or, failing his rectification, to the Engineer-in-Chief. If the man is still not satisfied and can show cause for going higher, he should be allowed to appeal to the Minister, who must then act with perfect impartiality, and not unduly favour the man in his complaint, as otherwise he risks the upsetting of authority. If matters were thus arranged I do not think there would be many appeals to the Minister; nearly all cases would be settled before they got as far.

The above conditions will meet the approval of all fair-minded men. No Board is required to select men; the selection should be made by the responsible officers. No Board is required for the selection of gangers; the officer in charge and the Engineer-in-Chief know what they want, and if their authority is supported the right men will be appointed. This method can be carried out, and is carried out under the Railway Commissioners in New South Wales and in some other States. In New South Wales it was so also under the Hon. J. H. Young, who ordered the commencement of the day-labour system, and it should be so now.

The Engineer-in-Chief should have full and complete authority. If he is worthy of his appointment at all he should be supported in his position. It is useless to talk of appointing a Board of Control or anything of the sort. He is the man upon whom responsibility is placed, who is called upon for an explanation if anything goes wrong, and he is the man who should have the power. If any one is placed in a position of high responsibility he should possess power to act. It is an incongruous thing with one hand to place a man on a pedestal and with the other to pull away the support.

The above conditions will, I venture to say, also convince the honest labour leader. There are distinct advantages to the labouring man in the day labour system, and his advisers should understand that the perpetuation of the system can only be justified when authority is upheld.

Finally, with regard to harassing departmental regulations: Let the engagement of gangers rest with the chief and the officer in charge only, and let them be kept free from all undue political interference, and let the writing in connection with their appointment be reduced to a minimum. The steps necessary for the ordering of material should be simplified, so that acceleration of delivery and payment for same may result. Any efforts directed towards this end will add to economy in cost and comfort in execution of work, which means better quality. Harassing regulations produce the reverse effect.

What I have said with regard to Government works applies equally to those carried out by Harbour Trusts, Municipal and other Boards, and it resolves itself generally into this: that it pays to carry out works without the aid of a contractor, provided (1) suitable men are forthcoming to take charge; (2) that they have fair and proper control of the engaging and managing of men; (3) that the simplest and least harassing method of ordering materials and keeping accounts be adopted.

Undue political influence should in all cases be avoided: it is in the truest interests of the community and of all classes comprising that community, including the working-man.

No. 1. ENGINEERING ECONOMICS.

By J. T. Noble Anderson, C.E.

No. 2. CENTRIFUGAL FANS FOR THE VENTILATION OF MINES.

By John Hayes, M.E.

No. 3.—THE DISFIGUREMENT OF TOWNS WITH PLACARDS AND ADVERTISEMENTS, AND ARCHITECTS' RESPONSIBILITIES IN RELATION THERETO.

By S. Hurst Seager, A.R.I.B.A.

It will, I think, be readily admitted by all who have any love for the beautiful that the disfigurement of our towns by placards and advertisements has grown to be a very widespread evil—so widespread, indeed, that it forms a very serious blot on our modern civilisation; for it shows that a very large proportion of our fellow-townsmen are so disregardful of the feelings of others that they destroy whatever beauty our towns might possess by the display of hideous signs, making appeals to us to purchase only their wares and "none other." In a spirit of retaliation this is repeated by rival vendors, and so we have what would be the ludicrous, if it were not so humiliating, spectacle of rival firms spending enormous sums in injuring their towns in the endeavour to get the better of each other; while so dead is the artistic spirit among us that we quietly submit not only to the positive injury to the sense of sight the disfigurements cause, but to the monetary penalty all have to pay who purchase the goods advertised.

I do not for one moment mean to imply that in this competitive age advertising is unnecessary; it is only the abuse of advertising and the wanton and the perfectly useless disfiguring of urban and rural scenes against which my protest is made. It is this which has called into existence societies in England and elsewhere for the purpose of obtaining united action in checking these abuses. That they have not been able to make very satisfactory progress is due partly to vested interests, but chiefly to the lack of artistic education among us. If the citizens as a whole only realised the very great contrast between what our towns are and what under artistic guidance they might become, there would arise such a volume of protest that all disfigurements would be immediately swept away. For so long have we patiently borne this evil that many of those whose taste in art in other directions is unquestioned have come to regard the problem of civic improvement as hopeless—have even ceased to regard it as a problem at all, but rather as something far outside the canopy of art. We, as architects, and those who have travelled through what is left of the ancient cities in Europe, know a town may be a perfect delight to the eye, and this without sacrifice of any useful feature. Glance, for instance, at the representations of Ludgate Hill as it was in the fifteenth century, at Nuremberg or Rotenburg as they are to-day, and then at the latest developments of our nineteenth-century art in any of our colonial cities. The contrast is appalling; but let us not therefore give up hope; let all who realise the refining power of art band together, and with one voice declare that they will not purchase the wares of those who proclaim them in an objectionable manner. This can be done without the slightest inconvenience, for it does not by any means follow that the wares so proclaimed are the best; but, even if they are, surely all who value their cities' welfare—all who wish to be regarded as good and faithful citizens—would be willing to make some slight immediate sacrifice for the general good.

The progress made by the London society ("Scapa"), to which I am proud to belong, is doubtless to be attributed largely to the judicious use of this power, but principally to the educating of public opinion by the issue of pamphlets for distribution by its members, and by working strenuously for legislative control. Such control has been partially granted—sky-signs have been absolutely prohibited, and municipal control has been accorded to Edinburgh, Dover, and other towns. An Act giving general control to all civic and rural authorities has been the aim of "Scapa" for some years. What they have striven for for so long is, I am glad to say, an accomplished fact in New Zealand to-day; for there was passed this last session a clause in the Municipal Amendment Act giving complete control over everything displayed within view of any public place—so that all that is now necessary is for the Municipal Councils to pass such by-laws as will conserve the amenities of their towns. The power therefore is provided; it awaits only the voice of the people to call for wise use of it.

As an architect I have taken the keenest interest in this question, because I have realised the utter hopelessness of creating any interest in architectural art so long as every architectural work erected was absolutely ruined, if not by placards placed upon it, then by placards so placed that the building could not be seen except in conjunction with most irritating displays; for suitable environment is as important to the effect of a work of art as the forms into which the work itself is moulded. The outlook now is brighter, for it will be possible for our beautifying associations and Councils to proceed with their good work in the knowledge that their efforts need not be nullified by the growth of the placarding mania. We as architects should rejoice in this, and should brace ourselves up to play our part, both as citizens and as artists, to whom the public may look for guidance.

We have not, I fear, in the past realised as fully as we should have realised our responsibilities in this, for some portion of the ugliness of our places of business is to be attributed to the want of care and thought—the lack, in other words, of artistic design—in the solving of the problems in hand. The artistic solution of any problem can only be arrived at by fixing our attention solely on the conditions under which our work is to be done. This is a truism, but its neglect is the cause of much that offends. The problem before us in our commercial buildings is not only to provide all the accommodation required in the most convenient and scientific manner, but also to express the purpose of the work in the ornamental forms which adorn it. This can never be accomplished by making it our endeavour to reproduce the architectural forms of the past, which were erected under different conditions, and for a totally different purpose from that to which, unfortunately, they are applied to-day. The fifteenth-century palatial architecture of Italy copied and brought into service as a nineteenth-century place of business—which with other reproductions of previous styles forms the main part of modern cities—is not by any means the method which will lead to an artistic expression of our needs. Every building for commercial purposes must of necessity have means for the proper display of signs, stating the nature of the business or businesses carried on within it, yet with very many of our offices and places of business a name-plate or sign is evidently a thing quite beyond the designer's conception. Thus we see entrances in which considerable labour and money has been expended, without the least provision for the name-plates of the tenants, and so these brazen intruders have to cling to the moulded bases, encircle the polished shafts, get themselves tacked on to the quoins or reveals anywhere, in fact, the ingenuity of the tenants can devise; and so the "noble entrance" becomes an eyesore, and the architect's labour is in vain, as all thoughtless labour ever must be. Architects cannot be held responsible for much further disfigurement than this, but perhaps if more regard had been paid to the requirements of the case the tenants or owners would not have been led so far astray. Simple appropriateness of design without thought of "style," but only of good straightforward building with sound and pleasing materials and honest workmanship, will be the road most likely to lead to artistic success. This is the road being taken by the leaders in our craft to-day, and is the one we must all follow more closely in the future than we have done in the past if we are to raise architecture to the place it once held in the affections of the people.

Although architecture is capable of expressing varied emotion, it cannot be made phonetic. Different styles of work may be used for different purposes, as Gothic for churches, Classic for banks, &c.; but it is not the style, but only its constant use for a particular purpose which gives it the function of a symbol by which we can tell what that purpose is. To make a building phonetic—to make it tell us the exact purpose of its erection—the sister arts of sculpture and painting must be embodied in the work now, as of old. The need for blatant placards would disappear if our buildings were made vocal by the judicious introduction of appropriate sculpture. I need not remind you of the modern works in England and other parts of Europe where this has been done with pronounced success. In Australia, too, the sculptor and architect have together produced works showing the happiest results.

Decorative sculpture, I need scarcely say, must be most artistically done or it should not be attempted, and this is true of all efforts at adornment; better by far the plainest of work than any but the best decoration of its kind—if not sculpture, then mosaic, glazed tiles, or scraffito might well be used for decorative signs. How delightful, too, were the wrought-iron signs which were commonly used in the Middle Ages! The reproduction of them for the decoration of Lombard Street, you remember, formed one of the most effective pieces of decoration at the time of the Coronation. Some beautiful ones have been erected on modern buildings, one of the most notable being that of Heath's, in Oxford Street. By any of these branches of art, then, can the architect satisfy the rightful demand for appropriate signs, and while satisfying it add points of interest and beauty to our cities, thus honourably discharging the responsibility which rests upon him.

No. 4.—THE DUNEDIN WATER-SUPPLY.

By G. M. Barr, M.Inst.C.E.

Dunedin as a settlement of Europeans originated in 1848, and since then has passed through various stages of development to its present condition, with a population of 26,000, and having suburbs with about an equal population, so that 52,000 may be taken as the number of persons for whom a water-supply should be calculated, with, of course, a proper allowance for increase. A large proportion of the suburban population have their business in the city, and this circumstance, combined with the fact that a single scheme comprehensive enough to serve all is better than numerous smaller ones, render it desirable that the whole should be included in the one work of water-supply. As the dwellings are ranged over areas of great differences in levels, the scheme must have two zones—a lower one serving the population from 8 ft. to 300 ft. above sea-level, and an upper one up to 700 ft.

Dunedin has neither a large river nor a lake within easy distance from which water could be derived, so that it must draw from the gathering-grounds in its neighbourhood. Immediately behind the city there is the Flagstaff Range, with its summit 2,195 ft. above the sea, and this stretches on the one hand southwards, sloping and stepping down towards the Taieri Plain, and towards the north merging itself in other mountains, with Swampy Hill as its most northerly shoulder. Towards the north-east Mount Cargill rises to about the same altitude, and between it and Swampy Hill the Water of Leith takes its rise and discharges itself into the harbour in the northern part of the city. Upon the southern side of a saddle, 1,207 ft. above the sea, between those two mountains the waters run towards Blueskin Bay, each considerable watercourse having a name, but all merging in what is known as the "Waitati." Within quite a short distance of its head-waters there rises the Waikouaiti, which flows towards the bay of that name and is there lost in the South Pacific. On the north-west of the Flagstaff Range and between it and the Silver Peaks there runs the Silver Stream, which becomes a tributary of the Taieri some twelve miles or so from Dunedin.

Of the streams coming off that country, Ross Creek, a tributary of the Water of Leith, has been drawn upon for the Dunedin supply for the last thirty-six years, and the Silver Stream for the last twenty-three years; and within the last few days the waters of Morrison's Creek, also a tributary of the Leith, have been added, and works are in progress with the object of utilising the head-waters of the Waitati. Taking the gathering-grounds within the district described, there are twenty-seven square miles high enough to supply the highest suburbs, and other five square miles of less elevation, but still capable of serving the greater part of the city. One object of the new scheme is the installation of a higher service whereby the parts of the town not hitherto supplied with sufficient pressure will be reached.

In 1865 Dunedin had a population of 15,000, and an annual valuation of about £200,000. It may be interesting to note at this stage a few figures which show the fluctuations of a growing town in the colony. In 1857 the annual valuation was £4,400, and four years later £42,016. In 1862 it was £155,696, and it reached up to £235,872 in the year 1864. By 1869 it had fallen to £116,933. The rapid rise was due to the discovery of rich gold-deposits and great influx of population, and the sudden drop to the reaction consequent upon unnatural inflation. It stands now at about £270,000. In 1864, at the time of top value, an Act was passed by the New Zealand Legislature incorporating a company and giving it power to appropriate the waters of Ross Creek and the Leith, to construct works for the supply of the residents in Dunedin, to take land compulsorily, and to levy rates. The capital was to be £50,000, afterwards extended to £65,000. with borrowing-powers up to £15,000. They were allowed to make profits up to 20 per cent., but when that point was reached the rates stated in the Act were to be reduced. On the whole these rates were not unreasonable, but the charge of £8 per annum for a bath in one's house was not calculated to promote personal cleanliness. Immediately after the works were started dull times seem to have set in, and it was not without considerable struggles that the works were completed in December, 1867, and no doubt the shortness of money was responsible for some of the defects from which the Dunedin people have suffered, and which they will now have to remedy. In the beginning of 1875 the City Council purchased those works for £122,977 4s. 5d., and since then extensions and improvements have been made, so that now they stand as an asset of £139,602 12s. 6d., after allowing for depreciation.

The reservoir was located upon Ross Creek, two miles and a quarter from the centre of the city, having a gathering-ground of about 1,000 acres. The site was well chosen as a position for the economic and safe construction of an embankment, but at a height too low for the proper supply of the higher parts of the city. In those earlier days, however, the men who directed this business could not be expected to foresee how residences would climb to what in natural conditions seemed quite unsuitable sites for the erection of buildings. The capacity of the reservoir was 50,000,000 gallons, its height of embankment 75 ft., area 7 acres, with a small basin above of $1\frac{3}{4}$ acres. The outlet-pipes were laid upon masonry piers and the embankment placed upon them, a mode of construction obviously much inferior to the usual method of placing them in a culvert. There is reason to believe that Mr. J. M. Balfour, M.Inst.C.E., who succeeded Mr. Donkin as engineer to the company, advised the better plan, but for financial reasons it was not adopted. There is a storm-channel upon the eastern side of the reservoir, but the experience of more than one flood has shown that it is not fully capable of the purpose for which it was designed. The upper reservoir was enlarged in 1875, the material from it being put upon the outer slope of the embankment of the main reservoir. Very early in the life of this reservoir a run of water outwards from the foot of the embankment was discovered, and in April, 1875, the City Surveyor found it discharging 8,020 gallons of water per day. Since then various examinations and reports have been made, and these have shown considerable fluctuations in quantity of flow, frequently being less than half the above, but within the last eighteen months there have been frequent occasions in which the issuing water has been heavily charged with clay. It is intended to empty the reservoir very shortly, thoroughly examine the embankment, and execute such remedial works as the inspection may show to be desirable. The presumption in the meantime is that the water is not derived from the reservoir, but that its origin is outside the puddle wall.

In 1878, after a very full discussion, it was resolved by the City Council to adopt the Silver Stream as a source of additional water-supply, and it was tapped at an elevation of 501 ft. above sea-level, at a distance of $21\frac{1}{2}$ miles from Dunedin, and about two years afterwards the first of the water reached the consumer. Previous to this the adjoining Borough of Caversham had sketched out a scheme of supply from the same source, but the interests of suburb and city were amalgamated upon the condition that the suburbs within three miles and a half of the Octagon should have the right to draw water from the Dunedin works, on payment at the rate of 6d. per 1,000 gallons, with special proviso concerning the construction of a reservoir on Ross Creek at a height sufficient for the supply of the higher suburbs, a provision which has not yet and will not now become operative, seeing that the scheme now in hand will provide in another manner for any demand at those high altitudes. From the intake the water is conveyed to a reservoir, situated south of the town, in an open race $19\frac{1}{8}$ miles long, with a cross-section of $13\frac{1}{2}$ square feet, and grades ranging from 2.4 ft. to 4.32 ft. per mile Those are flat grades, but no doubt they were adopted in the expectation of large bodies of water, and also so that the current should not exceed what was safe for soil of a rather tender nature. The reservoir has an overflow 424 ft. above sea-level—that is, 48 ft. above the overflow of Ross Creek reservoir and it was contemplated in the first design of the scheme by the late W. N. Blair, M.Inst.C.E., that the lower and older storage might on occasions have its water supplemented by contributions from the newer one, but as an essential feature of the scheme this was abandoned. The area of the reservoir is 6½ acres, its capacity 43,000,000 gallons, and the height of embankment 49 ft. Pipes of 14 in. diameter carry the water to Dunedin, supplying *en route* Caversham and other suburbs lying to the south of the city. These works are now valued as an asset at £83,082.

When this scheme was projected a too-liberal estimate was formed of the quantity of water which could be obtained, and there was also considerable loss by leakage from the race, so that there was a shortage of water within a few years after completion, and on several occasions it was found necessary to supply some parts of the town from the lower Leith. A disadvantage of any scheme upon the western side of Flagstaff is the want of good sites for storage-reservoirs, as compared to the localities upon the eastern side of the range, where there are many spots admirably adapted for such works.

The deficiency of water could be obviated either partially or wholly by two methods first, economy; and, secondly, further works. In 1890 the City Council wisely instituted an investigation into the amount of waste going on, and after a careful inspection extending over several months the then City Engineer, Mr. S. H. Mirams, reported that he found in all 1,096 leaks in service-pipes, valves, taps, and fire-plugs, and that 808 of these were the fault of consumers and 288 of the Corporation department. The repairs of these resulted in the saving of 552,000 gallons per day, and the reduction of the supply per head from 91 to 69 gallons. A quite recent investigation under the present City Engineer, Mr. R. S. Allan, has, I understand, shown a most unpardonable carelessness on the part of many consumers in allowing their taps to run when there was no use being made of the water. So difficult it is to teach people economy in regard to those articles for which they are not paying at the moment.

In 1898 the author put before the City Council a scheme having for its object the impounding the waters of the Leith and Waitati, to supplement present supplies both in quantity and pressures. The works are now in hand, and the first instalment now gives an addition to the Ross Creek supply fully double its own. In another two months or so the construction of a service reservoir at Maori Hill, elevated 485 ft. above the sea-level, will enable the city to be divided into a lower and higher service, and the continuation of a main pipe to the highest part of Roslyn, at an elevation of 700 ft. above sea-level, would enable the distribution to that borough and Mornington to be commenced, but in the meantime those municipalities have not arranged with the city for a supply. The catchment-area to be laid under contribution for this purpose is mostly at a high elevation, is of a rough and rugged character unfit for settlement, largely covered with bush, and with soil which retains the rain and then gradually parts with it to the streams. Where land was in private hands lying in such a position as would imperil the purity of the water, the City Council has acquired the land from the owner, so that by these purchases and the large reserves made for the purpose of water and timber conservation that body will have the command of a vast area of picturesque country. In these works the water will be lifted from the creeks in its natural purity, conveyed in pipes, and preserved from that pollution which is inevitable in open races.

In order to estimate the possibilities of the area referred to, it will be necessary to take account of the rainfall of the locality, and in the absence of observations made upon the ground it will be necessary to depend upon the gauges in or closely adjoining Dunedin. This is subject for regret, as the fall in different parts of the district is very various. In the earlier days of the settlement observations were made by the Rev. Dr. Burns, one of the founders, at his Manse, close to the harbour, and for the eight years from 1853 to 1860, the records of which I have obtained, the average annual fall was 26.6 in., with three years of what we should now consider almost drought years these were 1854 (22.2 in.), 1855 (22.79 in.), 1857 (22.98 in.). From 1866 onwards to December, 1885, when the observations were made for the Government by Mr. H. Skey at a station on the Town Belt, at an elevation 550 ft. above sea-level, the average was 34.37 in., the lowest being in 1871, with 22.14 in. The observatory was removed in December, 1885, to a situation in Leith Valley (elevation about 200 ft.), and for the twelve years from 1886 to 1897 the average has been 41.98 in., the lowest fall being 23.446 in. in 1889, and the highest 54.49 in. in 1893. In a technical work the author recently found a rule for finding the greatest fall in twenty-four hours from the mean annual fall, which was that for a fall of 20 in. the greatest daily would be 16 per cent., or 3.2 in., and the percentage would fall by one for each 4 in. up to 60 in., after which the rate would be stationary at 6 per cent. If this rule be applied to the period 1866–97 it would show 1.11 in. In August, 1886, on the 18th and 19th, the falls were respectively 4.26 in. and 4.6 in. Personally, the author regards this as more of a coincidence than as establishing a rule for the guidance of engineers.

In estimating the rainfall available for water-supply upon the eastern side of the Flagstaff Range, the earlier records, made close to the harbour edge, being too remote from the locality, may be disregarded. The next series, taken upon the Town Belt at a place also remote, though nearer, do not, the author thinks, do justice to the heavy and frequent falls upon the high lands, from which the water will principally be derived; but in deference to the principle of caution they should not be altogether rejected, so the average of observations at the two stations for the thirty-two years 1866–97, being 37.2 in., may safely be accepted. These were made at positions respectively 1,600 ft. and 1,995 ft. below the highest points, so according to usual experience they must be very much under what gauges would show at and near the summits. This is confirmed by the author's experience and by that of the survey parties he has had out upon these mountains, for not only is a general rain heavier there than on the lower lands, but there are very many occasions in a year when there is a fall there and none in the city. It is anticipated that, by running a line of stoneware pipes at a grade along the hillside, each shower and even the heavy fogs will be made to contribute substantial quantities to the storage reservoirs, one of which will shortly be constructed with a capacity of about 130,000,000 gallons.

Mr. George Gordon, M.Inst.C.E., hydraulic engineer, of Victoria, some years ago reported upon the possibilities of this locality, and he placed the probable yield at 700,000 gallons in summer and 450,000 in winter, quantities somewhat in excess of what the author has made the basis of his calculations.

The map now exhibited shows by red circles positions where reservoirs could be constructed with capacities of 60,000,000 to 140,000,000 gallons, with embankments from 45 ft. to 68 ft. in height, and no two reservoirs would be on the same creek, so that the risk of any one carrying away another in the event of a disaster to its own embankment would not exist. With judicious storage the author is confident that water could be found upon the areas treated of in this paper for the liberal supply of fully twice the present population of city and suburbs.

It is intended to place filter-beds in connection with the two existing reservoirs within the next twelve months, but the designs for these are not yet matured.

No. 5. THE PLANNING OF ENTRANCES AND EXITS FOR THEATRES AND OTHER PLACES OF ENTERTAINMENT

By S. Hurst Seager, A.R.I.B.A.

The recent appalling disaster at the modern theatre at Chicago has drawn attention once again to the very great danger incurred by all who visit any of our theatres or other places of entertainment. Evidence has been given only too often that the buildings which have hitherto been designed for holding a large number of people fail to provide against loss of life at times of panic. Such slaves are we to precedent, so willing to blindly follow example, that theatre after theatre is constructed in which are seen all the faults of construction which have led to such heartrending fatalities in the past, and which will without question be the cause of fearful loss of life in the future. To effect any improvement it is principles, not precedents, which must be carefully studied and understood. This is the lesson the Chicago disaster has driven home in such a painful manner, and is the lesson which must be at once taken to heart and acted upon. For, if a building designed in accordance with the latest approved methods, and erected in such a manner that it was regarded as one of the finest theatres of modern times, proves at the test to be nothing more than a gilded death-trap, what but the severest condemnation can be pronounced on the ill-designed structures—many of wood—into which colonial audiences are nightly crammed?

The responsibility which rests on mayors and corporations is a very great and most serious one, and is one which must not be shirked whatever private interests may be involved. The demand must be made with no uncertain voice for thoroughly safe panic-proof buildings, and care must be taken that the judgment is not warped by the display—as is far too often the case—of architectural magnificence and decorative adornments. These may follow at the pleasure of the proprietors, providing always that no decorative features shall be permitted which in the least degree interfere with the safety or utility of the building. In a critical article lately published on six of the finest New York theatres, no mention is made, no praise given, for skill in planning, but all are judged and placed in accordance with the art displayed in their adornment. As long as this is considered to be the right standard of criticism, so long will the attention of proprietors and architects be directed more to the display of architectural adornment than to the fundamental and absolutely essential principles of construction on which any public building must be founded, in order to lay any claim to be considered safe for public use. The principles are so extremely simple –can be so easily understood by any layman—that they only need to be clearly stated to at once place in the possession of all a standard of criticism by which every work can be rightly judged.

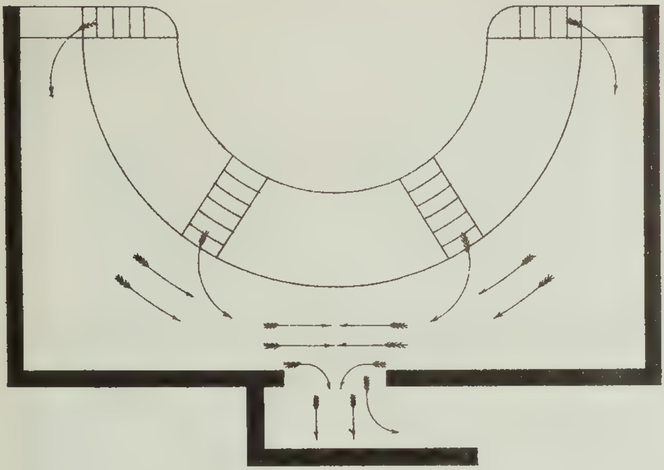
It requires very considerable skill and practice in planning to arrive at a perfectly satisfactory result under all conditions, but all who will take the slight trouble required to understand the principles can at once determine whether or not the design of any building is such as will insure, as far as possible, the safety of the public. No more important problem presents itself to the architect, and yet there is none which has been less successfully solved. It cannot be too firmly insisted that the problem is not to design a building in such a way that an audience may leave it without discomfort under ordinary circumstances, but to design one which shall be free from danger in times of panic, arising either from alarm of fire, earthquake, or any other cause. The safety of the public does not lie in precautions against the spread of fire, for no audience will wait calmly to see the result of such precautions, nor will they even go out quietly in the ordinary manner. Experience has shown conclusively that at the first alarm of fire –even whether there be cause for it or not –a mad rush will be made for the exits. The display of fire-buckets and hose and the presence of firemen are not reassuring; they are only perpetual reminders of an ever-present danger, and more likely to create that feeling of unrest which is the forerunner of a panic than to prevent one. To do away as far as possible with any grounds for fear from fire the whole building should unquestionably be built of fire-resisting materials, wherever practicable, and such inflammable materials as are necessary should be treated with fire-resisting liquids now obtainable from the Fire-proofine Company, of New York, or the Non-flammable Wood and Fabrics Company, of London. Asbestos paint should be used throughout, both for the structure and for the scenery. In this way, and in this way only, can the fear of fire be reduced to a minimum; but it cannot be too often repeated that the danger to life lies not in the fire, but in the impossibility under the present methods of construction for the audience to run away from it.

It is often stated as a matter for congratulation and as evidence of safety that an audience has been timed to leave a theatre in so-many minutes. This is quite delusive. The rate at which they leave under ordinary circumstances is no

1.

EXITS FROM SEATS.

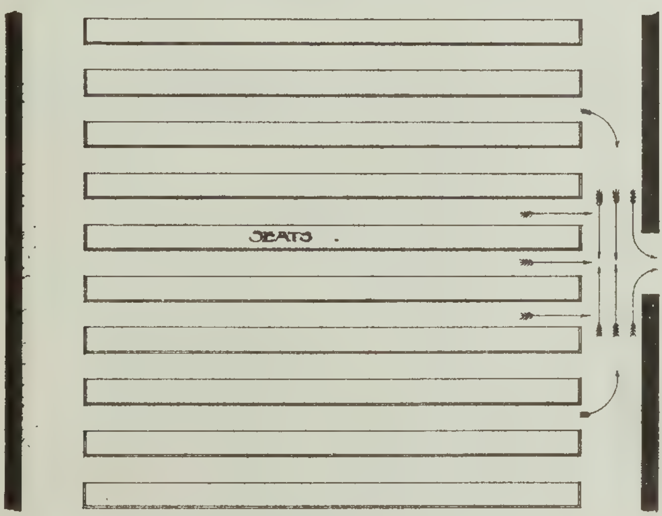
SHEWING PRESSURE AT DOORWAYS.



CIRCLE.

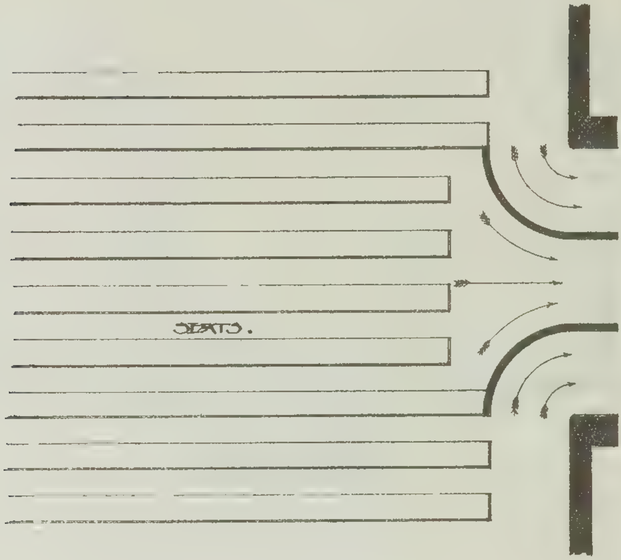
EXITS FROM SEATES. 2.

SHEWING PRESSURE AT DOORWAYS.



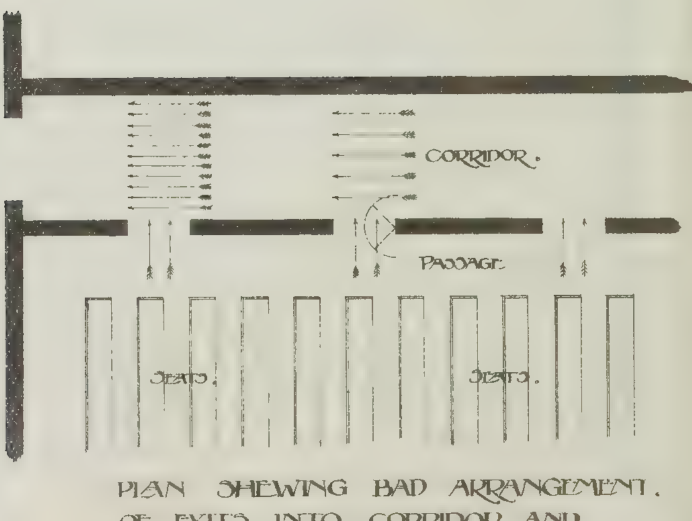
STALLS

Suggested Method of Forming Exits to Avoid Pressure. 3.



"The Safety Exit."

Corridors. 4.



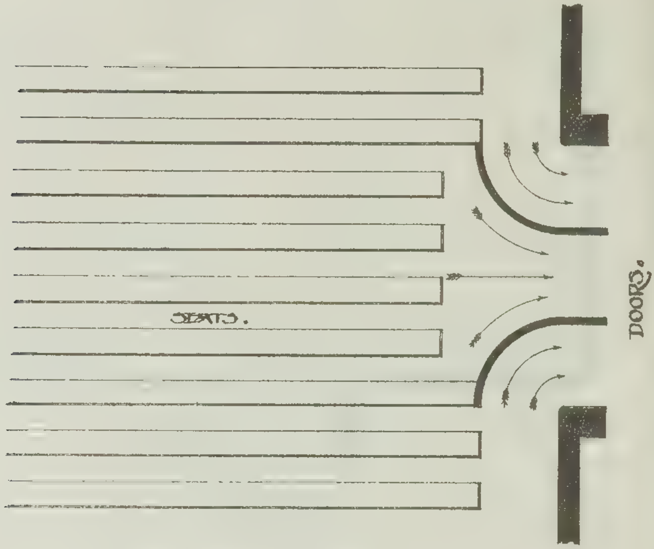
Plan shewing bad arrangement of exits into corridor and reduced width in doorway.

criterion at all as to the time that will be occupied in leaving when every one is anxious to get out first. The conditions under panic are made clearer by watching a crowd at an entrance at the time of a popular performance, when all are impressed with the idea that unless they force their way in quickly they will not get a good seat. All in this case are trying to get in first, and the struggling which takes place not only prevents any rapid progress being made, but is a serious element of danger to all present. Everybody knows this, yet the crushing goes on to-day as in the past; then how much less likely is it that people will ever be able to refrain from crushing where the fear which impels them is the real danger of loss of life, rather than the purely imaginary one of the loss of a seat! It must therefore be clearly borne in mind that the problem is not to be solved by demanding on the part of the audience a certain course of action under any unusual circumstances, for at that time they are incapable of thought, incapable of determining what action to take. Placards on doors, and notices of all kinds, are therefore absolutely useless, as tending to create a false security. The problem is to so plan a building that without any choice in the matter perfectly irresponsible people would be compelled to move towards their proper exit, which must be so arranged that it shall be absolutely free from all resistance throughout —that is, from the auditorium to the street or open space. *Without resistance there can be no pressure; without pressure there can be no danger.* By Diagrams Nos. 1 and 2, which represent the usual exit-doors, it will at once be seen how this fundamental principle has been totally neglected, for in all structures — both "magnificent" and simple — exit-doors as here shown are seen. The pressure exerted by the opposing streams of people as they approach the exit is shown by the arrows, and it will be clearly seen than any pressure exerted by the stream coming in one direction is met and directly opposed by the stream coming from the other. The pressure exerted does not tend to force the people out, but causes a complete block the more complete, the greater the pressure exerted. The danger is intensified when, as shown in the "circle" exit, those who have found their way through the doorway would in turn be forced against the opposite wall of the corridor. Here, then—as the records of disasters have proved only to often lies the most serious source of danger, and the one to which attention must at first be directed.

THE SAFETY EXIT.

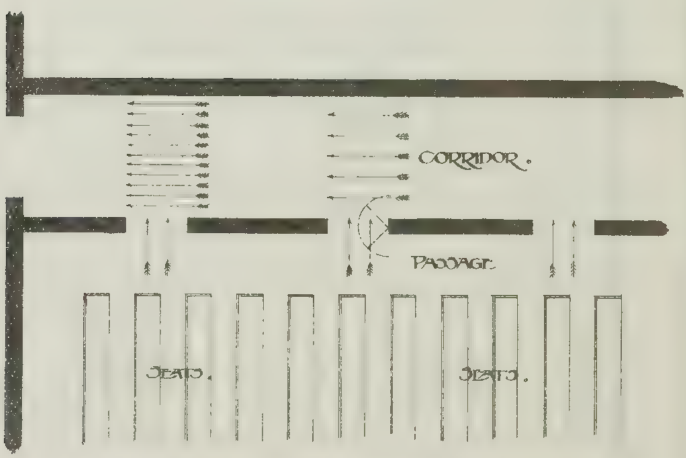
Diagram No. 3 shows the plan of an exit designed by the author, and described by him in a letter to the Christchurch *Press* in 1886, and again described (and the urgent necessity

SUGGESTED METHOD OF FORMING EXITS TO AVOID PRESSURE. 3.



"THE SAFETY EXIT."

CORRIDORS. 4.



PLAN SHEWING BAD ARRANGEMENT OF EXITS INTO CORRIDOR AND REDUCED WIDTH IN DOORWAY.

criterion at all as to the time that will be occupied in leaving when every one is anxious to get out first. The conditions under panic are made clearer by watching a crowd at an entrance at the time of a popular performance, when all are impressed with the idea that unless they force their way in quickly they will not get a good seat. All in this case are trying to get in first, and the struggling which takes place not only prevents any rapid progress being made, but is a serious element of danger to all present. Everybody knows this, yet the crushing goes on to-day as in the past; then how much less likely is it that people will ever be able to refrain from crushing where the fear which impels them is the real danger of loss of life, rather than the purely imaginary one of the loss of a seat! It must therefore be clearly borne in mind that the problem is not to be solved by demanding on the part of the audience a certain course of action under any unusual circumstances, for at that time they are incapable of thought, incapable of determining what action to take. Placards on doors, and notices of all kinds, are therefore absolutely useless, as tending to create a false security. The problem is to so plan a building that without any choice in the matter perfectly irresponsible people would be compelled to move towards their proper exit, which must be so arranged that it shall be absolutely free from all resistance throughout —that is, from the auditorium to the street or open space. *Without resistance there can be no pressure; without pressure there can be no danger.* By Diagrams Nos. 1 and 2, which represent the usual exit-doors, it will at once be seen how this fundamental principle has been totally neglected, for in all structures — both "magnificent" and simple — exit-doors as here shown are seen. The pressure exerted by the opposing streams of people as they approach the exit is shown by the arrows, and it will be clearly seen than any pressure exerted by the stream coming in one direction is met and directly opposed by the stream coming from the other. The pressure exerted does not tend to force the people out, but causes a complete block—the more complete, the greater the pressure exerted. The danger is intensified when, as shown in the "circle" exit, those who have found their way through the doorway would in turn be forced against the opposite wall of the corridor. Here, then- as the records of disasters have proved only to often—lies the most serious source of danger, and the one to which attention must at first be directed.

THE SAFETY EXIT.

Diagram No. 3 shows the plan of an exit designed by the author, and described by him in a letter to the Christchurch *Press* in 1886, and again described (and the urgent necessity for reconstruction of theatre-exits shown) in the same paper in 1903; but so apathetic is the public, so regardless of the great danger are those whose duty it should be to understand the problem and to see that it is in all cases successfully solved, that no steps have as yet been taken to alter the dangerous state of all exits. Nothing less than the fearful loss of life at Chicago would have been able to stir to action those who hold the safety of the public in their keeping. Now that the public are aroused to the necessity for something being done, it is to be sincerely hoped that the efforts the public voice now demands will not be frittered away in useless and delusive so-called "precautions"; nor that the public will allow themselves to be misled by the criminal assurances of actors and actor-managers that our New Zealand theatres, or any theatres constructed on the old methods, are safe. An actor, as such, is no more an authority upon the principles of theatre-construction than any of his auditors. The Press, therefore, are as much justified in seeking and quoting their opinions as those of "eminent authorities" as they would be in regarding every well-known preacher as an eminent authority in ecclesiastical art. If existing buildings could not very easily be made very much safer than at present, it might be well to allow the misleading assurances to do their work of supporting a do-nothing policy and of allaying public anxiety in the matter. But this matter of forming exits—which for easy reference I have named the "safety exit"—as can be seen by the diagram, is so simple, can be so easily applied to any existing opening, that public opinion should be most certainly led to demand its introduction, and such other necessary alterations to be made, before the buildings are licensed for public use. The design is purposely not patented, in order that every one may be free to apply it, or modifications of it, wherever a study of the conditions would prove it to be of service.

The invention consists in eliminating all resistance to outward progress by means of curved solid dwarf partitions, which must be at least shoulder-high—that is, about 4 ft. 6 in. They may be constructed of any material, but must be permanently and strongly fixed, and smooth on both sides. In the method of application shown in Diagram No. 3 it will be seen that the exit, whatever its width, is divided into three parts, the outer ones equal in width to that of the passages at the end of the seats, and the central opening proportionate to the number of people using it. By the use of this simple device any tendency to pressure at the exit by people behind pushing those in front would there being no resistance from opposing forces only tend to hurry the audience more quickly into the street. Where there is a change of direction there must of necessity be some resistance, but if the change of direction is made against a smooth curved surface the minimum amount of resistance is offered. This well-known law of hydrostatics applies equally to a stream of people as to a stream of water.

Diagram No. 5 shows another application of the screen by which it will be seen that it can be applied with equal success to several exits from one passage, the people being divided into as many groups as there are exits. This is most important in all cases, for the first impulse of every one at the time of imagined danger is to rush from their seats towards the entrance from which they approached them. This makes it perfectly clear that *the usual entrances must be the exits*, and that safety does not in any way depend upon any special so-called "escape-doors." These are in the great majority of cases simply delusions, and every theatre or other place of entertainment should be so planned that any further exits than the usual entrances are not needed. Every entrance should also be a "safety exit," and should be carefully calculated for the number of people occupying that portion of the house to which it leads. The communication between every separate portion of the auditorium must in all cases be free and uninterrupted from the seats to the street. The people from one corridor of communication must on no account be allowed to enter others. Each entrance and exit must be perfectly independent of all others. This *division of audience into groups* will very largely minimise the dangers of panic if, as stated, each group has its separate entrance and exit. Much more is needed than the usual division into "dress circle," "stalls," and "pit." Each part of the house should have at least two entrances and exits, and admission to them should be by specially marked and different coloured tickets, corresponding to the marking of the entrance and exit. Thus, for instance, one portion of the dress circle would be entered by "Entrance A," white ticket; the other portion by "Entrance B," blue ticket; and so on for all other entrances, each being proportioned exactly to the number of seats in that portion of the auditorium to which it gives access. The subdivisions of the different parts of the auditorium need not and, indeed, should not be divided by any form of barrier, for should one exit get blocked or become from any cause unavailable the other should be free of access to all in that portion of the theatre or hall.

It will be seen that the purpose aimed at—viz., that each portion of the audience shall leave by the exit provided for it—will be achieved without structural subdivisions (if the above arrangements are carried out), by reflecting that the entrance, consciously or unconsciously, will be fixed in the mind as the place of exit first, because, that portion of the audience having entered by it, it is better known to them than any other; second, because it would be the exit nearest of access: third, because, if properly arranged, it would be the only exit they could approach without inconvenience—*i.e.*, without resistance. The usual method of allowing large portions of an audience, sometimes even the whole audience, to enter by a single entrance can at once be seen to be a fatal mistake. That the scheme necessitates a greater number of doorkeepers should under no circumstances be allowed to weigh against its adoption. The greater number who would attend places of amusement if made safe would more than repay the management for the slight extra expense incurred.

The building should be detached. The perfect planning of entrances and exits can be achieved only when the building is detached on at least three sides, and has a sufficient space around it to prevent any chance of blocking. These spaces or streets should be kept free of vehicles during a performance, to allow of a free rush from the building at any moment. A great source of danger exists in allowing carriages to stand opposite, and only a few feet distant from, the only means of egress. The spaces all round the building should be brilliantly lighted, and should be at the floor-level; for in leaving a brilliantly lighted building people always hesitate and slacken their pace if it is difficult to see where they are going, and steps outside the exits or gutters close to them are a serious source of danger which should never be allowed to exist.

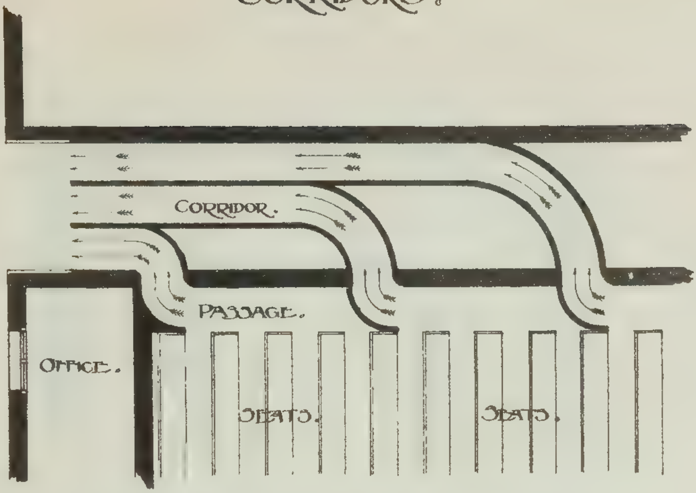
Although not absolutely necessary for safety, it would be a great convenience if provision were always made for those using conveyances to reach them without interfering with the flow of pedestrians. A method of effecting this is shown in Diagram No. 5, which would be suitable under certain conditions. Other methods have been designed for English and Continental theatres and halls, but all that is here necessary is to draw attention to the desirableness of some such provision being made wherever possible.

CORRIDORS.

From the principles already stated in regard to exits, it will be seen that all corridors must follow the same law—that is, that all the walls must be perfectly smooth up to the height of the shoulder, and all change of direction effected by curved surfaces. Any projecting pilasters, mouldings, and angles should on no account be permitted below 5 ft. 6 in. or 6 ft. from the floor-line; above this height they may be as broken and elaborately enriched as desired. This rule should apply to all parts of the building. The placing of sharp angles and projecting mouldings in such positions that they are a

CORRIDORS.

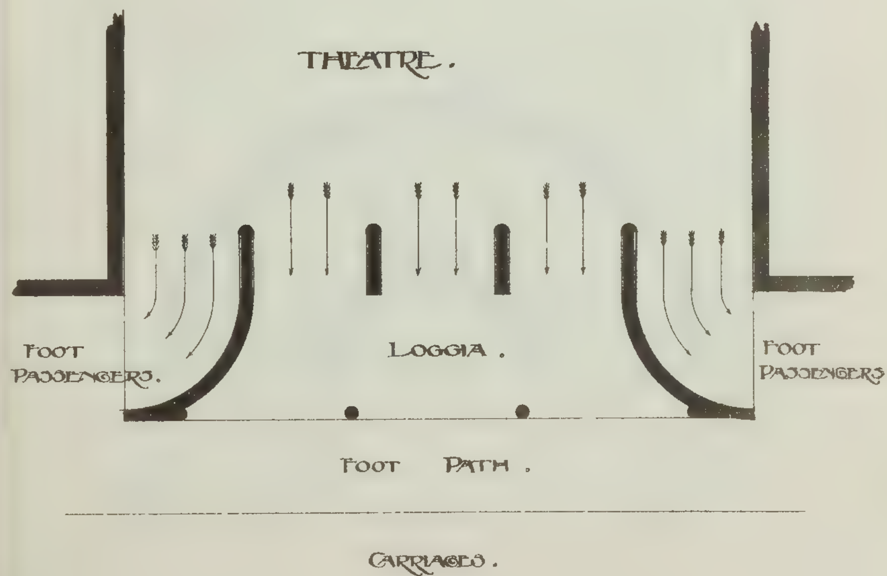
5.



PLAN SHEWING ARRANGEMENT OF EXITS INTO CORRIDOR TO AVOID CRUSHING.

6.

PLAN SHEWING METHOD OF PREVENTING CRUSHING AT ENTRANCES.



STAIRS. 7.

PLAN OF STAIRS AS RECOMMENDED BY. LONDON COUNTY COUNCIL.

STRAIGHT SHORT FLIGHTS AND QUARTER LANDINGS.

STAIRS 8.

PLAN OF STAIRS HAVING EVEN TREADS. THROUGHOUT. & SERVICE STAIR IN DRUM.

source of danger only needs to be referred to to be condemned, yet such are to be seen continually in places of entertainment in all parts of the world.

The width of the corridors -which must be proportioned to the number of people using them -must be even throughout. The doorway must be of the same width as the corridor, and the doors must be perfectly smooth on the inside, for when opened outwards they become part of the wall of the corridor, as shown in Diagram No. 5. To permit any contraction of the corridor by the reduced size of doorway is to rob the corridor of at least half its efficiency. A corridor which is the width of the doorway say, 4 ft. wide would, for instance, be very much more effective than a corridor 7 ft. or 8 ft. wide reduced to 4 ft. by the doorway; for in the one case there is no resistance, and in the other the resistance would be considerable. The resistance, and therefore the danger, increases in proportion as the width of the corridor exceeds that of the outlet, or any other contracted portion. If any exit from the auditorium does not open directly to the street or open space, then there must be a separate corridor leading from it to the street connected to that exit only. This is most important, for it is clear that, if a corridor is already filled with the people from one exit, those from another exit opening into it could not possibly enter without crushing, and therefore—as shown at A in Diagram No. 4 preventing free egress. Such extra exits, then, are not only useless, but are a source of danger wherever introduced. The division of any existing corridor, as shown in Diagram No. 5, by strong smooth partitions at least 4 ft. 6 in. high will render the exits safe by providing in this way for a separate and uninterrupted corridor to the street.

In the by-laws of the London County Council the minimum width demanded is 4 ft. 6 in. for a corridor for the use of not more than 400 people. This is not regarded by experts as wide enough; 6 ft. may be taken as a safe minimum if properly planned.

Sliding-doors into corridors should never be permitted, nor should doors ever be hung in such a way as to impede the flow of people. It will be seen in Diagram No. 4, at B, that by such an arrangement it is impossible to hang the doors with safety. They can be hung to open safely back against the barriers if the corridor is divided as shown in Diagram No. 5. Curtains should never be permitted at doorways, as being likely in a crush to be pulled down, and encumber the feet of persons rushing out.

It must be clearly understood that the arrangement of exits shown in Diagram No. 5 is not put forward as being a good method for a new building, but only as a method of making safe such corridors where they now exist; for No. 4 shows a very usual arrangement, and therefore its defects and dangers cannot be too strongly emphasized.

STAIRS.

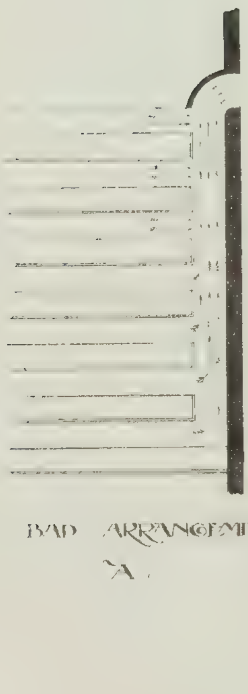
Staircases—as corridors—must be of even width and have curved surfaces; for, although the London County Council rules do not prohibit angular turnings, enough has been said to show, I hope, very clearly that they should on no account be permitted. The steps must be uniform throughout—that is to say, all the steps must be of equal height (not greater than 6 in.) and of equal width (not less than 11 in.), and all flights should contain the same number of steps, each flight containing not more than twelve steps, for an irregular number would lead to great hesitancy, and would thus retard progress. It must be remembered that in a crush people are unable to see the steps, and thus any inequality is dangerous. Great inequality—such as the use of some straight flights, some winding steps, and all of different lengths, as are now seen in the great majority of places of amusement—is highly dangerous, and should therefore not be tolerated for a moment.

Each staircase must be kept for the sole use of one group of people, as stated for corridors—*i.e.*, there must be no other openings to it than the one entrance and exit for which it is designed. If in any present structure more than one exit opens to any staircase, then the stairs must be divided by barriers, as already stated for corridors. If they cannot be so divided, then one or other of the exits must be closed, and fresh provision made for it.

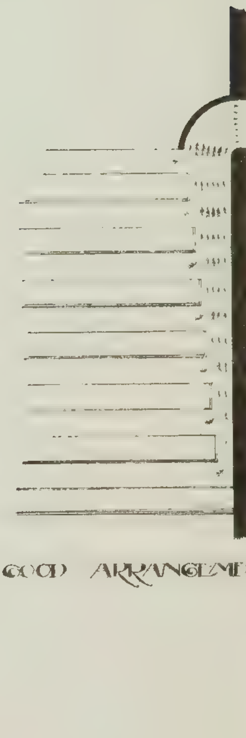
Diagram No. 7 shows the form of stair permitted by the London County Council, and shows also how it may be improved by the curved surface on the landing; but I am firmly of the opinion that a stair of the form shown in Diagram No. 8 is more safe, in that any one can run from top to bottom of the flight without the check that the right-angled turns on landings give. Such a stair could be used with the confidence created by a knowledge of the fact that there is no obstacle to beware of. Any one who has used this form of stair must have realised how easy it is, and how little liable it would be to cause a block; whereas, on the other hand, every one must have experienced the shock caused by miscalculating the number of steps in short flights.

Long straight flights are dangerous from the risk of loss of life should any one fall. The risk is practically just as great, or greater, in the case of short flights, but it is not so apparent, and therefore the danger, not being evident, is safely passed; but to stand at the top of a very long straight

PASSAGE WAYS AT ENDS OF SEATS.



BAD ARRANGEMENT.
"A".



GOOD ARRANGEMENT

flight is to realise that we are at a far greater height from the ground than heights to which we have become accustomed, and the fear of falling at once arises, and leads to the disaster it is wished to avoid. In curved stairs —as shown in Diagram No. 8—where the narrowest part has a minimum safe tread, it is impossible from any point to see further than the descent contained within half the circle, and the fear of falling is therefore not created, and greater safety is insured.

SEATS AND PASSAGE-WAYS.

Seats should always be very firmly fixed, and be a sufficient distance apart to enable people to easily pass between the rows. Loose chairs are a very great source of danger, for, as can be seen after any entertainment where they are used, people in leaving push them in all directions. If a panic occurred, the whole floor would immediately be covered with a hopeless entanglement of chairs and people. Halls used for a variety of purposes must of necessity have movable seats, but they should be forms rather than chairs, or, if chairs, they should be firmly secured together in the rows, and in either case they must be firmly screwed to the floor. This is of the utmost importance; so also is the arrangement of passage-ways at the ends of the rows. The London County Council's rules simply demand that there shall be at the end of the seats a 3 ft. way, without any reference to the length of the way or the length of the rows of seats opening on to it. This is a most serious omission, for a glance at Diagram No. 9, B, will at once show that the passage-way must, to be safe, increase in width in proportion to the number of the rows of seats. It should increase at least 6 in. for each row—that is the minimum; 9 in. would be better.

The corridor to which the passage-way leads should, of course, be equal in width to the widest part. No. 9, A, shows that with passage-ways as usually formed the majority of the audience are prevented free egress by the blocking of the ends of the rows.

Enough, I think, has been said to enable any intelligent layman to grasp the fundamental principles on which the safety of the public depends —to show that in the past the principles have either not been understood or else entirely ignored, and that there is a most urgent necessity for immediate action being taken to prevent a repetition of the fatal catastrophes which have already occurred.

No. 6. THE ECONOMIC ASPECT OF TASMANIAN FORESTS.

By Alexander North, F.R V.I.A.

Should it ever be the experience of an open-minded inquirer not personally conversant with the commercial value of Tasmanian timber resources to listen first to a glowing and optimistic dissertation by some enthusiast on the value, capabilities, and possibilities of our forest wealth, and then to hear some practical and prosaic member of the building fraternity roundly denounce the valueless character of our native timbers, I am afraid such fair and unbiassed truth-seeker would go away with the conviction that where doctors differed so radically it was certainly not his particular duty to decide. As a matter of fact, there would be more than a grain of truth in each statement; for the two men view the matter from entirely different standpoints. The one bases his facts from a few particular trees in a particular part of a particular forest; the other judges the matter by what he can purchase from the nearest timber-merchant. On the main question I think there can be no difference of opinion; and, whilst I recognise that Tasmania is a land of forests containing many valuable trees, I cannot admit that the forests of Tasmania are, as a whole, commercially speaking, valuable. Our forests contain some of the finest specimens of the vegetable kingdom, as well as some of the most unique and beautiful; but when we come to such questions as their ability to supply our own internal wants, their practical utility, their capability of supporting large export trade, and their actual value as compared with the forests of Europe or America, I am afraid that the outlook would be far from satisfactory.

Considering the extent of Tasmanian forests, their monetary value should be enormous. Yet does any scramble for timber concessions exist? Does anybody imagine that it ever will exist? Does any one believe that our forests are worth the ground they occupy, or that, if the timber they contain was offered for sale on the markets of the world, an offer would be received at all commensurate in value with the quantity of the wood which is growing in them?

Being an architect by profession, and having had twenty years' practical experience with the use of Tasmanian timbers, I am compelled to testify that they do not completely satisfy all architectural needs, but lack a certain fitness for building purposes generally. Launceston contractors know that I have always been a firm friend to Tasmanian timbers, and that I have invariably advocated their use wherever practicable. Unfortunately there are only too many instances where their employment would be neither an advantage to the building nor a credit to our natural resources.

The timber-producing trees of our forests mainly belong to one family, and there is great generic similarity in their productions and the uses to which they may legitimately be put. The wants of civilised man are multifarious; not so the commercial trees of the Tasmanian forest, where the great eucalypt family reigns supreme. These trees clothe plain and mountain, sheltered valley and bleak hillside; they climb to alpine heights, and defy the salt spray of the coast; they grow on stiff clay and fissured rock, undrained swamps and barren sand. It is, indeed, a difficult thing to get out of the sight of a gum-tree in Tasmania. Yet it is only certain species, grown under certain conditions, which produce commercial timber. The timber of these trees is largely used for carpentry, but scarcely ever for joiner's work. Even for carpentry, in our better-class buildings the employment of hardwood is abandoned in favour of imported pine.

The enormous size, weight, and bulkiness of eucalypts are not in their favour for practical commercial purposes, because they render the log expensive to handle in the bush, and, as their natural habitat is in broken and hilly country, the difficulty is thereby accentuated. Light pine logs, capable of producing planks of sufficient size for all practical purposes, could be handled at a fraction of the cost. Hardwood timber is of greater specific gravity than water, so that where rivers or streams exist they cannot be employed for floating lumber to a market. The wood is so hard that the desire for cutting it green is obvious, and, for the matter of that, also putting it in buildings before it is seasoned. Any amateur can testify that the sawing of dry hardwood is not a matter to be lightly undertaken, and that it is not every nail which sinks in a balk of well-matured timber, no matter how scientifically driven.

Then there comes the question of shrinkage—which is enormous—unsightly gum-veins, unevenness of colour, ugly gapings, and, above all, the erratic manner in which the timber will warp and twist.

Tasmanian hardwood is not classified on the local market. Indeed, such a course would not be easy, for the varieties are numerous and run into one another. Even botanists have not settled all points. Besides this, some species will differ materially, according to the soil and conditions under which they have been grown, or the age or season at which they are felled. Consequently a purchaser can never be sure that two planks he may purchase will be alike.

I have a great liking for well-matured stringybark, grown under suitable conditions of soil and climate, for high-class joiner's work. But, strange as it may seem, the cost of selection and working is so great that the price is prohibitive except in exceptional circumstances. Only a short time back I had a practical illustration, when alternative tenders were invited for certain work, and it was found that well-seasoned hardwood cost much more than pine, as much as American oak, and almost as much as the best English oak. The reason of this is not far to seek, as one peculiar feature connected with the seasoning of Tasmanian eucalyptus timber is that the wood must be seasoned in scantlings very nearly representing the size of the finished product, otherwise the material is useless for high-class joinery. This is a very serious obstacle to the employment of Tasmanian hardwood for anything except rough carpentry, as it is manifestly impossible for merchants to stock dry wood of all scantlings that may be needed. It is impossible to purchase dry Tasmanian hardwood except in a few isolated sizes, such as that required for floorboards and other special lines.

The trade term of "hardwood" is applied to all timber produced by the various members of the eucalyptus family, and the quality of timber marked under the name far exceeds in bulk the combined produce of all other Tasmanian trees.

The species which has the honour of producing the next largest bulk of timber is *Acacia melanoxylon*. This timber is marketed under the name of "blackwood," and, although when grown under some conditions the wood is of light colour, the bulk of the timber is dark, heavy in weight, and almost as hard as the produce of the eucalypt. Blackwood is largely used for ornamental joinery, and, although expensive to work, there can be no doubt but that it is a valuable timber. The most unfortunate circumstance connected with blackwoods is that they are not more numerous, and that a district becomes so very rapidly denuded of its marketable trees. These trees are not usually gregarious, but are scattered throughout our forests. Sometimes, it is true, they are found in considerable numbers in a given area, but this is not generally the case. I have known many instances where a few choice trees have been found, and some enterprising timber-getter has decided to market them, but I am sure practical men will believe me when I say that only too frequently, after the expenses of felling, clearing, road-making, sledging, carting, freight, and milling have been satisfied, the timber-getters have not earned current wages. I do not for one instant seek to depreciate the value of blackwood; I only desire to sweep away hallucinations and self-deceptions. This timber has a goodly reputation among our useful and ornamental woods, and rightly so;

but we must remember that the supply is not unlimited, and also, as I have already stated, that the cost of working renders it somewhat of a luxury even in Tasmania.

The valuable nature of those two conifers, *Dacrydium franklinii* and *Athrotaxis cupressoides*, known as "Huon" and "King William" pines respectively, is too well known to need any remark from me. Huon pine is perhaps the most durable soft wood in the world, and if the supply was unlimited there would be such a demand for this lumber as no other pine could equal. The celery-top pine (*Phyllocladus rhomboidalis*) would be another valuable timber if it could be produced in both bulk and quantity, but all these trees are confined to a few and restricted areas. As a matter of fact, a person might travel throughout the length and breadth of Tasmania in many directions without ever seeing a single indigenous conifer. Indeed, for all practical purposes their presence in Tasmania might be ignored when the economic value of our forest timbers is under discussion.

The Tasmanian beech (*Fagus cunninghamii*), locally known as "myrtle," is far more plentiful. It occurs in many sheltered forest valleys, and sometimes forms extensive forests. Although not a building-timber, there are many uses to which it can be properly put. For turnery, plain stocks, tool-handles, or, in fact, anything requiring a fine finish to the touch, it is excellent. Tasmanian beech may be as strong as English ash, but it does not possess the same qualities, for, whilst ash is one of the most elastic of all woods, beech is so brittle as to be unsuited for building purposes.

Concerning the balance of the fifty indigenous woods produced in the Tasmanian forests, they simply cannot be purchased in this or any other country. No doubt many of them would make attractive specimens for a national museum, or, if nicely got up, admirable examples for a show-case in the Agent-General's office; but let us be honest with ourselves, and admit that for practical commercial purposes they simply do not exist.

I do not think it is an act of friendship to advocate the use of Tasmanian timbers in cases where they have no natural fitness, neither do I think it wise to endow them with virtues they do not possess. Well-wishers of Tasmania, and those who desire to see her resources developed on sound business lines, should look the matter honestly and frankly in the face. If in our mistaken zeal we secure their employment in works for which they are not specially adapted, it will not be long before their unsuitability for that purpose becomes apparent. This means that their reputation will be impaired, and their chances of being employed in cases where no intrinsic unsuitability exists will be lessened. I am afraid that the uses to which our indigenous timbers can be profitably put are not extensive, and that their chances of being in high demand outside the limits of the Commonwealth are very remote.

Many of our woods are not without their special merits, and there are certain uses to which they can be put with greater advantage than timber of any other country. In spite of this, no large export trade has sprung up, and no great demand exists for our timbers on the markets of the Old World. So far as England is concerned, trade is unrestricted. She is one of the largest timber-importing countries, and searches for her supply in the most remote corners of the world. No doubt she would rather take wood from her colonies than from some unfriendly nation, yet her imports of timber from Tasmania are small, although we have frequently endeavoured to secure a larger share of trade. The reason, to me, seems obvious. Our timber cannot compete with the products of other countries except in highly specialised cases, nor can we supply it in commercial quantities. Let me take an instance. Supposing Huon pines were as plentiful as gum-trees, or blackwood trees as numerous as our wattles, does any one think we should have to canvass Europe for a market? If we possessed an adequate supply of timber having a high market value, speculators and brokers would be here quickly enough to solicit concessions; but all the pressing in the world will not persuade people to purchase an article for which they have no use.

By the courtesy of the State Collector of Customs, I am informed that the total value of timber exported from Tasmania during the year 1901 was £45,650, and that the total value of timber imported during that year was £30,155. From the returns of the previous year I find that the value of timber exported was £42,113. In this amount I include £2,155 for willows, which do not belong to the indigenous flora of the island. These figures, however, do not give an accurate idea of the relative values of exported and imported woods, because they are for unmanufactured timbers only. Our export of manufactured goods is practically *nil*, whilst for the one item alone during the year 1900 we imported furniture to the value of £19,195 5s. 2d., thus making our imports of timber, manufactured and unmanufactured, of greater value than our exports. In addition to this, there is a large import of timber architraves, doors, mouldings, skirtings, &c. All of those would certainly be manufactured in Tasmania if that State possessed appropriate timber. Tasmania also largely imports carriages, carriage-axles, shafts, spokes, naves, felloes, and poles, to say nothing of the almost endless number of articles made wholly or partially of wood, which are used for purposes of utility, adornment, or amusement.

When we consider that by far the greater portion of Tasmania is covered with forests we can scarcely consider this state of things to be satisfactory. I question if any country possesses a relatively greater proportion of forest land than Tasmania, and yet our imports of timber, manufactured and unmanufactured, exceed our exports. Not only do we annually send out of the colony a large sum for exotic timber, but we also yearly import a large amount of manufactured goods, which could be made equally well in Tasmania if we had the necessary woods. As time passes on this unsatisfactory state of things will be accentuated. We expect that our resources will be developed, and that our population will increase; so then will our requirements; and manufacturers will be sorely handicapped because they have not the materials they need growing in their own State.

It is perhaps needless for me to state that the bulk of our timber-export is to the adjoining States of the Australian Commonwealth.

It is almost a matter of daily occurrence with me to receive a request from some builder that he may be allowed to use imported timber in place of indigenous Tasmanian wood. Frequently the imported timber makes a far superior work, whilst economy has at the same time been effected. If, therefore, it is in some instances more profitable to employ imported soft woods in Tasmania than indigenous timber, how can we reasonably expect our wood to successfully compete with exotic products beyond the limits of the Commonwealth?

I have not the shadow of a doubt that nearly every wood we require could be profitably grown in Tasmania; indeed, I believe that had we exercised proper forethought we might now be exporting the same class of timber as it is necessary to import. The rapid diminution of the natural timber-producing forests of the world must eventually compel Tasmania to adopt measures similar to those now practised in almost every other civilised State. If she fails to avail herself of the assistance science has placed within her reach, she can hardly complain when outdistanced by more far-seeing rivals. I do not want to see Tasmania defer consideration of her possible forest resources until the inadequacy of the world's supply becomes painfully apparent, and local industries become severely handicapped by reason of the scarcity and increased cost of imported timbers. Afforestation on a large scale must necessarily be a matter of time, and, as economic timbers, such as do not grow naturally in Tasmania, are an indispensable adjunct to modern civilisation, they must either be grown on the spot or imported. Statistics tell us that foreign countries will not indefinitely continue to supply us with economic timbers at the favourable prices now ruling.

Still, even if absolute permanency of present supply and existing rates could be guaranteed, is it sound policy to continue purchasing an indispensable commodity from abroad which our own waste lands can produce in plenty? Let us make up our minds not to defer national action until matters reach an acute stage. Let us realise that now is the psychological moment for action, because trees require many years of growth before they produce the matured timber we need.

Much is talked about the expediency of developing our national resources, settling people on the land, and fostering native industry. Sylviculture is not the only question which should engross the thoughts of those who have undertaken to guide the ship of state, but it is of far greater national importance than many fleeting problems to which politicians have given undue prominence. In order to illustrate my meaning, let me make a quotation from the Victorian Forest Report of 1901 concerning the timber wealth of the United States of America: "According to the United States census of 1890, the estimated value of forest-produce in that year (in the United States) was over £200,000,000, the industries connected with the preparation and sale of timber, by-products, and manufactures of timber being second only to agriculture, and exceeding in value the products of mining by more than 50 per cent., while more than a million persons were employed directly or indirectly in connection with the former industries." The forest products of Tasmania should be one of the State's most tangible resources, for only thus can the greater part of her national estate be rendered productive. The planting, tending, and conversion of trees into timber would permanently settle many thousands of families on the land, and render many barren tracts fit for future cultivation, whilst many thousands more people would be employed at city industries now undreamt-of, because Tasmania would possess the raw material for manufacturing locally many articles she is now of necessity compelled to import. The formulation and realisation of any scheme which would thus so largely augment the population and increase the wealth-producing capacity of the island should produce an aspiration worthy of the creative ability of any statesman.

Belgium, although one of the smallest countries in Europe, and certainly the most densely populated, receives from 1,750,000 acres of forest land an annual revenue of £4,000,000 sterling. Tasmania has many million acres of forest land, but receives no such revenue. Two things are self-evident, either the class of timber grown in Belgium has a greater commercial value that grown here, or the trees are better suited to the soil and environment, and so produce a better crop. Distance from centres of population would not alone account for the high discrepancies in value, because we go further afield than even Belgium for our own requirements. Timber matures more rapidly in Tasmania than in Belgium, and it is scarcely necessary to tell the inhabitants of Launceston that the climate and conditions of Tasmania are almost ideal for timber-growing. We have seen tiny seedlings of both indigenous and exotic timber make trees of noble proportions in only a few years' time, so there can be nothing against the country as a timber-growing State. Our misfortune is that, with a few exceptions, our timber-trees have no great commercial value; secondly, that the land in many instances is not growing suitable trees.

It is a huge error to suppose that nature has always planted her trees in the places most favourable to their growth. Nature did not plant apples in Tasmania, peaches in Victoria, grapes in South Australia, or oranges at Paramatta; but she did plant gum-trees in many uncongenial parts of Tasmania, where they struggle to exist against adverse conditions, but never make timber-trees. It is easy enough to raise our hardwood trees from seed, but the result is not equally satisfactory so far as the production of timber is concerned. Indeed, our eucalypts are most exacting in their requirements, and only produce marketable timber under exceptional conditions. Yet it is more than probable that the very land which our native trees find so uncongenial would grow some exotic species to perfection. As a rule, the best timber is produced on land which is unsuited for agricultural purposes, and in more than one place in Tasmania I have seen exotic pines growing with luxuriance on sandy barrens, where our own majestic eucalypts refuse to develop beyond the proportions of mere shrubs. Trees, like other plants, do not always grow naturally in the places best suited for their development, but just spring up where their seeds chance to have been scattered. The seeds of pine-trees, and oaks, and kauris did not chance to find their way into Tasmania before the days of colonisation, consequently it is not surprising that Tasman failed to see them growing in our forests when first he visited Tasmania. The fact that certain timber-trees of ascertained high commercial value are not indigenous to Tasmania is no proof that they will not grow here as well as in their original habitat; perhaps they will thrive here better than in the spot where they were planted by nature, and produce timber of a size and quality hitherto unknown.

Froude was surprised at the increased size of the acorns he saw grown on the oak-trees in Victoria, and suggested the thought that they might be the ancestors of trees whose increased grandeur would eclipse the glories of Old-World oaks. The thought is poetic, and may be prophetic; but

Froude was not a botanist, and so may not be quoted as an authority on plant-life. Let me place before you some words of that eminent and accomplished botanist, Baron Von Mueller, who laboured so long, so faithfully, so loyally in the service of his adopted country, and whom almost every European State has honoured. It is true that Victoria has established plantations and woods of valuable exotic timbers at Mount Macedon and some other favoured centres, yet there seems something pathetic in the mingled warning and lament of the great botanist when he says, "When I largely shared in the labours of establishing for Australian trees a reputation abroad, I certainly did also entertain a hope to awaken here likewise a universal interest in the dissemination of an almost endless number of trees from the colder and subtropic girdles of the whole globe." [*Vide* Phil. Inst., 1858, pp. 93-109.] "A few scattered trees are of no national moment. We want the massive upgrowth of pitch-pines, just as in the pine barrens of the United States; we want whole forests of deal-pines, both cis- and trans-atlantic; we want over our mountains the silver-fir; we want the Australian red-cedar, scarcely any longer existing in its native haunts; we want the various elastic ash-trees which are so easily raised; we want the yarrah-tree; we want, indeed, no end of other trees. . . . But it would be vain to expect that Europe and America will continue for ever to furnish for us their timbers."

The question naturally asked is, will the timber of exotic trees be as valuable in Tasmania as that which the same tree would produce in its native habitat? That is a matter which actual tests alone can prove. No doubt the quality of some timber may deteriorate; but, on the other hand, it is equally possible that the lumber of other trees may be even superior. It is a well-known fact that the quality of soil even in the same latitude will, within certain limits, govern the commercial nature of the tree's product. As a rule, second-class or even poor land will yield a timber better in every respect than that grown in soil of great fertility. As we do not propose to afforest our rich land, we may take it for granted that the chances are altogether in favour of the lumber of foreign trees grown in Tasmania being equally as good as that raised in the forests of Europe or North America, because the conditions here are almost ideal for timber-growing. The South Australian Forest Department have lately cut down some trees of exotic pines and ash grown in that State, and experts speak in the most flattering terms of the quality of the timber. A few months ago I was able to secure logs from some exotic pines grown in Tasmania, and the timber looks all that could be desired. I have not yet cut up and worked any of the timber, as I wish to allow due time for seasoning. On two occasions I have had the pleasure of inspecting the wood of English oak grown in Tasmania, and, although the trees were cut before they had arrived at full maturity, I was delighted with the quality of the timber I saw. In my opinion, it was equal to anything which could, similarly, have been expected from an English-grown tree, and the flower or figure in the wood was certainly beyond the average in richness. I do not speak without experience, for I have carried out many works in English oak, as well as in its congeners of continental Europe and America. Only last week I was talking to one of the most experienced practical joiners in Tasmania on this subject. He told me that some years ago he cut and worked up an oak grown in Tasmania, and that, in his opinion, the timber was of good quality.

The commercial value of oak is well known, but perhaps few people are aware of the enormous sums which have occasionally been paid for single trees. One tree at Gelemos, Monmouthshire, brought its fortunate owner the small fortune of £870. The extraordinary sum realised for this tree is phenomenal, and must be regarded as a record price, obtained under exceptional circumstances. Some time ago, however, I came across the following interesting facts: A former forester of Lord Lyndoch, Mr. John Smeaton by name, lived to the ripe age of 102. One of his first duties after the care of the grounds attached to Balgowan House, Perthshire, were committed to his care was to plant out a number of oak-trees. Seventy to seventy-two years afterwards Mr. Smeaton had the good fortune to be present at the sale of these trees, and had the satisfaction of seeing them sold to purchasers as they stood in the ground at prices ranging from £65 to £70, the cost of cutting down and clearing away to be borne by the purchasers. It might be noticed that all of these trees thus earned their owner close upon £1 each for every year they stood upon his ground. This, of course, is the gross return, and allows nothing for interest upon capital or the cost of management; still, I doubt if any other crop would have given equal returns, especially as the land on which they were grown is stated to be of poor quality for agricultural purposes.

The fact that English oak commands a better price than Continental or American oak is no proof that England can grow better timber than these countries, because the English oak is produced by *Quercus robur*, whilst the American oak of commerce is the product of *Quercus alba*, or some other species. Even in England there is an oak-tree, the Durmast oak (*Quercus pubescens*), which produces an inferior timber. This tree is not common, but it occurs in the New Forest.

The many fine oak-trees which are scattered about Tasmania show that where favourable conditions and soil exist the tree will flourish amazingly. Oak-trees are more exacting in their requirements than pines, and it is almost necessary for the production of first-class timber that oak-trees should have a clay subsoil. The trees which are grown in this State have been planted for ornamental, not economic reasons, consequently they have been encouraged to branch and form a large mass of foliage instead of marketable timber. I call to mind one oak-tree I have often admired at Port Arthur, not as a specimen of good forestry, but as an object of enchanting beauty. I have made certain measurements of this tree, but as I have mislaid my notes I speak from memory. I think, however, I am correct in saying that the trunk is about 14 ft. in circumference at 5 ft. from the ground, and the spread of the branches about 60 ft. There can be no doubt whatever that nearly every commercial tree of the temperate zones will both grow and flourish in Tasmania.

It is only in exceptional instances that the forests which unaided nature plants are as valuable as those which are set and tended by the art of man. There should be no difficulty in convincing a scientific farmer that self-sown crops are usually inferior both in quality and quantity to those which are sown and cared for by the skilled agriculturist. A crop of spontaneously grown timber will command a lower price for precisely the same reasons. Where a natural growth of trees occurs only those species will be found whose seeds were by pure accident tossed on a patch of unoccupied ground. Under ordinary conditions similar trees will have been growing on the same soil for centuries, perhaps for ages. Scientific agriculturists tell us that there is usually a limit to the available plant-food a certain species will be able to abstract from a given area. Thus, no matter how available any habitat may once have been for the growth of a certain plant, the probabilities are that, given a sufficiently long period of occupancy by one species, total or partial exhaustion of the available plant-food needed must be the inevitable result.

It has frequently been noticed that after a great forest-fire in America a fresh growth has sprung up, consisting of trees of a different genus, sometimes of a quite distinct natural order. This is nature's rotation of crop; but America has more than its fair share of forest diversity, and the chances of natural rotation are considerably diminished in Tasmania, where a single genus claims the bulk of timber-trees.

A self-sown or badly tended farm crop may contain many weeds. A Tasmanian timber-getter knows only too well that our spontaneously grown forests frequently contain many weed trees. The timber-getter can no more than any other ordinary business-man afford to be entirely a philanthropist. Circumstances demand that he shall take the most marketable and best kinds, leaving the weeds to increase and multiply.

In a natural forest the seeds germinate where they fall or lie dormant. Such seedlings as are able continue to grow, the stronger, but not necessarily the better, timber-trees eventually strangling those that are less robust. They may be badly spaced and not occupy the whole ground, or they may be too close for ideal development as timber-producing agencies. They are probably of all ages and all stages of maturity, but just as the caprices of nature decided there they stand. Such is not a forest managed on commercial lines. In an ideal forest the trees are all of the same age, the timber of one species, equal maturity, and the same quality and value. A standard is thus realised, and its market value easily estimated. It might be advantageous to plant in sections, a new section being started in growth each season. The first section would naturally mature and could be cut first. Thus a continuous annual supply would be assured, and a certain staff of men secured in permanent employment. Probably it might be found more profitable to replant the denuded area with some other tree, thus insuring a scientific rotation.

Hitherto the natural spoils of the forest have been almost sufficient to supply the large demands of advancing civilisation, but the time draws near when timber must be regarded in the same light as that in which we regard any other economic crop. Is not the fact that our own large forests fail to satisfy the scanty requirements of our sparse population sufficient to force this aspect of the case on the people of Tasmania?

In a scientifically planted forest the ground should be entirely devoted to the production of marketable timber. The trees should not only be so spread about that the formation of useless branches and superabundant foliage is discouraged, and growth of large, straight, valuable boles insured, but they should cover and monopolize the whole surface, so that no other growth can find nourishment on the land.

Whilst it is necessary that the class of timber selected for growth should be valuable and readily marketable, it does not of necessity follow that the wood bringing the highest price per foot will give the best return. If the product of one species brings 6d. per foot, yet only produces 100 ft. of timber in the same space of time that another species will yield 200 ft. worth 4d. per foot, then the less valuable timber will be the more profitable crop of the two. It is therefore of paramount importance that the class of timber selected for growth shall be suited to the land on which it is to be planted, and if any exotic timber will give a more valuable return than trees indigenous to the State, then ordinary commercial prudence should induce us to decide in favour of what will be most profitable.

Although there can be no doubt but that a purely artificial forest planted and tended on scientific lines produces a larger, a more uniform, and a better class of timber than do woods of natural growth, yet we recognise the fact that it is not always practicable to plant out a forest in the same manner as that in which fruit-trees are set in a new orchard. A practical man will consider local conditions and environment, which makes one forest-site differ from another, and then be guided by the force of circumstances.

I can call to mind many suitable tracts of land in Tasmania, now practically valueless and bringing in no return, but which might be growing valuable crops of timber. In a paper of this description I cannot pretend to say how these lands should be afforested or with what class of trees they should be stocked, because local conditions vary to such a large extent that plantations which would undoubtedly be a distinct success in one place might not give satisfactory results in another locality.

Much as I desire to see Tasmanian woodlands stocked with more suitable timber than unaided nature has given them, I must add a word of caution to those who would commence operations without adequate knowledge of their self-imposed task. Forestry is a science, and if knowledge and good judgment are not employed the best results may not be expected. Ill-considered zeal may do more harm to a good cause than garrulous opposition. The conviction that a lamentable lack of knowledge does exist amongst farmers and landowners concerning the planting, rearing, and development of young trees has been again and again forced upon me. That such should be the case is scarcely a matter for surprise, for no examples of scientific forestry exist in this State, and therefore if a man's inclinations have not induced him to study the systems adopted in more progressive lands it is only natural that the spasmodic attempts at tree-planting occasionally made by Tasmanian landholders should so frequently result in depressing failures. I can recall to mind many instances in which I have been requested to supply choice timber-trees for planting purposes. In the majority of cases I have had the mortification to see these plants which I had propagated with so much care either killed outright or developed into stunted trees through injudicious management.

I desire that the Government of this State shall not only make a sufficient annual grant for the stocking of State forests with commercial timber, but also that they shall take steps to place sufficient information in the hands of those farmers and landowners who may wish to form private plantations. I am also of opinion that some teaching on elementary forestry should be given to all children attending country State schools, and that all teachers should be required to pass some test in this most important subject. I would like to see experimental plantations set out in the vicinity of the leading country towns, and, where possible, adjoining State schools. It would not be long before these plantations would be remunerative, whilst their educational effect would be invaluable. State nurseries for young trees should also be formed, and some inducement be afforded to those farmers who are willing to afforest their woodlands with suitable timber. In the adjoining States large numbers of trees are raised annually in the Government nurseries for public distribution, and in some cases a bonus is given to those landowners who afforest with trees of approved description. I have no desire to dogmatize concerning the methods to be employed for the improvement of our State forests; that should be left for the consideration of the Administration. I do, however, urge that some practical steps be taken; Ministers should receive the loyal support of members of Parliament, who, in their turn, ought to be backed up by a healthy and persistent public opinion.

It may be a difficult matter to convince pioneer farmers, who have been taught to regard timber as their natural enemy, that the product of Tasmania should be one of its greatest sources of wealth. A weed is simply a plant in a wrong place. Trees are not wanted on our best lands except for shelter purposes; an entire absence of timber even on our most fertile areas may be regarded as little short of a calamity. Still, even the forest settlers of Tasmania cannot fail to see that there are enormous areas in this island which will never profitably grow anything but timber, and I ask their influence so that valuable wood may be grown where now only weeds exist.

For many reasons it is desirable that the commercial forests should be largely in the hands of the Government, which would organize and work the reserves in the interests of the public. Obviously it is better that the whole country should benefit than an individual. Not but that individuals should be encouraged to add to the wealth of the land in which they live. If our forests may be made a source of future wealth—and I am convinced they can be—then in the interests of the public it is better that the country should benefit than an individual.

Further, there is a disinclination amongst individuals to invest in a crop—no matter how promising—which takes so long to mature as timber. The life of an individual is uncertain, but the State endures. Last week I submitted these remarks to a gentleman, who said, "I am so thoroughly convinced of the soundness of your arguments that if only I were younger I would go in for timber-growing, with the certain conviction that it was a safe and profitable investment." This feeling is prevalent among those whose thoughtfulness and experience have induced them to study the subject. If a man is not young he cannot personally expect to receive the profits of any timber-growing enterprise on which he may embark. Young men, as a rule, do not possess the opportunities. In some parts of France it is the custom to set out a small plantation on the birth of a child, so that when manhood is reached the profits of the timber may place the owner in the position of a capitalist. The French, too, have a proverb to the effect that a man lives his life over again in the life of his child. Surely these sentiments should induce those who look only for quick profits to pay some little regard to the welfare of their offspring. I like the proverb, it has a hopeful ring; but, if it contains any germ of truth so far as the individual is concerned, I think its argument is overpowering as applied to the duty—or shall I say the privilege?—of the State.

Section I.

SANITARY SCIENCE AND HYGIENE.

PRESIDENTIAL ADDRESS.

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(Delivered Thursday, 7th January, 1904.)

ON SOME HYGIENIC ASPECTS OF BORIC ACID.

I have never been quite able to feel that the infliction of a presidential address upon one's colleagues is an equitable way of thanking them for the honour of election as President. Nevertheless, I very highly appreciate the fact that I have been chosen to preside over the deliberations of this Section, and by way of cherishing the privileges of that position I must claim your indulgent patience whilst I try to discharge what is perhaps the most arduous duty of it.

Amongst the features by which the advancement of science has been signalised there is none that has been of greater benefit to humanity than the progress made in the branch represented by this Section. But, although much has been done in hygienic matters, there is still much to do, and the modern sanitarian is met by difficulties with which his predecessors had not to cope. It was their task to secure the remediation of flagrant sanitary defects, and the then limited scientific knowledge of their subject was entirely in their own keeping. Nowadays the matters to be dealt with are generally of less obvious urgency, and a widespread smattering of science permits plausibly supported contentions to be brought forward on behalf of vested interests. In no direction is this more evident or more to be regretted than in the matter of the adulteration of foods. The fact of having been "done" in the purchase of an "all-wool" garment which is half cotton, or in that of leather boots with soles largely composed of brown paper, may not be a serious matter; but no thoughtful man can realise with equanimity that his children are regularly exposed to the operation of mysterious concoctions sold as "pure raspberry jam," and of chemical mixtures labelled "genuine lemon squash." The loss of food-value which these "substitutions" involve is not compensated for by the covering of a "trade name," but this, supported by pseudo-scientific evidence, renders it possible to continue the imposition with impunity. But of all the matters of this kind with which the hygienist has to battle, the resistance is perhaps greatest with respect to the addition of so-called "preservatives" to food, and of the various chemicals which fall under this designation there is none more important than boric acid. Its harmless reputation, its comparative tastelessness, and its low cost combine to render this drug particularly suitable for such use. Notwithstanding its pretty universal condemnation by hygienists, the magisterial mind is frequently overborne by specious arguments in its favour, which, it must be confessed, cannot all be clearly refuted. Very often the prosecution fails by reason of the case being presented upon the too-narrow basis of immediate or gross injury to health. It is by way of directing attention to some other aspects that should be kept in view that I have selected the matter for the subject of this address. We may for our purpose very well concentrate our discussion upon the well-known use of the drug in milk.

The first aspect which invites attention is whether or not the addition of boric acid to milk is likely to involve injury to the health of persons who consume such milk.

As regards the physiological action of boric acid generally, there is, indeed, plenty of evidence. The subject has been many times experimentally investigated by observations upon animals, including human beings; it has been examined with respect to its influence upon the action of digestive enzymes; and we have, besides, the recorded experience of physicians as to its medicinal use. The results of the different sets of observations have been variously interpreted, but upon one point there is entire agreement. It is quite certain that boric acid is not a harmless drug; it can cause injury to health. But, that point being conceded, we have still to inquire if ill effects may be expected to result from its use as a preservative for milk.

It is generally assumed that as applied to this purpose the drug is added only in small quantities, and consequently the amount of it which would be ingested by consumers is too small to cause injury. As will be mentioned directly, observations indicate that, so far as the climate of Sydney is concerned, the amount necessary to preserve milk—I use this term in its trade sense is certainly not less than 10 grains per pint for ordinary weather, and must be much higher during the warm season. I take it, therefore, that expectation of injury may be validly discussed upon a basis that efficiently preserved milk will contain 10 gr. of boric acid per pint. The average healthy adult will probably not consume more than ½ pint of milk per day; an ordinary infant will take, say, 1 pint per day, and an invalid upon a milk diet will take from 3 to 6 pints per day. If the milk given contained 10 gr. of boric acid per pint, the healthy adult would get 5 gr., the baby 10 gr., and the invalid from 30 gr. to 60 gr. of the drug per day. The dosage of boric acid authorised by the British Pharmacopœa (1898) is 5 gr. to 15 gr.; and, according to the usual custom of administering the drug three times a day, an adult would be given from 15 gr. to 45 gr. per day, and an infant from 1 gr. to 3 gr. per day. It will be seen that, with respect to the milk predicated above, whilst a healthy adult would receive no great amount of boric acid, an infant would get some three times the regular medicinal dose, and an adult invalid nearly or more than the amount authorised by the Pharmacopœa. As a matter of fact, boric acid is not commonly given to adults in quantities exceeding 30 gr. per day, and this amount would be taken by a patient on the hospital allowance of 3 pints of milk per day if it were boricised as above specified. In view of these considerations there appears to me to be no warrant for the assumption that the use of boric acid as a preservative in milk involves the ingestion of only small amounts of the drug. If used to any purpose it would be taken in even larger quantities by infants and invalids than would generally be the case if it were prescribed as medicine by a physician

It has still to be considered whether even in these amounts boric acid would be likely to cause injury. I find from the scrutiny of available records that on several occasions the drug has displayed its toxicity in the case of patients taking 30 gr. of it per day. The details show clearly that the effects were due to the boric acid, and not to the complaints from which the patients were suffering. I have recently come across a reference* to the effects following the use of boric acid in the treatment of adiposity. There was nothing the matter with the subjects except that they were fat people, and their diet and usual mode of life were not interfered with in any way save as regards the administration of boric acid. In four of the six cases the treatment had to be abandoned owing to the disturbance of health caused by the drug. In these cases the dosage was 15 gr. to 22½ gr. per day. From conferences with medical friends I have been led to believe that intolerance to boric acid in ordinary medicinal doses (30 gr. per day) is by no means as uncommon as is generally supposed. On account of these facts, I take it one may regard

* "Treatment," Vol. vii., 1903, p. vii.

20 gr. to 30 gr. per day as an amount which may cause injury; it has done so in the past, and hence may do so again. By consequence an invalid on the milk above mentioned is getting enough boric acid to expose him to the risk of injury from it. Presumably infants fed upon this milk would be still more liable to suffer.

Notwithstanding that the foregoing considerations clearly display a tendency in that direction, it has still to be finally determined how far boricised milk is actually responsible for ill effects. Upon this point there is a dearth of information. So far as my personal inquiries have gone, although many authorities refer to the matter as a settled thing, I have been able to find but three instances in which such milk is explicitly asserted to have exercised what may be called an epidemic influence. Whilst there is, in so far, some positive evidence, one would have expected, at first sight at least, similar consequences to have been noticed more frequently than is here indicated. Hence before placing sole dependence on our records it is essential to inquire as to how far they may be looked upon as representing the facts of the case. Truly the paucity of recorded instances will not be regarded by those accustomed to epidemiological investigations as adequate testimony that such milk does not more often cause injury. The data available resulted from more or less accidental discovery; there may be other instances of the same kind which escaped observation, or were assigned to other than their real cause. For it must be remembered that the minor degrees of interference with health due to boric acid would very rarely, if ever, be seen by a medical man. The more marked, but still moderate, degrees of gastro-intestinal disturbance, or even the skin-eruptions, which might be produced by boric acid in milk would not often be so distinctive in character as to direct a physician's attention to their dependence upon anything other than some one of the many common causes of these familiar complaints. Consequently the ordinary course of medical practice will rarely contain events likely to induce a physician to incriminate boric acid. The usual stay of patients in hospitals is too short for untoward symptoms to reveal themselves in epidemic fashion, so that even here no clue would be afforded. In other institutions, as asylums or poorhouses, where the inmates remain for long periods, there is obviously more chance of their being displayed, but it is precisely in such places that on the one hand less attention would be given to the matter, and on the other hand the milk-supply would be specially arranged for, perhaps specially scrutinised, and would be thus less likely to contain boric acid. I need scarcely point out that valid epidemiological data are seldom obtained unless the facts are collected and analysed by special effort, and, as regards boric acid, this, so far as I am aware, has not hitherto been done. It is, indeed, questionable whether, even if done, it would be of much assistance in the case of the matter under review, for it must be confessed candidly that we are not yet in a position to determine the extent of injury which may be produced by boric acid. We have become acquainted with certain gross disorders occasioned by it, but our knowledge is defective as to any finer changes. Several other drugs *e.g.*, alcohol, lead, arsenic, opium, &c. in ordinary doses exhibit no more toxicity than boric acid as a matter of immediately discernible effect, but we know perfectly well that they cause very material, and it may be irreparable, injury as the result of prolonged action on the tissues of the body. It is to be noted that indications are not wanting with respect to something of this kind in the case of boric acid. As a foreign substance its absorption must be and is followed by its elimination, and it has been ascertained that this is not effected without interference with the renal functions. Increase in the amount of urine, followed by diminution, the occurrence of albuminuria, and even of hæmaturea, have been observed in patients taking this drug. There is thus the suggestion, at least, that if boric acid be taken continuously, as it would be if regularly added to the daily milk, its long-continued irritation of the kidneys might end in their becoming permanently damaged. With the kidneys doubtless other organs would also suffer, but as regards the kidneys, at all events, the position is not altogether hypothetical. The significance of this point is that a physician may meet with conditions really due to boric acid, but which he would not attribute to that drug. In view of these various considerations it is not surprising to find large blanks in the evidence upon what I have called the epidemiological side of boric acid in milk. Hence, while the recorded observations of injury from the drug under these conditions are admittedly few, it cannot rationally be maintained that they are representative of actual occurrences.

In what I have said above I have endeavoured to submit to you a summary review of the principal lines of the evidence known to me with respect to the toxicology of boric acid. I must say, for my own part, I have never been able to clearly gauge the potentiality for evil of this kind which is involved in the addition of the drug to milk. But that it would be injurious to some extent I see no good reason to doubt. Bearing in mind the unknown possibilities of its long-continued contact with the bodily tissues, and the fact that the milk would be given to infants as well as to older persons, the addition of boric acid to such a widely used article of diet must, I think, be regarded as extremely injudicious, to say the least of it. Prudential considerations demand the condemnation of this practice from the toxicological point of view alone. But this is only one of the aspects from which the hygienist must regard the subject ; there are several others which equally merit his attention.

Boric acid is added to milk by the trader, hence presumably for his benefit. It is as well to inquire what he hopes to gain by it, and what his action in the matter really involves. For this purpose it is necessary to direct attention to the bacteriological condition of natural and of boricised milks.

Sooner or later, under ordinary circumstances, natural milk undergoes the souring and curdling familiar to all housewives. So far as my observations made in Sydney furnish a guide, it would appear that milk kept under the same conditions as in an ordinary house begins to get acid in seven or eight hours after collection. The morning's milk was observed to give an acid reaction with litmus when tested at noon, having previously been neutral or amphoteric. By 5 o'clock in the afternoon it was usually strongly acid, and sometimes slightly sour. On the following morning the milks were either decidedly sour or were curdled, and in any case were curdled by the next morning. The curdled milks remained apparently unchanged for a day or two; but it has been observed that the strongly acid reaction which they at first possessed gradually became reduced, and in the course of a few more days they began to undergo putrid decomposition. The periods given are, of course, merely representative; the changes occur more slowly in cold weather and more rapidly in hot weather. The souring is due to the conversion of milk sugar or lactose into lactic acid by the agency of bacteria the lactic bacteria. The curdling is a purely chemical effect, and occurs when the lactic acid is formed in sufficient quantity to precipitate the caseinogen of milk. The cause of the subsequent reduction of acidity has not been accurately determined, but may be due to the action of moulds which make their appearance in the milk at this period (*vide* Tissier et Gasching, "Recherches sur la Fermentation du Lait," Ann. Inst. Past., xvii., 1903, p. 540). The ultimate putrefaction is due to the operation of ordinary saprophytic bacteria. It thus appears that the dissolution of milk, like that of other organic materials, is accomplished by a succession of changes, each due to particular groups of micro-organisms (lactic bacteria, moulds, putrefactive bacteria). At the time it leaves the udder milk does not, or does not usually, contain representatives of any of these micro-organisms. But lactic and putrefactive bacteria get into it with the milk-dirt during the process of milking; their universal occurrence in the surroundings of the milking-pail insures their almost inevitable presence in the milk. Moulds perhaps also enter the milk at this time as well as later, when they, together with further putrefactive bacteria, reach it from the air of houses, &c., to which the milk is exposed. The striking general fact with respect to the decomposition of milk is that, notwithstanding that both lactic and putrefactive bacteria reach the milk at the same time, the lactic changes (souring and curdling) invariably precede putrefaction; and, indeed, this latter, as above stated, does not usually occur until some days after the milk has curdled. This feature is dependent upon the special behaviour of the lactic bacteria in milk.

The lactic bacteria are not necessarily nor usually more numerous than putrefactive bacteria in recently drawn milk, and after a period of quiescence both kinds begin to multiply. But the conditions existing in milk are so much more suitable to the needs of the lactic bacteria as to exercise a selective influence and permit their development out of all proportion to the putrefactive species present. Very soon their production of lactic acid further aids their attainment of supremacy, the presence of acid being unfavourable to the growth of most putrefactive species. In the end the lactic bacteria may acquire almost exclusive possession of the medium. "So vigorous are they," says a recent writer upon the subject, "that not only do their actual numbers increase rapidly, but they seem to exercise a checking action upon other bacteria. Their percentage increases, at first, because they grow more rapidly than any other species, but eventually because the other species actually decrease in numbers. Some of the other types disappear, whilst others remain alive but without further growth. . . . By the time the milk has distinctly soured the lactic bacteria may be 70 per cent. of the whole, and later, when it curdles, they frequently comprise over 90 per cent., sometimes 99 per cent., of all bacteria present."* The increase in the numbers of lactic bacteria and in the production of lactic acid may continue for a time after the milk has curdled, but sooner or later the process stops. Smothered, so to speak, by their own product (as yeast is by alcohol), the lactic bacteria cease growing and die out, an event which is marked by a decrease in the numbers of bacteria in the curdled milk. During or towards the end of the lactic period moulds make their appearance in the curdled milk. They are not affected by the acid reaction of the medium, and flourish in such abundance as frequently to obscure culture-plates and prevent enumeration of the bacterial colonies. As already suggested,

* W. H. Conn, "Bacteria in Milk and its Products," p. 105.

they may be influential in the reduction of the acidity of the curdled milk.

As just indicated, the putrefactive bacteria have been under restraint during the lactic period. No doubt some of them have succumbed, but some survive, and the only remaining impediment to their growth is the acidity of the medium. This in itself does not entirely inhibit the growth of all putrefactive species, but it does interfere with many of them, and thus opposes a barrier to rapid and complete putrefaction. When the acidity becomes reduced the survivors of the lactic action multiply more rapidly, and their increase, reinforced no doubt by kindred bacteria getting in from the air, is indicated by a steady rise in the numbers of bacteria in the milk. Their further progress is the ordinary course of putrefaction.

The early predominance of the lactic bacteria, and their influence in checking putrefactive changes, is a matter upon which considerable stress is laid by most modern writers. For instance, Conn says, "The lactic bacteria are the milk bacteria *par excellence*, not because they are the most common around the dairy, but because, of all species of bacteria, they seem to be best adapted to a life in milk, and capable, in ordinary milk, of taking possession of the milk to the more or less final exclusion of other types of micro-organisms. Though other species have the start of them at first, the lactic organisms soon overtake the others, surpass them in influence, and finally cut off the action of other types of bacteria. The lactic organisms may therefore be looked upon as protecting the milk from the action of other bacteria."* The same view is expressed in recent papers by European authors. Thus Gustav Schweitzer says (July, 1903), "In der Milch wird durch die Gegenwart der zucherhaltigen Kohlehydrate das Wachstum von Spaltpilzen geforördert welche in diesen Kohlehydraten den ihnen zusagenen Nährboden finden. Sie greifen mit Vorliebe diese leicht veränderlichen stoffe au un schwächen als antagonisten die peptonisierenden und Faulnis produzierenden Bacterien in ihrer Entwicklung und hemmen ihr Wachstum vollstandig."† In referring to the same point, Tissier and Gasching remark (August, 1903), "Les ferments protéolytiques - subtilis, mesentericus, putrificus — subiront eux aussi l'action empechante de l'acide. Leur diastase trypsique ne peut plus agir sur la caseine. Ils tendent a disparaitre et donnent des spores."* The observations that I have personally made on this subject are in accord with

* "Bacteria in Milk and its Products," 1903, p. 107.

† "Milchhygienische Studien," Centralblatt für Bacteriologie, Zweite Abtheilung, Bd. x., s. 501.

‡ "Recherches sur la Fermentation du Lait," Annales de l'Institut Pasteur, Tome xvii., p. 557.

these views, and I have no reason to doubt their general accuracy. All the same, I have found some ground for thinking that when milk is kept in open vessels, such as the household jug, the period for which putrefaction is retarded is not always as long as the general statement would lead one to expect. In most of my observations the reduction in the numbers of bacteria after curdling was very pronounced, and putrefactive changes were not noted till the sixth day or later. In one instance the curdled milk was actually sterile for a period of two days, and there was no sign of putrefaction during the week it was kept under observation. But in other specimens the micro-organisms surviving the lactic action were still very numerous, and putrefaction was manifest on the third or fourth day. So that, although the lactic phase invariably preceded any other change in the milks, and most often exerted a very decided inhibition over other processes, there were instances in which its influence was comparatively slight. The early sequence of offensive changes suggests that putrefaction, albeit restrained, was nevertheless in progress to some extent during the period of lactic fermentation. The significance of this point is that, whilst neither sour nor curdled milk is harmful in itself, it may not always be free from certain less innocent products of incipient putrefaction, as, for instance, toxic albumoses or ptomaines. Perhaps the occurrence of so-called ptomaine poisoning from milk (galactoxismus) is dependent upon such an event. However, I take it that from a hygienic point of view we should consider that the natural curdling of milk indicates a period after which it may not be safely used as diet. It may indeed be looked upon as a warning of dangerous staleness, a warning that is the more valuable in that it is one which can scarcely be overlooked.

The effect of the addition of boric acid upon the natural changes of milk has not been much investigated. In what I have to say about it I am obliged to rely almost entirely upon my own observations. Whilst I believe these are sufficiently complete to justify the inferences I draw from them, I ask you to receive my statements with this reservation: that further researches may lead me to modify my views upon some of the details. But, so far as I know at present, my remarks are accurately representative of the facts.

I have not found boric acid in the proportion of 5 gr. per pint to materially alter the natural progress of events. In our ordinary cool weather 10 gr. per pint will delay souring and curdling for about twenty-four hours beyond the occurrence in these changes in the control unboricised sample of the same milk. In our hot summer weather it requires 20 gr. per pint, or even more, to effect the same purpose. With 35 gr. per pint I have not yet seen curdling within a week, this period being that to which I have hitherto limited my observations. But, although souring and curdling are deferred as stated, I have not observed a corresponding retardation of putrefactive changes. On the other hand, I have quite commonly noted a putrefactive taint in the milk upon the third day of observation, and in some cases even upon the second day; that is to say, earlier than in unboricised milks. Some of the boricised milks have been most decidedly putrid within the week, a condition which I have not observed in natural milks within the same period. I have only to say, further, that with amounts between 5 gr. and 35 gr. per pint the exact quantity did not materially influence the time of onset of putrefaction; it occurred as early in 35-grain samples as in 10-grain samples. These modifications of the natural changes of milk find their explanation in observations upon the bacteriology of the milks. I find, as in the case of natural milks, that in those boricised milks which do eventually curdle there is an increase in the number of bacteria up to the period of curdling, and then a decrease, and so on. But there is this difference: that the numbers of bacteria developing in the same time are very much higher in the boricised than in the unboricised control samples of the same milk. For instance, in examining the milks at the time the control curdles, I have found the boricised samples to contain from two to three times as many bacteria as the control. Coincidently I have noted that the acidity of the boricised samples is less than that of the control. It may be further noted that the decrease after curdling is less marked in boricised milks. I infer from these results that the effect of the boric acid has been either to restrain the development of the lactic bacteria, or to intervene between them and the conversion of lactose into lactic acid. This is one of the points upon which I reserve final decision pending further investigation of it. But, whatever be the precise *modus operandi*, the formation of lactic acid is delayed, and there is thus afforded to the putrefactive bacteria the chance of developing to an extent to which they would not otherwise attain. This circumstance reveals itself in the greater numbers of bacteria in the boricised milks and in their earlier entry into a state of putrefaction. In those boricised milks which do not curdle—*e.g.*, those containing 35 gr. per pint—the process is one of direct putrefaction. The lactose remains intact, for a time at least; there is no acid formation, and consequently the sequence of increase and decrease in the numbers of bacteria above described does not take place. From this review of the bacteriological aspect of the question it will be gathered that the principal effect of adding boric acid to milk is to delay souring and curdling. This, it is to be observed, answers the trader's purpose: he merely desires to prolong the period during which the milk will remain in a saleable condition. Viewed from the consumer's side, however, the practice not only has no advantage, but is vested with the capacity of causing mischief. It predisposes to putrefactive possibilities, and so tends to encourage the production of toxic bodies which are not likely to be present in natural milk. By doing away with the warning afforded by souring and curdling, it enables the trader to foist upon his customers a stale article, richly laden with objectionable bacteria, as if it were fresh and wholesome milk. That a trader should be allowed to make use of such a means of disguising the character of his wares is to be regarded, I imagine, as a very undesirable state of things.

A procedure reasonably suspected of being injurious, and clearly undesirable, must yet be tolerated if it can be shown to be unavoidable. It is therefore necessary to consider boricised milk from this aspect. There can be no question that the addition of boric acid is superfluous as regards the milk-supply of cities. In most European countries and in most of the American States its use is entirely prohibited, and stringent measures are taken to enforce compliance with this requirement. In any case, only a minority of traders resort to its use. At the present time in Sydney only about 4 per cent of the samples taken are found to be boricised. Evidently, as far as cities are concerned, the business can be and is conducted without boric acid. It is often suggested, however, that it serves a useful purpose as regards supplying milk for persons dwelling away from populous centres, or in the case of persons on board sea-going vessels. Setting aside the dubious point of the value of boric acid for such purposes, it is obvious that the persons referred to are not dependent upon boricised milk. There are other forms of preserved milk—condensed milk, frozen milk—free from boric acid, which can meet their wants. It seems needless to further dilate upon the unconvincing nature of the arguments that attempt to justify the addition of boric acid to milk on the plea of its necessity.

There is still one more aspect of boricised milk to which I would like to refer before closing this already lengthy address, and that is its moral aspect. Whether or not it be injurious, desirable, or necessary, boricised milk contains an ingredient foreign to its normal composition. In that it does so it is not of the "nature, substance, and quality" of the article demanded, and its sale is "to the prejudice of the purchaser," who asks, and pays, for milk, and believes himself to be getting pure milk. This contention may not be legally valid, but it is morally true. I must confess that I cannot perceive any moral distinction between the trader who adulterates his milk with water and he who adulterates it with boric acid. Both result from commercial greediness which attempts to secure a gain by defrauding the customer: in the one case by selling him milk whose natural food-value has been reduced by the addition of water; in the other by selling him milk whose staleness is disguised by the addition of boric acid. The suggestion that this moral obliquity might be covered by labelling the product is more specious than valuable. There are numbers of persons who live or take their food in hotels or restaurants whom the information would never reach, and to the man in the street it would not appeal if it did reach him. He is not in a position to discriminate between the possible effect of 5 gr. and that of 50 gr. of boric acid. His view would be, I think, that it was the appointed authority's business to attend to those matters; if they allowed it, he would take no exception to it. The responsibility rests with the authorities, and, be it said to their credit, they are generally quite alive to it. In another way, too, the addition of boric acid to milk is morally defective in principle. It is subversive of the disciplinary regulations designed to secure the cleanly handling of a valuable article of diet. The dairyman who can with impunity conceal his dirtiness and neglect by throwing a handful or so of boric acid into his churn of milk is not likely to conduct his business with that regard for the purity of his commodity which its use as food imperatively demands. And, again, connivance in the addition of boric acid to milk involves connivance in its addition to various other food-products. With each of them we should get the largest quantity the trader dares to use: in the aggregate a quantity in excess of any safe limit. Finally, it has to be remembered that in the use of boric acid in milk, a drug, a substance not by any means destitute of medicinal action, is being administered, not regularly by a physician or by any skilled person, or by a parent or guardian, or even with the knowledge of the person taking it, but promiscuously by a trader, who knows nothing about it beyond the fact that it suits his purpose, who is indifferent to whom it goes, and who, in short, has no direct responsibility in the matter.

I have spoken specially of the use of boric acid in milk, because that is the use of it with which I am most familiar. But, in view of the fact that it is also to be found in sausages, pickled meats, preserves, pasties, prawns, fish, and other articles of like character, the hygienist's concern with this substance obviously does not begin and end with milk. If boric acid be viewed as the representative of a class, then, indeed, the matter is of not merely hygienic, but of national import. But such questions as the future stamina of a race fed upon falsified articles of diet, or the economic value of industries built up on such unstable bases, are not for discussion here; our business is with boric acid from a hygienic standpoint. In bringing the subject under your notice I have endeavoured to submit in outline the reasons which lead me to regard its addition to milk as possibly injurious, clearly undesirable, certainly unnecessary, and decidedly pernicious from a moral point of view. That its employment has a wider scope than I have included in my discussion is, to my mind, but additional emphasis to the objections to its use. Whether you concur in these views or not, I venture to hope my discourse has not been without interest to you, and that it has at least suggested some of the aspects in which the trade use of boric acid merits hygienic consideration.

No. 1.—NEW ZEALAND'S ATTITUDE TOWARDS CONSUMPTION, FROM A LEGISLATIVE POINT OF VIEW.

By Sir J. G. Ward, K.C.M.G.

It was with some slight misgiving that I allowed myself last night to be persuaded to enter an arena so crowded with scientific men and women. I lay no claim to any special scientific knowledge; but the protection of the people against the ravages of consumption is, I submit, a very proper subject upon which laymen as well as scientists should be heard. Without the aid of the law, which, after all, is only public opinion crystallized, no great or permanent reform can take place. I make no apology, therefore, in occupying your attention for a few minutes in setting out what our colony has done and intends to do in this war with the mighty bacillus.

A disease which yearly destroys between sixty and seventy thousand people in England and Wales alone is one which every one interested in the welfare of the race must carefully consider. Although the celebrated scientist, Koch, a good many years ago discovered the particular little body which causes the disease, it took, as you all know, a long time before the people realised that there was danger of it spreading from one person to another. To His Majesty the King no little credit is due for the efforts that are being made in the Old Land to stem the onward progress of the disease. Great efforts have been put forth by the National Society, of which he was the founder, to bring the people to a proper sense of the importance of the disease and the methods by which it is spread. Roughly speaking, there are two ways in which consumption or tuberculosis is spread—to children by means of milk, though I have read that Koch has recently asserted that danger from this source is small, and to others by means of infected expectoration. Now, I have no wish to claim credit unfairly, but I do not hesitate to say that we have here a system of meat and butter inspection that is equal to that of any other country.

New Zealand has been the scene of some pioneer legislation, much of it good, though I dare say some of you may think otherwise; but in the crusade against this disease we at least deserve credit. To place consumption in its proper position, amongst infectious diseases, was the first important step. In this way the exact number of the poor sufferers is ascertained. Some hardship undoubtedly at first resulted, but by a careful and tactful administration of the regulations this has been greatly lessened. Possessed of the knowledge of the power of the enemy, so to speak, our next step was to set about the erection of sanatoria for the treatment of those afflicted. One at least of these institutions is now in working-order in the North Island. I had the great pleasure the other day to formally open "Te Waikato" Sanatorium. There was a goodly gathering of men and women from many far-distant parts of the world. Some of the visitors had seen and were well acquainted with several of the best-known sanatoria in the Old and New Worlds. Yet I was assured by not a few of these far-travelled people that they had never seen in the course of their travels an institution better fitted for its purpose than that situated close to Cambridge. Certainly no fairer picture could have been asked for than that which met the eye from that lonely peak on the Maungakawa Range. It gave me the greatest pleasure to see among those gathered round on that occasion several who had been inmates of the institution, and who had gone back to the "workaday world" very greatly improved, if not absolutely restored to sound health. The establishment of an up-to-date sanatorium for the treatment of consumption on the latest scientific lines is another fact that must go to the credit of this colony's pioneer legislation.

To attempt to stem the tide with one such institution would be as hopeless as the efforts of the old lady with her broom. Realising this, I was able to convince my brother lawmakers that further powers were necessary; and it is my intention, at an early date, to ask the Hospital Boards in those districts whose climates are known to be beneficial in chest-ailments to undertake the new responsibilities which the law has cast upon them. In the course of my work as Minister of Public Health, every day brings sad cases before me. The medical profession have, I understand, decided that cases of consumption should not, for the sake of other patients, be treated in a general hospital.

Now, while we laymen must be guided by expert advice, there is one aspect with which we alone must deal—that is, the monetary one. Willing as a Government may be to carry out the suggestions of the scientific man, it often finds itself confronted with an expenditure which, if incurred, would seriously hamper other necessary works. Now, in the scheme which I intend to have carried out, we shall, I think, be able to obtain all that the experts ask for, and yet not make an unfair demand upon the colony's general funds. The addition of a few shelters to each of these country hospitals would entail in most cases but little expense, while the working-cost would be small. With thirteen or fourteen annexes, capable of holding, say, thirty patients each, the colony would be enabled to house and care for all those afflicted with this fell disease. I propose to have these institutions established at the following places: viz., Auckland, Hamilton, New Plymouth, Masterton, Otaki, Nelson, Christchurch, Naseby, Lawrence, Queenstown, and somewhere in the vicinity of Dunedin.

More important even than the effect upon the patients themselves would be the safeguarding of the public at large. Within the walls of these institutions every precaution would be taken to destroy the infected material, and thus the greatest of great dangers would be averted.

Apart altogether from the humanitarian aspect of the question, the course which the colony is now carrying out, and will, I hope, continue, is absolutely justifiable upon purely economic grounds. At the opening of the Sanatorium at Cambridge I drew attention to some figures recently published by a well-known American authority. Calculating the value of each individual at £300, he showed that the cost to New York City alone in one year through this disease amounted to £4,600,000, while the total for the whole of the United States reached the appalling sum of £66,000,000.

I have no wish to detain you longer, but I trust that this short sketch of what we are doing in this great work will at least convince you that politicians do—despite the criticisms occasionally levelled against them—take time and thought to turn aside from the hurly-burly of every-day questions, and not only think, but legislate for the unborn millions which we trust may inhabit this fair land of ours.

Among the many subjects upon which the scientific world has been engaged, it must be admitted that sanitary science occupies a foremost place, and the wide world is indebted to an unpayable extent to students in preventive medicine for the great discoveries they have been the means of unfolding, and by which an amelioration of the condition of people of all classes in all countries has been brought about.

May I be allowed to congratulate the scientific men at present assembled in the City of Dunedin upon the good work that they and their associations are doing for humanity at large? I congratulate also Dunedin upon having been selected for this meeting. It has much indeed to recommend it, for it has always been renowned for its interest in scientific research. This city, like its prototype in stern Caledonia, forms an appropriate setting to a gathering of scientific men. That their labours may be fruitful and their enjoyments many is the wish which I have the very greatest pleasure in giving expression to.

Section J.

MENTAL SCIENCE AND EDUCATION.

PRESIDENTIAL ADDRESS.

By John Shirley, B.Sc.

(Delivered Thursday, 7th January, 1904.)

EDUCATION AND NATIONAL TRADE COMPETITION.

I. INTRODUCTION.

The wealth of a country depends mainly on the quality of the race inhabiting it, on the economic policy of its Government, and on the system of education in force. Any change in the fiscal policy of the Government is followed by the nation at large with the greatest interest, but very little attention is paid by the public to changes in its educational system, and these changes are generally due to the deliberations of a few officials. Neither have the universities played any part in shaping the national system of education. A chair of political economy is endowed at not a few of the British universities, but it is only of late that we begin to hear of a professor of pedagogy, although American universities generally provide for pedagogic study.

Within the British Empire university and secondary education are usually based on classical study. A discussion of the value of classical study as a preparation for the trained professions does not come within the scope of this paper.

The almost complete organization of British secondary schools on a classical basis is a fact that greatly concerns our commerce and manufacture, and until this is changed, and secondary education is organized with at least a provision for independent modern and classical schools, British trade will be carried on under conditions favourable to our rivals.

II. NATIONAL COMPETITION.

In the commercial growth and development of the British Empire three great crises may be studied. The first was the fight for the free navigation of the open seas, which ended in 1588 with the destruction of the Spanish Armada. By this victory the division of all non-European countries between the Spaniard and Portuguese was set at naught, and

Britain entered on a career of discovery and foreign adventure.

In this field of maritime adventure and colonisation Britain was not without rivals, and Spain, Holland, and France tried to check her attempts at colonial expansion. Their rivalry was finally settled at Trafalgar, by which victory Britain was left for nearly a century, with little check or hindrance, to add coasts and islands to her Empire by peaceful annexation or by conquest.

The third crisis is now developing, and its causes can easily be traced. The European countries, with the one exception of Britain, have trained their subjects by compulsory military service to work together in vast armies, yielding an implicit obedience to a select staff of highly trained and intellectual officers. Having obtained this passive obedience from the masses, and having tempered the nation into a military machine of most perfect action and destructive power, it is now desired to organize the disciplined nation for commercial warfare, by giving a thorough elementary education to young children; by extending the school course through the period of youth by means of continuation schools; by organizing secondary schools to suit the threefold requirements of professional, scientific, and commercial students; by the endowment of scientific research; by applying scientific knowledge to commercial requirements; and by keeping the home markets to native manufacturers under a rigid system of protection.

In this field of commercial rivalry the chief exponent of the new system is Germany. As surely as Denmark, Austria, and France fell before the onslaughts of a militarily trained Germany, so surely will the commerce of ill-educated people fall before the commercial attacks of nations more intellectually trained than themselves, and endowed with a more perfect scientific equipment.

Dr. Karl Pearson,* in his prefatory essay to the eighth of the new volumes of the "Encyclopædia Britannica," says, "The future is to the nations which not only realise the international struggle in all fields of activity, but consciously develop all the factors of national efficiency with this end in view." The most intelligent nations will be victorious in the struggle, and it befits each nation that would be great to-morrow, as well as to-day, to educate and organize itself from the statesmen at the top to the plough-boys and factory-hands at the basis. Professor Pearson therefore demands that national education be "a specialised education suited to develop the intelligence of each caste and class"—

* *Educational Times*, p. 14, 1st January, 1903.

"specialised to each social activity from statesman to dairy-maid."

Sir Norman Lockyer,* in his presidential address to the British Association, 9th September last, put the case similarly: "The struggle for existence in modern communities is between organized species -nations -not between individuals or any class of individuals. It is, moreover, a struggle in which science and brains take the place of swords and sinew, on which depended the results of those conflicts which, up to the present, have determined the history and fate of nations. The school, the university, the laboratory are the battlefields of this new warfare."

III. THE UNIVERSITIES IN RELATION TO TRADE.

Education in China is held up for derision by Englishmen, but it is questionable whether they can safely do so. A young Chinese of the governing classes is given as his text-books certain old Chinese classics, and when he is letter-perfect in them is sent to one or other of the great public departments, for none of which has he received any special training. In England, and in such of her colonies as have copied her old-time universities, a youth of the middle or upper classes is given an education devised in mediæval times for the education of clerics, and leaves his university unable to speak fluently a modern language, having little knowledge of any of the sciences, and utterly unprepared for commercial life, having passed the age when commercial acquirements are best assimilated, and this in a country which looks to commerce and manufacture for its very existence.

A student of the Herbartian system might present the English case in this way:—

"The (general) idea is that when a man is trained in formal mathematics or formal language, in algebra, geometry, trigonometry, Latin, and Greek, there will be developed a power which will give him an intellectual ascendency in all fields of life. A man thus trained at Cambridge, Oxford, or any other university was considered a trained man above all others. Though he lacked any concrete acquaintance with the endless variety of the world and of the life about him, though he knew little of the nation's history, her commercial relations, her scientific acquisitions, he was easily chief in the intellectual world, because he had a so-called trained mind that could be turned on to any piece of work with success at a moment's notice.

"It was against this absurd formal view of mind that Herbart, like Rousseau, protested. He submitted for it a concrete view. He defined ability not as a certain power

* *The Chemist and Druggist*, 12th September, 1903, p. 471.

that may be turned on to any piece of knowledge with success, but in terms of ideas—ideas relevant to the occasion. An able man in any sphere now becomes one who has a big active stock of ideas and experiences. A lawyer is an able lawyer not because he was a senior wrangler, but because he knows the law; a doctor is an eminent medical adviser not because he took 'a double first,' but because he knows his pathology, &c., and has had large experience in the treatment of cases."*

Let us ponder upon the words of Andrew Carnegie on this topic: "The total absence of the college graduate in every department of affairs should be deeply weighed. I have inquired and searched everywhere in all quarters, but find scarcely a trace of him. Nor is this surprising. The prize-takers have too many years the start of the graduate; they have entered for the race invariably in their teens—in the most valuable of all the years for learning anything—from fourteen to twenty. While the college student has been learning a little about the barbarous and petty squabbles of a far-distant past, or trying to master languages which are dead—such knowledge as seems adapted for life upon another planet than this, as far as business affairs are concerned—the future captain of industry is hotly engaged in the school of experience, obtaining the very knowledge required for his future triumphs. I do not speak of the effect of college education upon young men training for the learned professions; but the almost total absence of the graduate from high position in the business world seems to justify the conclusion that college education as it exists is fatal to success in that domain. The graduate has not the slightest chance, entering at twenty, against the boy who swept the office, or who begins as shipping clerk at fourteen. The facts prove this."

It might be thought that Carnegie's ideas are directly opposed to those of Sir Andrew Noble,† one of the partners of the great Elswick engineering-works, who, in addressing the students of the City and Guilds Central Technical College, London, 3rd October, 1899, said, "I am continually being asked what education I should recommend for a lad entering Elswick. I always say, 'Send your son to as good a school as you can; do not curtail his time of schooling; do not stint his early intellectual growth by narrowing it down to any special study.'"

Those who think these statements are at variance have given little heed to trade requirements. In all forms of manufacture there is a necessity for two classes of experts—the scientific expert whose genius makes the production of a

* W. Laskar, in the *New South Wales Educational Journal*.

† Special Reports on Educational Subjects, Vol. viii., p. 215.

finished article possible, and the commercial expert, who gives the finished article the best and widest market. Noble spoke of the scientific expert; Carnegie refers to the business manager.

The difficulty well-nigh impossibility of inducing an English university to alter its time-honoured system is plainly shown by Mr. J. C. Tarver* in his "Debateable Claims": "A few years ago an attempt was made in the University of Cambridge to release the schools from teaching Greek by allowing an alternate subject in the first public examination. This proposal was rejected. The method of its rejection is worth noting. Ultimately any disputed question of organization at either of the universities is referred to the Senate. For ordinary purposes the Senate consists of the resident masters of arts and men who hold degrees of the same or higher standard—that is to say, that the question is decided by the men who are actually engaged in the teaching and organization of the University. But all masters of arts, &c., whether resident or non-resident, have a right to vote, and whenever any highly controversial question is raised, such as this question of Greek, or the admission of women to degrees, non-resident members of the Senate are whipped up from the country, and vote according to their lights—in other words, questions involving an intimate knowledge of the inner working of the University may be decided by men who have ceased for many years to be in close personal contact with the place in which they completed their education."

Competition and an imperative public demand have compelled some universities in English-speaking countries to place the Faculties of Medicine and Engineering on a sound and practical basis; but the Faculty of Science, with all its national potentialities of economic and successful manufacture, is seldom sufficiently equipped, and is not organized so as to admit of the necessary differentiation of studies. It has been asserted by experts of the English Board of Education that German secondary schools are better equipped with scientific apparatus than some of our universities.

Of training for the sons of our leading merchants and manufacturers the English universities offered nothing. Carnegie believes that such men are absolutely rendered unfit to succeed their parents as captains of industry by the bookish training of an ordinary arts course. As far back as 1864 Faraday† found it necessary to protest against the narrowness of the old classical education, because he had found that it did not give that "mode of mind, that management of the mind, which enabled a man to think and speak

* "Debateable Claims," pp. 246–47.
† Report of Public Schools Commission, 1864. Vol. iv., pt. 2, Q. 48, 55–58.

with understanding about matters of natural science." Until lately it has been necessary to send young Britons who desire the benefits of a higher commercial training to Belgian, German, or French commercial colleges. It is pleasing to note that the authorities of the new Birmingham University have created a Faculty of Commerce, and that a draft scheme for a similar faculty was recently under consideration at Manchester. In Birmingham it is not intended that the curricula shall be devised solely for the benefit of that fraction of the students preparing for the law, medicine, or the Church. In a pamphlet by the newly appointed Professor of Commerce the following statement is noteworthy: "The establishment of such a faculty, the first in England, is the outcome of motives similar to those which are leading to the creation of like institutions in the two other great commercial countries of our time—the United States and Germany. It is believed that a training can be devised which, while strengthening the powers of judgment, widening the sympathies, and stimulating the imagination—the ends of all really liberal education—will yet be of real value as a preparation for the practical duties of later life. It is felt that if the universities are to maintain their position in the modern world they must have regard to the dominant interests of the world; that they must not be content simply to prepare men for what it has been customary to call the learned professions."

In an article by Carl Snyder in the *North American Review*,* entitled "America's Inferior Place in the Scientific World," the author declares, "It would be hardly too much to say that during the hundred years of its existence the Royal Institution alone has done more for English science than all of the English universities put together." This statement is vouched for by Professor Dewar,† who has ascertained the expenditure of the Royal Institution from the date of its foundation, and finds it to be nearly £120,000, or the modest average sum of £1,200 a year.

According to Carnegie the universities have done little in the cause of trade, and according to Dewar English universities have done less in the cause of science; yet Newman‡ has laid it down as an axiom that "if a liberal education is good it must necessarily be useful too."

Rosseau, in his "Emile,"§ a book that every parent and teacher should read, states that the reason why teachers in all countries and of many ages have shown such a partiality for the teaching of dead languages is simply because they are

* January, 1902.

† Inaugural Address, British Association, Belfast, 1902.

‡ "Idea of a University," Discourse 7, p. 154 *et seq.*

§ Rosseau's "Emile," by Payne: International Education Series, p. 74 *et seq.*

dead languages, and therefore there is no keen public criticism of the methods used or the results attained. Similarly, in modern languages our tests are almost invariably written ones, and the questions deal mainly with abstruse points of grammar, akin to those which, by a recent decree of the French Minister of Education, have been thrown aside in French schools as useless. The supposed inability of the ordinary Briton as a linguist is due far more to faulty teaching, and tests so devised as to conceal these faults, than to any innate want of capacity.

Mr. Fabian Ware,* in his report on the teaching of modern languages in Prussian secondary schools, says, "The fact that young Germans have a more thorough command of modern languages than the boys who leave our secondary schools was first remarked in commercial circles. The conclusion immediately drawn was that the gift of tongues had been bestowed on the German nation but denied to us. . . . I have obtained the opinion of many German authorities on this interesting theory. All were exceptionally qualified to pronounce, some of them being professors at universities where there are a number of Englishmen studying German. They were unanimous in their opinion. They stated that the Englishmen who came to Germany with the serious intention of learning the language—for example, those who further qualified for the English teaching profession by studying at a German university—showed themselves as capable of learning a foreign language as the Germans: but that, on the other hand, they started with a knowledge of the language which was infinitely inferior to that command of English possessed by German boys on leaving school, and that at the same time they betrayed a lamentable ignorance of the manner in which a modern language should be learnt. These authorities have only one explanation to offer: the teaching of modern languages in English schools was unsatisfactory."

The connection between sound scientific teaching and training and rapid commercial development is well shown in the following extract from a recent report of Dr. Frederick Rose, H.M. Consul at Stuttgart: "The total value of the annual production of the German chemical industries was valued at £50,690,000, and this sum was considered as the interest accruing from the capital invested by the German States in chemical instruction." "If this demonstration, however, is true concerning one branch of technical education at the technical high schools and its corresponding branch of the national industries, it must also hold good for all branches of technical education taught at the technical high schools,

* Special Reports on Educational Subjects, Vol. iii., p. 321.

and the growth of the corresponding branches of German industries during the past thirty years."

In contrast with the foregoing stands Dr. Dewar's sweeping condemnation of the state of chemical study and chemical research in Britain. Similarly, the President of the Royal Society, Sir William Huggins, in his address of the 1st December, 1902, referring to the present national apathy with respect to scientific knowledge, said "he must come to the conclusion that it was our system of higher education which was at fault, clearly through being too mediæval in spirit. In accordance with the tradition of the past, our higher education dealt with words rather than with things. The present inappreciative attitude of our public men and of the influential classes of society generally towards scientific knowledge and the modes of thought must be attributed to the too loose adherence of our older universities, and through them of our public schools, and all other schools in the country downwards, to the traditional methods of teaching of mediæval times. With the experience of Germany and the United States before us, the direction in which we should look for a remedy for this state of things would be for the teacher and the student to be less shackled by the hampering letters of examinational restrictions. Into the dry bones of the present academic system of reading and examination must enter the living breath of the spirit of research."

IV. SECONDARY SCHOOLS AND TRADE.

A moderate endowment of secondary education has been granted in the Australian States. Queensland has ten State grammar schools, each receiving £1,000 a year as Government subsidy. New South Wales has a grammar school, four high schools, and numerous superior public schools; South Australia has an advanced school for girls in Adelaide; and West Australia has a high school for boys in Perth. The other Australian States maintain no secondary schools, but grant scholarships to schools not under State control. The education given in the Australian secondary school is mainly determined by the standards fixed by the State University for its junior and senior public examinations. As Queensland has no university of its own, the requirements of the Sydney public examinations determine the curricula of its ten grammar schools, as well as those of the secondary schools of New South Wales. Candidates can matriculate on either the junior or the senior public examination. In 1901, 1,060 candidates sat in Queensland and New South Wales for the lower of the two examinations, and 697 were successful. The same year Sydney University enrolled 125 matriculated students.

The main industries of New South Wales and Queensland are pastoral, agricultural, mining, and commercial. As a preparation for playing leading parts in these various industries, the children of our leading business-men are given an education designed mainly to lead up to an educational course, ending in one of the learned professions.

Many of the Australian grammar schools have a so-called modern side, but this is generally viewed with disfavour by grammar-school teachers: the requirements for teaching the subjects are costly; the pupils taking this course are regarded as dunces by teachers and fellow-scholars; and from the nature of the public examinations they bring few prizes and little public credit to their schools. This is a very poor substitute for the threefold division of the German secondary schools into modern semi-classical and classical schools, fitted for the early training of youths intended for commercial, scientific, and professional occupations. In Australia conditions tend to force a boy to take the classical course, although a classical education may be of little service in the occupation for which the boy is intended.

In a report* by the Under-Secretary, Department of Public Instruction, Queensland, on a proposed amendment of the State Education Act of 1875, dealing mainly with secondary education in New South Wales, the following occurs: "I was informed on authority which admits of no questioning that the capital of the southern colony (New South Wales) is overrun with young men locally reared, well educated, graduates of the University, who are unable to find work congenial to a man of education. 'Education is a drug in the market; the time is past when a liberal education is a stepping-stone to a billet,' said one gentleman; 'Greek and Latin won't earn a living,' said another. . . It would be lamentable if the New South Wales system of public and university education, admirable as it is, conduced to the formation of a class mentally disqualified to earn a living under the conditions of the time, and brought on the State the dangers of an educated proletariat. I may be unduly impressed, but I came to regard the danger as not improbable."

V. ELEMENTARY-SCHOOL TEACHERS.

In all Australia there is no arrangement for the training of secondary-school teachers, unless the course for the arts degree may be regarded as the training required. The primary-school teacher, on the other hand, is generally supposed to require training in pedagogy and methodology. As a rule, the British elementary-school teacher passes through the three stages—pupil-teacher, assistant teacher, and head

* Twenty-first Report of the Secretary for Public Instruction, Queensland, p. 77.

teacher. The first stage he commences at the early age of fourteen years. He is teaching all day, and his mornings and evenings are given to study. There are exceptions to this rule, but they are few in the Southern Hemisphere, and the half-days formerly granted for study in Victoria have lately been withdrawn. A pupil-teacher is therefore cut off from almost everything except his text-books, his pupils, and his master. Is it strange that this training usually makes him more bookish than practical, and gives his teaching peculiar limitations? Reformers may try to correct these defects by insisting on kindergarten, heuristic teaching, nature-study, and the like; but the limitations still remain. Shut off from everything but the little world of his studies and his school, the pupil-teacher at the end of his course is sent, or, rather, a small proportion of selected individuals are sent, to a training-college. If this so-called training-college is not affiliated with a university, as in Sydney and Adelaide, or with such institutions as Canterbury College, Christchurch, or the Auckland University College, or with a good secondary school, as are many of the Swiss training-colleges, then the bringing-together of these imperfectly developed youths to live in an educational barracks, and to concentrate all interest on books and the practising school, is more likely to produce automata than men of fully developed, well-balanced minds.

In one of the reports on educational subjects published by the English Board of Education, it is stated that, "except in Great Britain and some of the poorer parishes of Russia," the pupil-teacher system is no longer in vogue. To the exceptions stated we must add Holland, Australia, New Zealand, and the West Indian Colonies. If you look through the reports of inspectors in Great Britain and in these southern States you will find exactly the same complaints running through them. The subject-matter of the reading-lessons is imperfectly understood, the teaching of geography and history is mechanical, mental arithmetic and the working of arithmetical problems are failures, and so on through the intellectual subjects; but mechanical subjects give satisfaction. Go back as many years as you like and the same holds true. To what are these faults to be attributed? In great part, I believe, to the pupil-teacher system. The one redeeming feature of this system is the disciplinary power that it usually confers, and this power of control over numbers has saved the system from extinction in English-speaking countries. But it leaves the youth at the end of his apprenticeship ignorant of nearly everything in the world of nature of the plants in the garden and by the wayside, of the insects that inhabit them, of the shells on the sea-beach, of the rocks over which he travels; he has no time for healthy hobbies. You may put nature-study as a subject on your schedules, but you will get little that is natural from men of this mechanical habit. A large proportion of our head teachers are men of culture and all-round development, but this is in spite of the pupil-teacher system, and not because of the opportunities it affords. If you question these successful teachers you will find that their real education began when the pupil-teachership ended. In Queensland it is sought to secure teachers of superior culture by admitting as pupil-teachers successful pupils from the secondary schools, from fifteen to seventeen years of age or over, and by shortening their pupil-teachership to a two- or three-years course.

VI. ELEMENTARY-SCHOOL CURRICULA.

In the construction of elementary-school curricula there are two opposing schools of thought: the first, which is most strongly exemplified in the Scandinavian countries, regards the preparation for industrial life as the great office of the primary school, and seeks at an early age to implant in the child a love of work, to prepare him for his work by training and developing his manual dexterity, and to put him at the end of his elementary-school course in a fair way towards the earning of his own living. It is stated by the advocates of this system that the teaching of the ordinary school subjects - the three Rs, grammar, geography, history, &c. is rather assisted than injured by being taught side by side with manual training.

The second school is represented by Germany, and is to a great extent the system of all German-speaking countries. It looks with disfavour on any specialisation of study during the elementary-school course. It lays the greatest stress on the teaching of the mother-tongue as a key to the national literature and to the history of the nation. It does not crowd its schedules with subjects; it aims at first implanting a patriotic spirit, and leaves the teaching of handicraft-work to the continuation schools, when the youth has definitely selected the occupation to be followed. I am not inclined to slavishly copy the system of any foreign country, and believe that the history and spirit of each race must be considered in devising its educational system; but in all questions of psychology and the study of child-nature Germany is in the van; and this absence of manual training from the elementary-school course is the result of conviction after long deliberation.

VII. CONTINUATION SCHOOLS.

Our English and colonial systems of elementary education have the grave defect of omitting from consideration the very important years of a boy's life, between the ages of fourteen and eighteen. During these years in most of the German States attendance at a continuation school for not less than two hours a week is compulsory. Ordinary school subjects are usually taught the first year after leaving the primary school, after which the lessons become more and more technical. The British youth usually leaves the primary school, forgets much of what he has learned there, and when his deficiencies compel him to attend an evening class has to again acquire the knowledge that he once possessed but has since lost. The addition of the continuation-school course to our system of elementary education and the enforcement of attendance on all males under eighteen would add much to the industrial endowment of Australasia, and would give scope and aim to the energies of youths who have no sensible outlet for their surplus activity and intelligence.

VIII. ENGLISH COINAGE AND WEIGHTS AND MEASURES.

Among the greatest hindrances to commercial expansion and to primary education are our antiquated systems of coinage and of weights and measures. It has been pointed out again and again that a decimal system of coinage can be introduced requiring only two new coins, and permitting the use of almost all those now in circulation. Briefly put, this plan is to retain the sovereign as the coin of the highest value, to make the florin the next lower denomination, to issue a groat or silver coin of one-tenth the value of the florin, and a bronze farthing of one-tenth the value of the groat. All calculations would be in pounds (or sovereigns), florins, groats, and farthings. The half-sovereign, crown, and half-crown could be retained in circulation as convenient fractions of the sovereign, as could also the shilling and sixpence as convenient fractions of the florin.

As a proof of the cumbrous nature of our system of weights and measures, let me give an example.* A pint of water at 59 deg. Fahr. in air at 62 deg. Fahr. weighs 1.25032 lb. av., and is equal to 34.659 cubic inches, or to the contents of a box 3 in. by 3 in. by $3\frac{8}{9}$ in. Under a metric system the unit of length is also the fundamental unit of surface, capacity, and weight; and a somewhat parallel statement in French weights and measures would be "a gramme is the weight of a cubic centimetre of distilled water, at 4 deg. C., weighed at Paris." It seems impossible to reform our English system of weights and measures, and the only course remaining is the adoption of the French metric system, giving English titles to replace the French denominations. This course has been already adopted by scientific men throughout the world.

* "Everybody's Pocket Cyclopædia," p. 164.

IX. CONCLUSION.

New Zealand is known in Australia as the home of a nation of brave citizen-soldiers, as the cradle of a race of athletes. It is admired for its spirit of Imperial patriotism, for its daring social legislation. It occupies a geographical position unrivalled for its commercial advantages. What the Mediterranean was to the ancient world, and the Atlantic in recent centuries, that and much more will the Pacific be in years to come. But the waste places of the world are being rapidly settled; European annexation in Africa and Oceania has run its course—there is nothing more to annex. The smaller States are disappearing, or exist only through the mutual jealousies of rivals, to disappear by partition when these jealousies are allayed. The population of the world advances in numbers by leaps and bounds. The struggle for existence between nations grows keener. To exist a race must be prepared to defend its shores against all invaders, and must be mentally and technically trained to win by agriculture, mining, commerce, and manufacture its due share of the world's wealth. The nation that is not prepared for this double contest must become hewers of wood and drawers of water to peoples of greater foresight and patriotic self-denial. New Zealand has shaken itself free from so many of the clogs and encumbrances of the past that I look with confidence to her leading the British race in a reform of our coinage and measures, and in such educational reform as shall place its citizens on a footing of more than even terms with its greatest trade rivals.

No. 1.—MENTAL OPERATIONS AND NATURAL PHENOMENA.

By G. Woolnough, M.A.

No. 2.—THE NATURAL BASIS OF MENTAL PHILOSOPHY.

By Aubrey Gualter.

No. 3.—A PLEA FOR THE STUDY OF ART AS A FACTOR IN GENERAL EDUCATION.

By S. Hurst Seager, A.R.I.B.A.

[*Abstract.*]

It is with considerable diffidence that I bring before this body of eminent educationists my "Plea for the Study of Art as a Factor in General Education." I have for a considerable time very firmly held the views I shall endeavour to express, but should not have ventured to place them before you if it were not for the hope that their expression may be the means of eliciting much more valuable expressions of opinion from yourselves. Since formulating my ideas sufficiently to indicate them by a title I have been reminded by the receipt of the last meeting's Transactions that two papers having somewhat kindred aims were read before this Section at that time—one, "Poetry as a Factor in Education," by Professor Wall, and the other, "A Plea for the Study of Literature," by Mr. Percy Rowland. In both it is the cultivation of the emotional side of our natures that is insisted on, and in that aim my own will be found to be in perfect agreement; but that literature, whether as poetry or prose, should alone be regarded as the means by which that aim is to be realised is, I hold, a widespread error, which at the outset must be refuted. For literature, whether in its highest form as poetry or as prose, produces its effect by means of signs in calling up images of individual things or of definite realities of experience. But no description, however truthful it may be—however it may be tinged by the glow of enthusiasm of the writer—can convey the full power of the thing described. It may convey an emotion similar and equal in force to that which the thing spoken of would arouse, but it cannot convey a distinct image of those things with which we are unacquainted. We may be deeply moved by the beautiful language, by the flow of eloquence; and the emotion which is called up by the words of a master will be exactly of that kind the thing itself would create, and there his power stops. He may, it is true, give us a good idea of what it is like by comparing the whole and every individual part with things which we have seen and know of; but the excellences of every pure work of art arise from the genius of the individual who created it, and therefore his conceptions cannot be conceived of by comparing them with the productions of others, or with the natural examples upon which the work has been founded. Every work which may be numbered among the fine arts stands alone, and to it, and to it alone, must we appeal if we wish to receive the full expression of its power. We are incapable of receiving this if we have not learned the language in which it is expressed. We can receive its teachings only in proportion to our degree of culture—of knowledge of the method it adopts. By the study of literature only, therefore, we leave untouched a vast range of creations which have equal power to call forth or deepen all ennobling emotions by which our higher natures may be developed.

Painting, sculpture, architecture, and speaking are methods of expression. Poetry is the employment of any of these for the noblest purposes, or, as defined by Ruskin, poetry "is the suggestion, by the imagination, of noble grounds for noble emotions." This similarity of aim and use of the fine arts will, I think, at once be admitted: and yet there exists the remarkable anomaly that our university students are nominally following an "arts course," and are rewarded for their success therein by the presentation of degrees in art. We therefore have bachelors and masters of arts who have brilliantly achieved all our colleges offer, and yet may remain profoundly ignorant of the whole range of art, with the exception of one branch of it—literature—which cannot possibly be perfectly understood without extensive knowledge and appreciation of the principles and beauties of these other branches of art, and of the beauties of nature from which it draws its inspiration. This lack of art-knowledge creates false impressions even in the finest poems. Milton, for instance, describing ancient Rome in "Paradise Regained," speaks of—

> Mount Palatine,
> The Imperial palace, compass huge and high
> The structure, skill of noblest architects,
> With gilded battlements, conspicuous far,
> Turrets and terraces and glittering spires.

Here are no noble, but absolutely false, grounds of emotion, for such features as "battlements," "turrets," or "spires" were never seen in ancient Rome, nor can her palaces be rightly described as the creations of "noblest architects."

In the great majority of instances where the arts are drawn upon it will be found that such false images are created. So powerless have most writers found themselves to discover wherein consist the elements of beauty in works of art—so powerless to describe the wealth of thought and feeling all noble works possess—that they have almost invariably fallen back, in order to create the desired effect of magnificence and splendour, on the far less noble display of wealth of material. Thus we have a purely imaginary architecture of gold, silver, and precious stones running through all the earlier poets, and expressed in the Book of Revelation.

Sir Walter Scott has, perhaps, done more than any other poet for architecture, or, at least, for that mediæval art he loved so deeply. The truth and full beauty of the images he creates cannot, as I have stated, be felt without previous knowledge. His description of Edinburgh conveyed in the single line,

Piled deep and massy, close and high,

can, for instance, only be fully appreciated by those who know that the fine effect of Edinburgh arises rather from the piling-up of the city than from any architectural interest in the buildings themselves. And, again, the truth and beauty of his description of the buildings on the Holy Isle in "Marmion" can only be fully realised by those who have sufficient knowledge to call to mind at his suggestion examples of the Norman art he describes.

It would be of the greatest interest to gather further instances of the use which literature makes of the arts, both in description and metaphor; for, as Mr. Statham says in his book, "Architecture among the Poets," "by the power of poetically expressed truths about art the subject can be raised to a higher plane of intellectual interest than it can generally occupy in actual practice, by connecting it through imagery and associations derived from art with the highest subjects of contemplation with which the human intellect can concern itself."

But I must not dwell further on this aspect of the question, as the chief value of the study of art is not that we may the more readily comprehend poetic descriptions and metaphors, for, as I have already stated, it is the works themselves, and nature, from whence they are drawn, that exercise a beneficial influence upon us. It is not the sense of hearing, but the sense of sight, which stands in most urgent need to-day of cultivation -"not a slight thing to teach, this; perhaps, on the whole, the most important thing to be taught in the whole range of teaching. To be taught to read—what is the use of that if we know not what we read is false or true? To be taught to write or to speak—but what is the use of speaking if we have nothing to say? To be taught to think—nay, what is the use of being able to think if we have nothing to think about? But to be taught to *see* is to gain thought and word at once, and *both true.*" The art-teaching, then, which should form a branch of general education should have for its aim the development of the power to see rightly, to understand and appreciate all those beauties of nature and art which, without such development, would pass unheeded.

Art-teaching as usually understood and undertaken is the training of artisans and artists in order that they may produce better and more valuable work; the influence of the study on the individual is either not regarded at all, or else is regarded as of slight value as compared with the increased wage-earning power such study will give. It is, of course, impossible to learn to produce art-works without the study exerting a beneficial influence on the character of the worker to some extent, but the curriculum which aims at excellence of manipulation and skill in production is not the one best fitted to lead to that range and refinement of thought, that delicacy of feeling, which the presentation of noble grounds for noble emotions will create, and with which alone we are now concerned. But, although it is not necessary for the appreciation of art that we should ourselves be capable of producing art-works, still it is impossible to feel their influence to the full unless the sense of sight has been cultivated; and this can best be accomplished by drawing by the effort, that is, of the hand to record the mental impression produced by facts of form. It is the necessary means of acquaintance with them, as arithmetic is the means of acquaintance with facts of numbers. The facts which an elementary knowledge of drawing enables a youth to observe and note are of as much importance to him as those which he can describe in words or calculate in numbers. The drawing that is required is only that which will be sufficient to create or develop the faculty of observation, and therefore it should be regarded not as an end in itself, but simply as a means of fixing clearly in the mind given facts of nature and of art. It should be regarded as a means of expression all through the elementary and advanced school courses, just as it is by very young children whose efforts are always directed to the representation of observed facts, and, as their power of expression in words is usually more fully developed than their power of expression in form, they make clear their intention by stating in words what their drawing represents. Drawing, either with pencil or brush, or clay—as modelling—then, should not be considered as a thing apart from the ordinary subjects of education, requiring a special master for its development, but should be welcomed and encouraged as a most valuable aid to the study of all the sciences, and to the study of any subject in which its services are available.

The development in this mode of expression should be synchronal with that of words, and with the development in all branches of study, so that the power may at any time exist to record truly the facts of form then acquired, from the simplest to the most complex. The method to be followed in recording the acquired facts must differ from the methods of teaching drawing usually adopted, which may or may not be suitable for craftsmen, but which is certainly most unsuitable when regarded as a handmaid to culture. From the first, absolute truth must be demanded, and any device must be received which will attain it. Tracing, transferring, squared paper, measuring, drawing solid objects as seen through a sheet of glass—any means, in fact, which will insure that the pupil shall lose no fact worth the noting, shall record all the facts rightly, and shall retain a true conception of whatever beauty of form or colour the object may possess.

Nothing should be drawn simply for the sake of the drawing, but each drawing or model should recall some definite reality of experience. In this way, and, I think, in this way only, can we be led to look always beyond the description or representation to the thing itself as the ground of our emotion. We shall learn to despise mere tricks of craftsmanship, all affectation and shallowness, and to appreciate to the full all honesty of purpose wheresoever found. But, although a love of truth must be the foundation on which all right feeling is to be erected, there must coexist a deep and lasting love of the beautiful—a love, that is, for those "material sources which are agreeable to our moral nature in its purity and perfection."

Our aim, therefore, must be to create the power to discriminate between those sources which are agreeable to our moral nature in its purity, and which are therefore helpful and stimulating, and all those sources which are agreeable only to our imperfect moral natures, and which, if dwelt upon and encouraged, are hurtful and degrading. This power of discrimination—this faculty of enjoyment only in those things which appeal to our higher being, which arouse in us noble emotions—is, in a word, *taste;* so that perfect taste has been defined as "the faculty of receiving the greatest possible pleasure from those material sources which are attractive to our moral nature in its purity and perfection." He who receives little pleasure from those sources lacks taste; he who receives pleasure from any other sources has false or bad taste. This, I must assume without demonstration of its truth, you hold with me; and also that you agree with me that it is an utter fallacy to suppose that "about taste there is no dispute," for if about taste there is to be allowed unlimited latitude of opinion, then all art-teaching were vain.

This pernicious and far-reaching error—behind which even now those laying claim to a high degree of culture take refuge—would never have been accepted as truth were it not for the still greater error of regarding literature as the only branch of art worthy of earnest study in our schools and universities. "Earnest study," for I have never heard it claimed in regard to pure noble literature that love for it and taste in it came by instinct, or that they could be obtained in any other way than by a scientifically graduated course spreading over the whole range of school and college life. It has been recognised in this branch of art what is so deeply true of them all — that "art, properly so called, is no recreation; it cannot be learned at spare moments, nor pursued when we have nothing better to do. It must be undertaken seriously or not at all. To advance it, men's lives must be given; to receive it, their hearts."

That lack of taste in all branches of art is lack of knowledge—lack of that culture which is the result of knowledge—cannot be too firmly insisted upon. If this were only as fully realised as it should be, no more should we be comforted with the thought, no more convinced by the utterance of this puerile fallacy, "De gustibus non est disputandum."

The urgent necessity for the recognition of the fact that taste in all the arts can be, and should be, earnestly cultivated as a branch of general education will at once be evident on reflecting that it is not the artists—not those trained in art—but the public who are the final arbiters in every branch. The choice of a home, of every article of decorative art which is to adorn it; the choice of the pictures to be hung on its walls; the choice of everything, indeed, demanding knowledge in order that the choice may be wise is jealously retained in the hands of those who "know what they like," but who in the majority of instances show only too clearly and painfully but slight evidence of taste in the choice made.

And in the case of civil and ecclesiastical art the same method obtains. Councils, boards, committees, and vestries, as well as individual men of business, are the powers who, with absolutely no training fitting them for the task, yet with equal jealousy guard their right to determine the architectural and decorative features of our cities. In spite of this untrained jurisdiction, here and there works of merit are erected; but there is no force existent to prevent the erection of those works which make our modern cities a wilderness of material almost wholly devoid of beauty. The comparison between an ancient and a modern city shows at once the chaos into which our art-expressions have fallen. The only power capable of raising them once again to the level of those glorious works produced in ancient times is that of educated public opinion. Artists now, as in ancient times, can but reflect and advance; they cannot create a love for the beautiful in the minds of the community in which they live. This must, as I have already shown, be created and developed in our schools and colleges. Firstly, in order that we may put the happiness and knowledge which the study of art conveys within the conception of pupils, so that they may in after-life pursue them if they have the gift; and, secondly, as you will have gathered, to enforce as far as possible such knowledge of art among those who are likely to become its patrons or the guardians of its works, as may enable them usefully to fulfil those duties; and, thirdly, in order that we may be enabled to distinguish pre-eminent gift for the production of works of art, so as to get hold of all the good artistic faculty born in the country, and leave no Giotto lost among hill-shepherds.

This I consider should be our aim, and in the attainment of it I ask for no further burdens to be placed either on scholar or teacher, for by a proper involution of studies a knowledge of art can be gained, and taste can be cultivated, while prosecuting those studies which now form the curriculum of our schools and colleges. And, further, I would say that those subjects which are now considered of importance as studies in our schools would be rendered of far greater interest, and consequently would be far more easily taught, more readily learned, if approached through the medium of art.

I have already shown the value of the study of art to descriptive literature, and would remind you that nature cannot possibly be described except in terms of art. All visible nature consists of form, colour, and texture; without a knowledge, therefore, of these three things all the exquisite descriptions of nature with which our own and other literatures are enriched can have not the least value to those for whom the symbols or signs used recall no "definite reality of experience."

After gaining knowledge of the simple facts of nature by the endeavour to record them, the subtle beauties of nature and her partially hidden truths will most readily be revealed by a study of the representations of nature which the great painters have left us for our instruction and delight. Therefore it is of importance that pupils and students should be led to the study of the best examples into the excellence of which their knowledge permits them to enter. The Art for Schools Association renders this easily possible, but the indiscriminate purchase and hanging in the schools of reproductions of gems of art which the pupils have not knowledge enough to appreciate does far more harm than good, for "the contemplation of works of art without understanding them only jades the faculties and enslaves the intelligence."

To regard pictures chiefly as a means of relieving the bare walls of our school and lecture rooms is to have a totally erroneous conception both of their use and power, and of the elementary principles of decorative art. Pictures so used do not decorate or adorn in any degree the rooms in which they are placed. Let our schoolrooms be made as bright, as cheerful, and as beautiful as possible by artistic colour-schemes, and let them be adorned with simple, well-designed stencil decoration based on indigenous flora and fauna, or, where possible, with simple decorative historical figure-subjects; but let the reproductions of works of fine art be kept apart—if not hung in a special gallery, then stored ready for use in such order as the progress of the students demands.

In this we should follow the teaching of the artistic Japanese, who know that the lesson and fullest pleasure to be derived from any work of art can only be gained when the work is singly and only occasionally presented to the sight. It will then be truly seen and its influence felt. The permanent and crowded display of all our art possessions, characteristic of the modern European and, I regret to say, colonial home, is a practice which should not be followed in our schools.

Unquestionably the best form of illustration for all educational purposes is the limelight picture. In this we have absolute truth of form, rendered often with such beauty that the emotion created by their proper use is equal to that produced by the work itself. I say "proper use," for no educational medium has been and is so much abused as this. It should never be used except by those who have mastered thoroughly the subject to be illustrated. From the earliest days of civilisation until the artistic chaos of modern times the arts of architecture, sculpture, and painting have been used equally with literature as a means of expression by all peoples; so that the art-works a nation produced give as clear and oftentimes a much clearer and truer conception of their habits and customs, their thoughts and feelings, their migrations and conquests, than can be obtained from their written historical records. In regard to all ancient nations it is the monuments and the fragments of their works which have to be studied in order to elucidate or verify the facts as recorded in histories; and the story of modern nations is told by their works with no less truth and clearness. Especially is this true in respect of our own nation, for English art from Saxon to Tudor times forms a perfect and complete chapter of history, with a wealth of illustration and detail such as can be nowhere else found.

By the study, therefore, of the historical development of art not only will a clearer and truer conception of the history of nations be gained, but by studying the geographical distribution of their works in conjunction with the works themselves a far more accurate mental picture can be formed of the different portions of the world's surface and their relation to each other than can be formed in any other way.

Environment, if not the chief, is certainly a most important factor in the development of a nation, and to clearly understand the art which reflects that development the physical and social conditions under which it grew must be carefully studied. Therefore, geography, history, and art form but one complete course of study that can be so graduated that it shall appeal strongly to the imagination of all pupils and students from the earliest to the latest school or college days.

That an appeal should be made to the sense of sight as well as to that of hearing in the study of history is recognised by the introduction of illustrations in our later history-books; but here, as in the introduction of pictures into schools, they can serve no useful purpose—firstly, because in nearly all cases they are so inferior that the beauties of art they are supposed to represent cannot possibly be appreciated from their study; and, secondly, as already stated, the faculties are jaded by looking at illustrations without knowledge sufficient to understand them or the work they represent. And, moreover, it will be noted that the history is not approached through the study of art, but art is merely added in the attempt to give attractiveness to the written page, with which the illustrations have but rarely any direct relation.

I have said that it is through the medium of art that these among others of our school subjects can receive added interest —that is to say, that the development of art-forms should become a central line of study, into which should be interwoven all others capable of giving unity and strength to the whole. If studied in the manner suggested, art might again, as in the past, take its rightful place among us—it might be raised to the true appreciation such study would give, to as high a standard as ever before. More than this cannot be; for, while science is ever progressive, ever rising higher and higher as the coral reef in the ocean on the foundations laid in past ages, the spirit of the nation causes art to rise and fall as the waves around it—no crest rising higher than those which have passed away.

No. 4.—MODERN METHODS OF LANGUAGE-TEACHING.

By Professor T. G. R. Blunt, M.A.

[*Abstract.*]

According to the latest ministerial utterances in Germany, France, and America, language-teaching has for its objects the effective acquisition of languages for three distinct purposes—(*a*) practical needs, (*b*) literary studies, (*c*) scientific pursuits. The second and third of these have existed for many years in a constantly increasing ratio: how far is it advisable to turn our attention to the first?

The objection usually urged is that the spoken tongue, especially in Australasia, is rarely required. The reply to this is that a knowledge of the spoken tongue *is* required by a growing number of Australasians who continue their studies in Europe. But the point chiefly to be noticed is that the full educational value of languages is not realised without a knowledge of how to speak them. Educationists of the Renaissance and later fully recognised this, and insisted on the speaking of Latin and Greek. When the latter ceased to be spoken they lost much of their educational value. Moreover, Latin and Greek are not well adapted for modern scientific discussions or theses, a fact recently recognised officially in France. Nations a large portion of whom are naturally "bilingual" show a greater alertness of intellect than those who are not—notably the Swiss. Note, in passing, that a knowledge of a spoken language should not be fostered to the detriment of its grammar; there is a tendency towards this in America.

Unity of tongue is a most important feature in preserving unity of empire. The degeneration of Latin helped to break up the Roman Empire. The development of an American accent has helped to keep the United States and the British Empire apart. It is noted by several authorities that an Australasian dialect is developing. The unity of the English tongue throughout the Empire may be promoted or preserved by teaching children how to form language-sounds. This teaching is more likely to be successful when inculcated in the case of foreign tongues as the mother-tongue is learnt at home rather than at school, and children are therefore disinclined to accept innovations taught at school—that is to say, an indirect method of teaching how to produce English sounds is likely to be more successful than a more direct method.

The study of the physiological character of sound-production as employed in human speech is making rapid strides.

One most important hypothesis is now generally accepted—namely, the intimate connection existing between the organs of speech and the organs of hearing; an uneducated person actually hears, for example, words which begin with an *h* not in the way in which the word is actually sounded, but in the way in which the hearer is accustomed to sound the word. In the case of a foreign language no amount of hearing the language correctly spoken, no amount of mere repetition by the teacher, will have the desired effect unless the pupil be taught by methods which physiological knowledge alone can give to form a sound for himself in the first instance: "There can be no doubt that flexible organs well trained together with only an average ear will yield better results than even an exceptionally good ear without organic training" (Professor Sweet). *Cf.* also M. Michel Bréal and others.

A child of ten (*circa*) will have learnt its mother-tongue by methods of which the following is a summary:—

1. The adult has transmitted a vocabulary to the child with no other explanation than the association between the object and its name.

2. The adult has transmitted the vocabulary without reference to any order.

3. The variation of words, grammar, and so forth, have been similarly transmitted.

4. The words have been transmitted orally.

5. The child, having received these elements, assimilates them, and thereby expresses its own thoughts.

Thus, then, in teaching the child of ten (*circa*) a new language, the following order should, logically, be observed:—

(*a*.) Explanation of vocabulary.

(*b*.) Training of organs of speech.

(*c*.) Training of judgment.

(*d*.) Training in grammar.

As regards (*a*), in France ministerial instructions have decreed that beginners shall master things appertaining to the school, the human body and its requirements, the house and family, numbers, seasons, and the temperature. Grammar should be taught *pari passu* with vocabulary, the grammatical names being given and explained only when the forms themselves have been thoroughly grasped. [NOTE.—In certain points, such as the use of prepositions in German, a great deal of the initial difficulty may be eliminated, and consequently greater initial speed obtained, by making use of the above method.]

As regards (*c*), the pupil should be made to express his own ideas in the foreign tongue without the intervention of the mother - tongue. Beginning with mere repetition, the teacher goes on to require simple variations until the pupil has at hand the elements of the means of delivering a judgment.

As regards (*b*), a careful use of the phonetic system is absolutely necessary. The initial labour spent in acquiring familiarity with a set of phonetic symbols is of the nature of expenditure upon a labour-saving contrivance—*e.g.*, a sewing-machine. It acts radically and goes straight to essentials. "The separate sounds must be learnt with just so much correctness that the speaker can dispense with substitutes drawn from his own language." If this much has been achieved, the result will satisfy a native that the foreigner has really learnt his language; he will probably not "speak like a native," or, at all events, only now and again in a short sentence; but he can, and will, really talk the new language, and not substitute for it a disgraceful sham.

As regards the tendency to teach colloquial forms of speech, such authorities as Passy, Beyer, and Koschwitz have protested against this. We have every right to be as conservative as old-fashioned people in France and Germany. The whole matter may be summed up in M. Passy's dictum, "Aux étrangers je recommande, en cas de doute, les formes les plus saignées."

In teaching a new language a phonetic transcript is indispensable. For beginners a year should be devoted to purely oral work and work by means of phonetic transcripts. Two terms might be sufficient for unusually intelligent children. In proceeding to the upper classes tests may be allowed consisting of a number of short prose passages, stories, or historical facts set forth in an interesting fashion. The pupils will have their books open before them, the teacher will read the selected passage slowly and distinctly, explaining every word which presents the least difficulty, and adding examples. The pupils will then close their books and reproduce the sense of the passage in the foreign language. They may occasionally be allowed to reproduce it in their own language.

As regards home-work, all oral exercises may serve as written exercises.

In Australasia our immediate aim must be to secure more widespread understanding of modern methods by teachers, and recognition of those methods in examination. In France and Germany ministers of education have the control of what shall be taught in secondary schools, and how; and they exercise that control with conscientious care, instructing teachers what to avoid, without trammelling their initiative. Here the corresponding control is vested, indirectly but effectually, in the senates of the universities. Is it too much to hope for some recognition by them of what industry and science have done to raise the status of modern language-teaching?

No. 5.—NOTES ON THE TEACHING OF MATHEMATICAL GEOGRAPHY.

By G. Hogben, M.A.

No. 6.—NOTES ON THE USE OF PICTURES IN THE TEACHING OF GEOGRAPHY.

By G. Hogben, M.A.

No. 7.—SHORT SKETCH OF THE PRESENT NATIONAL SYSTEM OF EDUCATION IN NEW ZEALAND.

By G. Hogben, M.A.

No. 8.—THE TEACHING OF ELEMENTARY MATHEMATICS.

By G. Hogben, M.A.

[See No. 9, Section A.]

No. 9.—ELEMENTARY EDUCATION IN QUEENSLAND.

By John Shirley, B.Sc.

No. 10.—PHYSICAL CULTURE IN SCHOOLS AND COLLEGES.

By F. A. Hornibrook.

No. 11.—EDUCATIONAL REFORM.

By Rev. A. C. Hoggins.

No. 12.—THE PLACE OF "FEELING" IN KNOWLEDGE.

By Ivo E. Bertram, M.A.

[*Abstract.*]

Life begins as mere sentiency—the earliest life is the life of feeling. The impulses of the nature clamour for satisfaction, and here the will emerges and is trained. Thought comes much later. When reason awakes it is the reason of a person with an inchoate character, with likes, dislikes, and tendencies that immensely influence thought. The primary element of feeling, being first in the field, colours and shapes the later development and profoundly affects the will and the reason. There is also a kind of reflex action which insures a deeper interest in what belongs to, surrounds, or engages us, akin to the law of protective colouring in insects and animals. It is this large composite element of feeling that explains the wonderful diversity of opinions and positions in life and thought—that forms, in fact, the "idols" of Bacon.

Hence no philosophy can assume the working of reason as a pure and insulated power, nor seek to attain truth, without taking into account the whole range of the nature. Pure reason can deal with abstract truth alone. The nearer you approach to the concrete the more imperative it is that the judgment shall proceed on the dictates of the whole nature. Practical men are guided by a kind of subtle instinct founded on a wide knowledge of human character and experiences of actual life. This "tact" is the product of long and varied intercourse with concrete life, in which moral insight and emotional sympathy have had a large part. Judgment is founded on moral feeling and sympathy conjoined with reason.

There appears the great necessity of developing the nature *pari passu*. Reason and will need cultivation. But too often the deepest element of all—feeling—is left disregarded. The training and mental history of J. S. Mill emphasize this tremendously.

Further, feeling must be given a recognised place in judgment. It may be easily distorted, but it brings into the field a real factor, and no judgment can be true that rules it out. To carry the demands of abstract methods into concrete life means inevitable error and misrepresentation.

The success of modern school methods is due to the recognition of this. The appeal is made to the sensuous interest, which is the first real life of a human being.

Feeling plays a most important part in moral understanding and advance. A certain flow of feeling is necessary to prepare the mind for the reception of moral truths as living forces and motives. "The understanding is no motive," Aristotle declared; but when emotions are stirred they move the will and carry the intellect forward with them.

In philosophy and religion the place of feeling is very prominent. Schleirmacher's conception of desire—feeling moving out into action—has coloured all later thinking. In religion feeling has necessarily a large place, since love is its base, its inspiration, and its consummation. It is noticeable that every time of renewed religious interest is a time of song. Feeling is the first impulse to comprehension of great realities, and afterwards becomes the expression of it. In tidal rivers a ship may be heeling over on the sands; but with the flood tide she rights, floats off, and sweeps out to the infinite sea. So with human souls. The flood tide of feeling lifts them off the shallows, and bears them into fuller and wider relations.

REPORTS OF RESEARCH COMMITTEES.

REPORTS OF RESEARCH COMMITTEES.

No. 1. REPORT OF THE COMMITTEE FOR RECOMMENDING A UNIFORM SYSTEM FOR THE NOMENCLATURE OF THE IGNEOUS ROCKS OF AUSTRALASIA.

This committee was elected at the meeting of the Association held in Hobart in January, 1902, and was instructed to report at the present meeting upon the practicability of the adoption of a uniform nomenclature for Australasian igneous rocks.

Not only are identical names frequently used in the different States for different rocks, but different names are also used for identical rocks, and the confusion in the application of even well-known names is considerable. If, therefore, some degree of uniformity be attainable, it must be recognised by all of us as highly advantageous.

The object which the committee has had in view has been to ascertain what measure of inter-State agreement is possible, and with this view lists of well-known rock-names with definitions given by the best authorities have been circulated among its members, who have been asked to signify in what sense they use these names or any others which may suggest themselves.

Unfortunately, various circumstances have prevented seven members of the committee from furnishing full statements. The statements now presented emanate from nine members, of whom one (Captain F. W. Hutton) represents New Zealand, one (G. W. Card) represents New South Wales, one (Professor Gregory) represents Victoria, two (W. H. Rands and W. A. Macleod) represent Queensland, one (Mr. Woolnough) represents South Australia, and three (W. F. Petterd, George A. Waller, and W. H. Twelvetrees) represent Tasmania.

The following rock-names, eighteen in number, have been considered by the committee: Obsidian, pitchstone, rhyolite glass, tachylyte, rhyolite, quartz porphyry, felsite, granophyre, microgranite, eurite, granite porphyry, granitite, lamprophyre, porphyrite, basalt, melaphyre, dolerite, diabase.

Five names (obsidian, pitchstone, rhyolite, basalt, dolerite) have been unanimously accepted, and one (granophyre) has been unanimously rejected. Agreement has therefore been found to exist to the extent of 33 per cent. of the terms submitted. But before any final decision can be arrived at it will be necessary to be assured that the meanings attached to each name by the members are absolutely identical.

As indicated, there is a general agreement to abandon "granophyre," and there is a disposition to use the adjectival form only in describing structure. Professor Gregory says, "Use only 'granophyre' for structure." W. A. Macleod says, "Reject; simply a granophyric quartz porphyry." G. A. Waller prefers the term "micropegmatitic quartz porphyry." Petterd and Twelvetrees use it only in a structural sense for granophyric quartz porphyry.

The names most in disfavour are "melaphyre," "microgranite," "eurite," and "granitite." The votes in favour of these may be tabulated as follows:—

Melaphyre.	*Eurite.*	*Granitite.*	*Microgranite.*
Petterd. (T.)	Hutton. (N.Z.)	Gregory. (V.)	Gregory. (V.)
Twelvetrees. (T.)			
Waller. (T.)			

With reference to *melaphyre,* Professor Gregory says, "Have never used it, because of the strong prejudice against it, but logically see no objection to its use for altered basalts; analogous to porphyrite in relation to andesite, but practically there is no advantage in use of name as in other altered igneous rocks." Petterd and Twelvetrees say, "Essentially the same rock as basalt, but bearing the impress of the changes due to age. We do not attach any age-signification to the name. The term is in general use and it is easily understood. We fail to see any advantage in changing it to 'metabasalt,' even if the latter be more expressive."

Microgranite.—This name is used by Professor Gregory for fine-grained non-porphyritic granite dyke rocks, but it is rejected by other members. Petterd and Twelvetrees have, however, applied it structurally to microgranitic quartz porphyry. W. A. Macleod, in discarding it, says, "It is a microscopic term referring to the ground-mass of a variety of quartz porphyry." G. A. Waller prefers to use "microgranular quartz porphyry" and "microgranular felsite," denoting quartz porphyries and felsite in which the groundmass is microgranular.

Eurite.—F. W. Hutton retains this = microgranite. G. W. Card would like to use it, but considers it best to abandon it, as not generally utilised. Professor Gregory regards it as a synonym of microgranite, which he defines as "fine-grained dyke rock, same composition as granite porphyry, but not porphyritic." W. H. Rands replaces "eurite" by "felsite." W. A. Macleod does the same. G. A. Waller substitutes "quartz porphyry." Petterd and Twelvetrees say, "The term appears unnecessary, as the names 'granite,' 'quartz porphyry,' and 'felsite' cover the whole ground."

Granitite.—This is retained only by Professor Gregory, who says, "Granitic texture, rock of quartz, alkali felspar, and biotite (no muscovite)." G. W. Card, W. A. Macleod, G. A. Waller, W. F. Petterd, and W. H. Twelvetrees propose "biotite granite" as a substitute.

The remaining names which have been under consideration are as follows:—

Diabase.—The retention of this name is favoured by Messrs. Gregory, Hutton, Rands, Waller, Petterd, and Twelvetrees, and as a field term only by W. A. Macleod. G. W. Card "would prefer not to use it at all, but if retained it should be equivalent to altered dolerite." Petterd and Twelvetrees say, "Essentially the same as dolerite, but altered by chloritisation. Hence in large masses partly fresh, partly altered—there is a difficulty in applying either of the names. We have followed European usage in applying the name 'diabase' to the massive, partly altered mesozoic dolerite of Tasmania, and use the term 'dolerite" parenthetically. 'Diabase' has the advantage of being understood abroad, while 'dolerite' has more than one meaning. Dolerite is chloritised to such an extent throughout the world that the altered rock seems to need a name. If 'melaphyre' be retained for altered basalt, 'porphyrite' for altered andesite, 'quartz porphyry' for altered rhyolite, then 'diabase' can very well be applied to altered dolerite."

Tachylyte.—This name is favoured by Professor Gregory and W. A. Macleod for basic glass. Messrs. Card, Waller, Petterd, and Twelvetrees prefer "basalt glass."

Porphyrite.—This, too, is a debateable term. It is favoured by Messrs. Waller, Petterd, Twelvetrees, and Professor Gregory, but rejected by Messrs. Hutton, Card, and Macleod. Professor Gregory says, "Altered andesite and dacite." Petterd and Twelvetrees say, "The changes in the rock which distinguish it from fresh andesite are oxidation, chloritisation, and devitrification."

Granite Porphyry.—This is supported by Messrs. Gregory, Macleod, Waller, Woolnough, Petterd, and Twelvetrees. It is discarded by G. W. Card, and has not been used by W. H. Rands. Mr. Card says, "It seems superfluous, is generally covered by 'quartz porphyry.'" Members are apparently not agreed upon their definitions of the term. W. A. Macleod says, "This is a porphyry in which the chief phenocrysts are quartz and mica—two of the leading constituents of granite." Professor Gregory says, "A dyke rock of porphyritic granite (*i.e.*, alkali-felspar, quartz, muscovite, and biotite)." G. A. Waller says, "Quartz porphyry with a macrogranular ground-mass." Petterd and Twelvetrees define it as "a porphyritic granite dyke rock, consisting of a quartz-felspar ground-mass, with potash and lime, soda, felspars, and quartz as phenocrysts. In the ground-mass, mica, hornblende, and pyroxene are often present, and the same minerals may also be found among the porphyritic constituents. The Cornish elvans are granite porphyries, rich in muscovite. Granite porphyries form dykes of enormous length in granite and the neighbouring rocks. Granophyric and microgranitic structures occur in these porphyries, and sometimes a felsitic ground-mass, making it difficult in such cases to distinguish them from quartz porphyries. The SiO_2 per cent. of quartz porphyries is usually smaller."

Rhyolite Glass.—This term is favoured by Professor Gregory, G. W. Card, G. A. Waller, W. F. Petterd, and W. H. Twelvetrees. It is rejected by W. A. Macleod, who would replace it by "obsidian" or "pitchstone." Professor Gregory says, "= obsidian, acid glass, vitreous lustre." G. W. Card says, "Use it as a general term covering 'obsidian,' 'pitchstone,' &c., which should be retained as very general popular descriptive terms only." G. A. Waller suggests "hydrous" and "anhydrous rhyolite glass" for "pitchstone" and "obsidian," using the latter names only prior to exact determination of any acid glass. Petterd and Twelvetrees say, "'Rhyolite glass' covers obsidian and pitchstone. Obsidian = anhydrous rhyolite glass with vitreous lustre and conchoidal fracture; pitchstone = hydrous ryolite glass with resinous lustre and splintery fracture."

Lamprophyre. Six members only express an opinion on this term. Four of these use it in the Rosenbuschian sense. Mr. G. W. Card says, "It seems to supply a real need if used as a broad group-name, Harker's sense." Professor Gregory says, "I use it in Rosenbusch's sense, including the minettes and kersantites." Petterd and Twelvetrees say, "We understood it to comprise syenitic (minette, vogesite), dioritic (kersantite, alnoite) dyke rocks, with dominant ferromagnesian minerals (biotite, augite, hornblende), orthoclase, plagioclase, or the felspathoids. The term 'mica trap' is applicable to many of them, but biotite is absent from vogesite and odinite, and it does not cover the felspathoid members. 'Lamprophyre' is a convenient general name for the entire series, but includes widely different rocks." W. A. Macleod says, "An intermediate to basic porphyritic rock; chief phenocrysts, biotite, augite, and hornblende." F. W. Hutton suggests "aphanite," and defines it as "a microcrystalline compound of plagioclase and one or more ferromagnesian minerals; often porphyritic."

Felsite.—This term is rejected by F. W. Hutton. Professor Gregory and G. W. Card abstain from expressing an opinion. The remaining six members adopt it. W. A. Macleod says, "An acid to intermediate stony to semi-vitreous, non-porphyritic rock." Mr. W. H. Rands uses it in the place of "eurite." G. A. Waller says, " = quartz porphyry in which the phenocrysts are absent, or present only in small quantities." Petterd and Twelvetrees say of quartz porphyry and felsite, "The same as rhyolite, but altered by oxidization and devitrification. We would call it felsite when no phenocrysts are visible to the eye. If the quartz porphyry has a felsitic ground-mass, the term 'felsaphyre' or 'felsitic quartz porphyry' is applicable; if a granophyric ground-mass, 'granophyre' or 'granophyric quartz porphyry'; if a microgranitic ground-mass, 'microgranite' or 'microgranitic quartz porphyry.' In some quartz porphyries the only phenocrysts are those of felspar. For such the name 'felspar porphyry' seems the only one available. The rock occurs as volcanic sheets and their accompanying dykes or small intrusions. Sometimes granite porphyry dykes and apophyses of granite masses take on a quartz-porphyry facies."

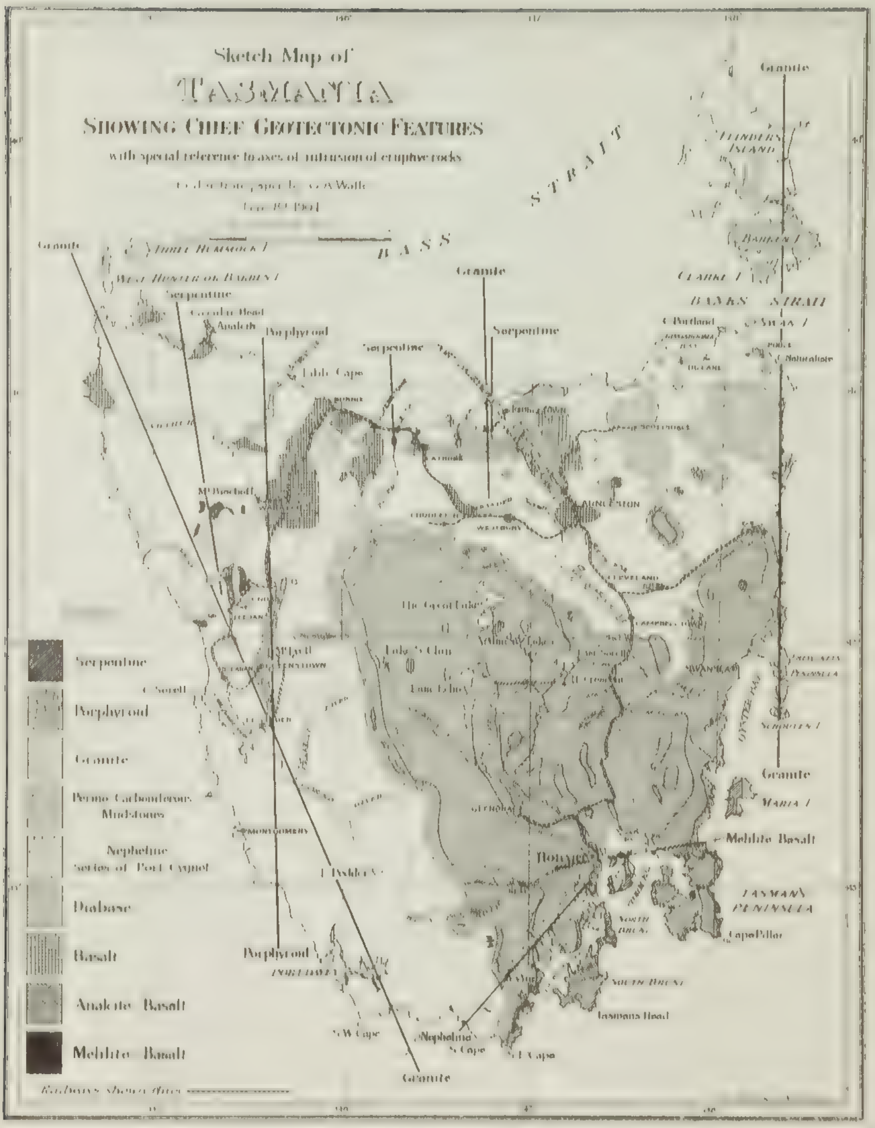
Quartz Porphyry. F. W. Hutton suggests "eurite" in lieu of this term, and W. H. Rands "quartz felsite." The other members agree in retaining "quartz porphyry." Dr. Gregory says, "Acid dykes with glassy base and phenocrysts of quartz and orthoclase." G. W. Card says, "I would retain it as a most convenient general field name, although it must overlap rhyolite." W. A. Macleod says, "A porphyry in which the phenocrysts are chiefly quartz." G. A. Waller says, "I consider that there is need of both 'rhyolite' and 'quartz porphyry,' the latter representing altered (devitrified) forms of the former. 'Quartz porphyry' is one of the few rock-names that are generally understood and correctly applied by mining-men, and I think that it would on that account alone be inadvisable to change it. Also it is very often of local convenience to the geologist to have two terms to represent rocks of different ages, even though these may have been originally identical. Again, if we abandon 'quartz porphyry' because it is an altered rhyolite, why not abandon 'serpentine' because it is an altered peridotite, or, to take an extreme case, why not abandon the names 'shale,' 'slate,' 'schist,' &c., because they are altered clays? These remarks also apply to the terms 'porphyrite,' 'melaphyre,' and 'diabase.'"

The above remarks of members are quoted in order that Australian geologists may be in possession of the opinions of their colleagues, and as a first step towards making mutual agreement possible

Some of the members have submitted additional names for the consideration of the committee, as follows: W. A. Macleod, tonalite; F. W. Hutton, orthophyre, propylite; Petterd and Twelvetrees, diorite, limburgite, aplite. There has not been time to obtain the views of the members upon these names, but if the work of the committee be continued it will be advisable to discuss them.

It must be understood that there has been no opportunity for members to discuss the several views expressed. In view of the divergencies of opinion which have been disclosed, the committee does not consider it possible at present to bring up a report recommending any definite system of nomenclature. It suggests, however, that the effort which has been begun in this direction be continued, and that this or a similar committee be instructed to report progress at the next meeting of the Association.

The vexed question of classification has not been touched. Although intimately associated with that of nomenclature, it seems at present to be outside the bounds of possible agreement, and its discussion would probably be fruitless.


Sketch Map of
TASMANIA
SHOWING CHIEF GEOTECTONIC FEATURES
with special reference to axes of intrusion of eruptive rocks
BASS STRAIT
BANKS STRAIT
FLINDERS ISLAND
Granite
Serpentine
Porphyroid
Analcite
Table Cape
LAUNCESTON
The Great Lake
Lake St Clair
HOBART
TASMAN PENINSULA
Cape Pillar
Tasmans Head
Nepheline
S.W. Cape
Melilite Basalt
Maria I
Perme Carboniferous Mudstones
Nepheline series of Port Cygnet
Diabase
Basalt
Analcite Basalt

No. 2.—REPORT OF THE GLACIAL COMMITTEE.

Members: Captain F. W. Hutton, F.R.S.; E. G. Hogg, M.A.; A. Gibb Maitland, F.G.S.; W. H. Rands, F.G.S.; R. M. Johnston, F.S.S.; G. Sweet, F.G.S.; W. H. Twelvetrees, F.G.S.; W. Howchin, F.G.S.; Professor Gregory, F.R.S.; and Professor T. W. E. David, F.R.S. (Secretary).

The committee has this year received three reports—two for Tasmania, respectively by Messrs. W. H. Twelvetrees and G. A. Waller, and one for West Australia by Mr. A. Gibb Maitland. Messrs. Twelvetrees and Waller's conclusions quite confirm the earlier views of Mr. T. B. Moore*—viz., that during the last glaciation of Tasmania, in late Cainozoic time, the glaciers on the west coast of that island came down to within at least from 200 ft. to 300 ft. of sea-level. This interesting evidence suggests that, if in Tasmania in latitude 42 deg. S. the glaciers came down in late Cainozoic time close to sea-level, in Australia in latitudes such as that of Kosciusko, 36.4 deg. S., the ice probably came down very much nearer to sea-level than the lowest limit to which traces of glaciation have as yet been traced—viz., 5,800 ft. above the sea. This suggests the need for careful search for traces of late Cainozoic glaciation in the high lands of New South Wales and Victoria. The following is Mr. Waller's report:—

NOTES ON RECENTLY OBSERVED EVIDENCES OF GLACIATION ON THE WEST COAST OF TASMANIA.

By G. A. Waller, Assistant Government Geologist, Tasmania.

North Dundas, Rosebery, Pieman River.—The evidence of glaciation in the valley of the Ring River in the vicinity of Williamsford (formerly Deep Land), to the west of Mount Read, was first noted by Mr. A. Montgomery, formerly Government Geologist in Tasmania. The direction of flow of the old glacier is believed to be directly opposite to that of the present head-waters of the Ring River—namely, almost due north. The Ring River now takes its source from a high ridge of boulders which appears to be blocking up an old valley which originally was continuous from Williamsford to the Pieman River, and separated Mount Read from the Colebrook Hill. This deposit appears to have dammed back the old Ring River, forming a lake on the south side, which found an outlet around the south ends of the Colebrook Hill. This outlet has now become the main channel of the Ring

* Proc. Roy. Soc. Tasmania, Vol. iv., 1893 (1894), pp. 147–49.

River, and has cut itself down and drained the lake. The evidence of the former existence of the lake is afforded by a large deposit of soft shales and clays, forming an extensive flat to the south of the ridge of boulders. It is unfortunate that no organic remains have yet been found in these shales.

The evidence of glaciation, apart from the huge deposit of boulders at the head of the Ring River, consists of the presence of large quantities of boulders, principally red sandstones and conglomerate, which are strewn all along the lower western slopes of Mount Read and the eastern slopes of the Colebrook Hill. Many of these boulders are as much as 6 ft. or 8 ft. in diameter. Along the road from Williamsford to Rosebery several boulders exhibiting grooves and striæ of unmistakable glacial origin have been observed. In the road-cuttings numerous beds of "till" are exposed, exhibiting the characteristic unstratified and unclassified structure. These deposits may be observed over an area of from a quarter to half a mile wide and four miles long. They extend from a little south of Williamsford in a northerly direction as far as the Pieman River, the valley of which appears to have been one of the main arteries of the system of glaciers which traversed this portion of the west coast.

The source of the boulders of red sandstone and conglomerate at the head of the Ring River presents some points of interest. Precisely the same rock occurs as a capping of many of the mountains to the east and south-east of Mount Read. It overlies unconformably the Silurian schists, felsites, &c., of Mounts Murchison, Tyndall, Sedgwick, Lyell, Owen, and Darwin, but it has not been observed on Mount Read. It seems probable that the boulders have, however, come from Mount Read, but that the whole of the original conglomerate capping has been removed by denudation.

All around Rosebery and the southern slopes of Mount Black there are similar evidences of glaciation. In the north-west portion of Section 62, 93 G.L., belonging to the Primrose Mining Company (No. 1), a portion of an old moraine has been uncovered by a party of gold-miners. This moraine appears to cross the spur diagonally. It cuts off the Primrose lode sharply to a depth of at least 30 ft., at which depth the till was struck in a drive at a point almost immediately below the spot where it was cut off at the surface. This is unmistakably glacial in origin, consisting as it does of boulders of all sizes up to 2 ft. 6 in. diameter, irregularly imbedded in a gritty dark-coloured cement or till. This till is more compact, and has the appearance of greater age than the beds exposed on the road from Williamsford to Rosebery. The boulders are mostly schist and keratophyre, and most of them are much decomposed.

Numerous boulders and pebbles of fresh keratophyre have been found throughout the Rosebery district, showing ice-markings very distinctly. One of the most easily accessible deposits may be observed in a cutting just to the north of the Rosebery Railway-station. Numerous other deposits may be seen along the Emu Bay Railway to the west of Rosebery, along the south bank of the Pieman River. The prevailing rocks represented consist of the red sandstones and conglomerates, schists, felsites, and keratophyres. Occasionally one meets with a boulder of Mesozoic diabase, the nearest known locality from which this rock could have come being the top of Mount Dundas.

The evidence of the glacial origin of these boulder-beds on the banks of the Pieman River is based upon the general appearance of the deposits. There is no regular structure observable, boulders of all sizes being irregularly distributed. The beds are about 200 ft. above the present level of the Pieman, and from 700 ft. to 800 ft. above sea-level. Ten miles lower down the river, at the Stanley Crossing, boulder-beds of somewhat similar character have been observed, though they are not sufficiently well exposed to be diagnosed with certainty; these beds are from 200 ft. to 300 ft. above sea-level.

Henty River.—On the Zeehan - Strahan Railway for about two miles north of the Henty River many of the railway-cuttings have been made in boulder-beds of probably glacial origin. The boulders consist largely of white sandstone, most of which is probably of Permo-carboniferous age, and of quite local origin. Numerous other boulders are composed of what appears to be a highly decomposed basic eruptive, probably connected with the gabbros which occur abundantly some miles further north, to the south of Mount Humskirk. A number of boulders of Mesozoic diabase have also been observed, some of these being at least 3 ft. or 4 ft. in length. It is possible that this rock occurs *in situ* to the north of the railway. Several specimens have been brought in from here, but it is not known definitely whether the rock is really *in situ*. It is noticeable that many of the boulders in these deposits certainly are, and all may be, of quite local origin. The red sandstone and conglomerate boulders, which are common in most of the glacial deposits, are absent here. The deposits have a decided glacial appearance, though definite evidence in the form of ice-marked stones is so far wanting.

Zeehan.—Definite evidence of the existence of glacial deposits has recently been found to the north-west of the Town of Zeehan. To the north of the Oonah Hill there is a belt of heavily timbered country about 10 to 20 chains wide and half a mile long, stretching away in a westerly direction towards the old Doric Mines. This belt of timber proves to be the covering of a detrital deposit consisting of boulders and pebbles imbedded in a fairly compact cement. From an old prospect hole which was put down in this cement to the west of the timber a number of pebbles were collected showing unmistakable evidence of ice-action. Some were scored in several directions with the characteristic parallel grooves and striations. Others exhibited flattened surfaces evidently produced by grinding against other rocks while firmly imbedded in the ice. The till also is quite characteristic. The pebbles consist largely of sandstone or quartzite, micaceous schists, and micaceous quartzites; pebbles resembling the keratophyre at Mount Read were also observed, but these have not yet been critically examined. There are said also to be large boulders of granite in some of the till, and these at one time led to some prospecting being done for tin. The country to the north of this deposit consists of undulating button-grass hills, composed of siluriate slates and sandstones covered by not more than a few inches of soil. The creeks are remarkably free from detrital matter of any kind. To the north-east, however, along the western tramway, a quite similar till outcrops. It forms a terrace on the side of a button-grass spur. Further north on the pack-track to the Stanley River many similar deposits may be observed for a distance of two miles after leaving the western train. This till is unmistakably glacial, and bears no resemblance to river deposits. It is more compact and has the appearance of greater age than the deposits in the Read-Rosebery district. It is quite evident that the whole of this country to the east of Mount Humskirk has at one time been covered with ice, and that the deposits which have been observed are merely fragments of a very extensive formation, most of which has been removed by denudation. The height of these deposits above sea-level is from 600 ft. to 1,000 ft.

Note by Secretary.

The glacial deposits of the west coast of Tasmania, described in the above paper by Mr. Waller, are evidently all of very late Cainozoic age, with the possible exception of the till at the Primrose Company's mine. The fact that boulders of Mesozoic diabase were found by Mr. Waller to be associated with the till along the south bank of the Pieman River to the west of Rosebery, and also in the glacial beds of the Henty River, is obvious proof that these glacial beds are of much later origin than the Permo-carboniferous glacial beds of Tasmania, such as those described by E. J. Dunn* and Pro-

*Proc. Roy. Soc. Vict., new series, Vol. vi. (1894), pp. 133–38, and pl. viii.

PHOTOGRAPH OF BOULDER BED IN THE CARBONIFEROUS ROCKS, WYNDHAM RIVER, WEST AUSTRALIA.

fessor E. G. Hogg* at Little Peppermint Bay, Tasmania, and by A. E. Kitson† at Table Cape. It is highly probable that the newest of these glacial beds in Tasmania are of Post-tertiary age, and are homotaxial with the recent evidences of glaciation recorded at Kosciusko, New South Wales.‡

NOTE.—Since the Dunedin meeting of the Association an important paper on the glacial geology of Tasmania has reached the Secretary, read before the Geological Society of London by Professor Gregory.§ His views as to the glacial ice having come close down to sea-level in late Cainozoic time quite accord with those of Messrs. Moore, Twelvetrees, and Waller. Professor Gregory concludes (*op. cit.*, p. 52), "Some of the glaciers may have actually reached sea-level."

REPORT II.—WESTERN AUSTRALIA.

Mr. A. Gibb Maitland, F.G.S., the Government Geologist of West Australia, has sent a few notes about the evidence of Permo-carboniferous glaciation of West Australia. His important discovery of glaciated boulders near the Tropic of Capricorn in West Australia is reported in the paper quoted below.‖

Good plates are given in Mr. Maitland's Geological Survey Report of the ice-scratched boulders. Plate 6 of Bulletin No. 10 of the Geological Survey of West Australia (By Authority, Perth, 1903) shows the principal outcrop of the glacial conglomerates from near the Tropic of Capricorn at the Minilya River southwards for a distance of over a hundred miles, across the Lyons, Wyndham, Gascoyne, and Wooramel Rivers. The accompanying plate shows the general appearance of the boulders weathered out of the Carboniferous rocks at the Wyndham River.

Mr. Maitland has also identified the glacial boulder-beds at the Irwin River. He finds at the last-mentioned locality that their horizon is low down in the Carboniferous system.

With regard to the exact geological horizon of the West Australian Permo-carboniferous glacial beds, reference might here be made to Bulletin No. 10 of the Geological Survey, West Australia.¶ On plate 6 of this work the approximate

* "The Glacial Beds of Little Peppermint Bay, Tasmania." Annual Report of Secretary of Mines for Tasmania, 1900-1. Also see Rep. Austr. Ass. Advt. Sci. Hobart, 1902, p. 192.

† Proc. Roy. Soc. Vict., new series, Vol. xv. (1902), pp. 28–35. Also see Rep. Austr. Ass. Advt. Sci. Hobart, 1902, pp. 193-94, and plate facing p. 192.

‡ "Geological Notes on Kosciusko, with Special Reference to Evidences of Glacial Action," by Professor David, Richard Helms, and E. F. Pittman. Assoc. R.S.M. Proc. Linn. Soc. N.S.W., 1901, pt. i., pp. 26 74, pls. iii.–ix.

§ "A Contribution to the Glacial Geology of Tasmania," by Professor J. W. Gregory. Q.J.G.S., Vol. lx., pt. i., pp. 37–53, pls. vii.–viii.

‖ Annual Prog. Rep. Geol. Sur. West Australia for Year 1900, p. 28. See also Rep. Austr. Assoc. Advt. Sci. Hobart Meeting, Vol. ix., 1902, pp. 200–201.

¶ "Descriptions of Carboniferous Fossils from the Gascoyne District, Western Australia," by R. Etheridge, jun. By Authority. Perth, W.A., 1903.

position is shown of the "Carboniferous glacial conglomerate." Mr. Etheridge speaks (*op. cit.*, p. 1) thus as to the geological horizon: "The facies of the fossils is purely Carboniferous." Mr. A. Gibb Maitland states in his prefatory note to the same work: "The Carboniferous rocks of the Gascoyne district form part of a very extensive formation which covers a wide area of country in Western Australia, and which bids fair to become of considerable economic importance. . . . In the Gascoyne district the beds consist of sandstones, shales, limestones, and conglomerates. Near the base of the series is a well-marked boulder-bed, showing undoubted evidences of glacial origin. The boulder-bed is made up of a heterogeneous collection of all varieties of crystalline rocks, together with many very large flat-sided boulders of granite. This bed, which forms a very valuable stratigraphical horizon, has been traced across country for a distance of about sixty miles. The Carboniferous rocks of the Gascoyne, although arranged in a series of gentle folds, have a prevailing dip to the west. The thickness of the series cannot at present be ascertained, though the bore now being put down at Pelican Hill, near Carnarvon, at the mouth of the Gascoyne, has shown it to be at least 1,600 ft. thick."

From these important statements it is clear (1) that Mr. Etheridge considers the whole of the Gascoyne district rocks as "purely Carboniferous," and (2) that Mr. Maitland considers the glacial boulder-beds of that district to be at the base of the Carboniferous rocks. If these conclusions are correct, then the West Australian glacial horizon under discussion is considerably older than the well-known horizon in the Permo-carboniferous rocks of eastern Australia and Tasmania, at such localities as Bacchus Marsh and Heathcote in Victoria, Lochinvar in New South Wales, and Table Cape and Mount Lyell districts in Tasmania. In this case the glacial beds of West Australia are to be correlated perhaps with the supposed glacial beds of the Queensland Carboniferous system, as recorded by Mr. B. Dunstan, F.G.S., as occurring at Windah, on the Mackenzie River, near Rockhampton.*

Possible evidence of ice-action in Australia in rocks as old as the Carboniferous in the form of boulders imbedded in the fine-grained Gympie strata of Queensland have been recorded by Mr. W. H. Rands.†

While at present the arguments for assigning a Carboniferous rather than a Permian or Permo-carboniferous age to

* "Report on the Geology of the Dawson and Mackenzie Rivers, with Special Reference to the Occurrence of Anthracitic Coal." Queensland Parliamentary Papers, C.A. 9, 1901, p. 10. (Folio, Brisbane, 1901. By Authority.) See also Rep. Austr. Assoc. Advt. Sci., Vol. ix., 1902, p. 202.

† "Notes on certain Boulders met with in the Beds and Reefs of the Gympie Goldfield, Queensland." Austr Assoc. Advt. Sci., Vol. i., 1887, pp. 297-99.

the Gascoyne district boulder-beds are very strong, the Secretary desires to point out that the following facts in favour of a Permo-carboniferous age for the beds should not be entirely overlooked: (1.) That, as pointed out to him by Mr. A. Gibb Maitland, the boulder-beds at the Irwin River conformably underlie at no great depth the limestones and coal-seams of that district, and the coal-seams are probably distinctly newer than Carboniferous. (2.) That, as regards the palæontological evidence, while such good Carboniferous types as *Productus semi-reticulatus*, *Orthotetes cremistria*, and *aulooteges* occur in the strata associated with the boulder-beds of the Gascoyne district, forms like *Strophalosia* and *Aviculopecten tenuicollis* also occur, and in the Irwin River area the foraminifer *Nubecularia*, so characteristic of the Lower Marine Permo-carboniferous rocks of New South Wales, is met with in abundance.

The following interesting problems may be suggested in connection with the interesting glacial evidences of West Australia: (1.) If the age of the glacial beds is Carboniferous rather than Permo-carboniferous, was it the case that the ice ages responsible for the glacial boulder-bed persisted in Australia (with perhaps interglacial epochs) from Carboniferous down to Permo-carboniferous time?

(2.) If the glacial boulder-beds of the Gascoyne and Irwin districts are homotaxial with those of Permo-carboniferous age in eastern Australia and Tasmania, was it the case that Carboniferous marine types lingered on in West Australia after they had become more or less extinct in eastern Australia, and had been partly replaced by Permian forms?

On the whole, the evidence at present seems to be strongly in favour of the Gascoyne and Irwin boulder-beds being older than Permo-carboniferous, which obviously makes Mr. Maitland's discovery all the more interesting and important.

No. 3. REPORT OF THE SEISMOLOGICAL COMMITTEE.

WESTERN AUSTRALIA.

A MILNE horizontal pendulum seismograph is installed at the Perth Observatory, and has been continuously at work during the period covered by this report.

The Government Astronomer, Mr. W. E. Cooke, communicates his seismograph-records to Professor Milne for publication in the Annual Report of the Seismological Committee of the British Association. No special events have been reported from this State.

QUEENSLAND.

No records available. There are no seismological instruments of any kind in this State so far as I know, nor any official channel through which seismic occurrences are systematically reported and registered.

NEW SOUTH WALES.

A Milne (horizontal pendulum) seismograph has been installed at the Sydney Observatory, but has not yet been started for systematic registration, owing probably to the indifferent state of health of the Director, Mr. H. C. Russell, which culminated in his recent severe illness. No seismic occurrences have been reported from this State.

SOUTH AUSTRALIA.

There are no registering instruments in this State.

Sir Charles Todd has furnished the accompanying list of earthquakes which were reported to him from observers in various parts of the State.

The most remarkable occurrence was the severe earthquake of the 19th September, 1902, in regard to which Sir Charles Todd supplies,—

(1.) His own report, with map showing distribution of seismic energy, and location of the epicentrum;
(2.) A report by Mr. E. H. Matthews, with diagrams;
(3.) A geological map of the region of the epicentrum by Mr. H. Tarlton Phillips;
(4.) Notes by Mr. H. Tarlton Phillips, with a geological map of the macroseismic region;
(5.) Press clippings giving a full descriptive account;
(6.) Supplementary list of shocks reported from various places on the 19th September;
(7.) Supplementary list of shocks felt at various places on the 19th, 20th, 21st, 22nd, and 24th September;
(8.) Supplementary list of shocks felt at various places on the 19th, 20th, 21st, 22nd, 24th, 25th, and 26th September, 1902; also on the 7th, 17th, and 22nd October, 1902.

VICTORIA.

A Milne (horizontal pendulum) seismograph has been continuously at work at the Melbourne Observatory since the 19th April, 1902. The instrument was made by Mr. R. W. Munro, of London, and is of the pattern recommended by the Seismological Committee of the British Association. It was installed in one of the underground rooms in the basement of the main building of the Observatory, following in every respect the instructions published by Professor Milne in 1901. The room is dry, well ventilated, and not subject to great changes of temperature, and the supporting brick pillar rests on very good foundation.

No difficulties were experienced in setting the instrument to work. The boom period was regulated at 16.5s., and no readjustment has as yet been required, the extreme range of variation being from 16.2s. to 16.8s. Occasional interruptions have been caused chiefly by stoppage of the driving-clock, stickage of registering-paper, failure of the light, or other accidental causes. The total aggregate amount of registration lost is about fifteen days in two years. The recentring of the boom plate by means of the graduated levelling-screw has been very frequently required, and generally in the same direction; but no other readjustment has been made on the boom since the commencement of registration.

A list of the principal movements registered by this instrument is supplied herewith. A list of earthquakes reported by observers in various parts of this and other States since the 1st January, 1902, is also supplied.

The principal seismic events of the last two years are the Warrnambool earthquakes of the 7th April and the 14th July, 1903. The effects of these disturbances were examined by Professor Gregory and myself, and a detailed survey of the damages was made at our request by the Town Engineer, Mr. Ross, assisted by the Shire Engineer, Mr. Cawley. A full report of this investigation will shortly appear in official publication.

RECOMMENDATIONS.

1. That one or more competent and influential members be added to the committee to represent Queensland.

2. That the Government of the State of South Australia be asked by the Council of the A.A.A.S. to enable Sir Charles Todd to procure and install a Milne seismograph at the Adelaide Observatory, and a similar one at Port Darwin.

3. That the Government of the State of Tasmania be asked to establish a Milne seismograph at the University or at the Weather Office.

4. That the Sydney Observatory be requested to start as early as possible the seismograph now installed at the Observatory.

No. 4.—REPORT OF COMMITTEE FOR RECORDING STRUCTURAL FEATURES, SUCH AS IMPORTANT FOLDS AND FAULTS IN AUSTRALASIA, WITH A VIEW TO STUDYING THE EVOLUTION OF THE AUSTRALASIAN LAND-SURFACE.

Members: Professor J. W. Gregory, D.Sc., F.R.S.; Messrs. W. H. Twelvetrees, F.G.S.; G. A. Waller; T. S. Hall, M.A.; H. Y. L. Brown, A.R.S.M.; Walter Howchin, F.G.S.; A. Gibb Maitland, F.G.S.; E. F. Pittman, A.R.S.M.; W. H. Rands, F.G.S.; W. J. Clunies Ross, B.Sc.; and Professor David, B.A., F.R.S. (Secretary).

Three reports were received from respectively Mr. W. H. Twelvetrees, F.G.S., the Government Geologist, Tasmania; from Mr. G. A. Waller, Assistant Government Geologist, Tasmania; and from the Secretary. The last is held over for the present, while Mr. Twelvetrees's views are chiefly embodied in the joint map by himself and Mr. Waller. The following is Mr. Waller's report:—

NOTES ON THE GEOLOGICAL STRUCTURE OF THE WEST COAST OF TASMANIA.

By G. A. Waller, Assistant Government Geologist, Tasmania.

The geology of the west coast is so complicated, the country so rough and heavily timbered, and in consequence the difficulty of making geological observations so great, that very little has so far been accomplished in the interpretation of the geological structure of the country.

For the present we must be content to record such facts as have been observed in the hope that this will lead to a more general recognition of the nature of the problem, and to the bringing-together of the observations made by all observers who have had the opportunity of carrying out geological researches on the west coast.

Geological Formations.

The geological formations which have so far attracted attention may be summarised as follows:—

(1.) *Pre-Cambrian*, consisting of quartzites, quartz-schists, crystalline mica-schists, and gneisses. These rocks probably occupy a very large area, though they occur in those parts of the coast which have been least explored. The general strike of the schists is believed to be a little to the north of east or nearly at right angles to that of all the other older formations on the west coast. They occur to the east of the "copper-schist belt" at Mount Lyell, and extend northwards to Mount Pelion, the Barn Bluff, Cradle Mountain, and the Dove River. North of this the country is largely overlaid with Tertiary basalt. Their presence has also been noticed as far south as Port Davey.

(2.) *Lower Silurian.*—The rocks which are usually referred to as Lower Silurian include the following groups: (*a*) The Gordon River group; (*b*) the Dundas group; (*c*) the copper-schist group. Of these only the first contains definite palæontological evidence as to age. The Gordon River limestones are highly fossiliferous, and have enabled Messrs. Gould and R. Etheridge, jun., to place the group definitely in the Lower Silurian. They are thus referred to in Mr. R. M. Johnston's "Geology of Tasmania": "Mr. Gould describes the members of the group as consisting mainly of quartzose sandstones, conglomerates, slates, and limestones, and also states, in respect of the principal or most characteristic members—the fossiliferous limestones—that 'in passing from west to east we have these limestones appearing again and again at intervals of many miles in distance, at Port Hibbs, the Franklin River, the great bend of the Gordon, and the Florentine Valley, the axes of the anticlinal embracing the larger intervals and developing the inferior metamorphosed beds consisting of quartzites, micaceous and chloritic schists, &c., which form the principal mountain features of the country.' "

The Dundas Group: To the north of Macquarie Harbour the fossiliferous beds have not been found; what are here referred to as the Dundas group very likely belong to the same series. These consist of claystones and dark-coloured slates, occasionally limestones or calcareous slates, and in certain localities abundance of fine-grained conglomerates and grits. It has been suggested that some of the coarser conglomerate beds which are exposed along the North-east Dundas Tramway may be of glacial origin, but so far no definite evidence in favour of this theory has been discovered. In some localities, especially in the vicinity of the eruptive rocks, there are great quantities of actinolite rock and actinolite schist. These are, no doubt, alteration products of limestones or calcareous slates due to after-actions connected with the eruptive rocks. Only in one or two localities have any organic remains been discovered—namely, a few obscure graptolites of no value as determining the age of the rocks. The general strike of the strata in this group is a little to the west of north and the dip to the east at high angles. Over large areas, however, the strata are so disturbed by intrusions of igneous rocks that no reliable observations of strike can be made. The Dundas group appears to have an extensive development on the west coast, though only in the North-east Dundas district has any attempt been made to define its limits. In this district the members of the group may be observed along the North-east Dundas Tramway from a point directly north of Leslie Junction to Williamsford, at the foot of Mount Read. The contact between the Dundas group and the Mount Read schists runs approximately north and south from Williamsford. The western limits of the Dundas group are less regular, and to the north of the North-east Dundas Tramway, in the vicinity of the Renison Bell Mine, they appear to be overlain by the Upper Silurian sandstones. In a northerly direction the Dundas group extends at least as far as Mount Bischoff. The Magnet Tramway has exposed a section about four miles in width, measured in an east and west direction, consisting of quite similar claystones, and in the vicinity of the Heazlewood River some miles further west Mr. W. F. Petterd has observed the Upper Silurian sandstones overlying the claystones uncomformably. In a southerly direction from Dundas apparently the same formation is exposed in the cuttings of the Mount Lyell Railway, on the banks of the King River, and here they probably extend westward till they are either overlaid by the Upper Silurian sandstones in the Queen River Valley, or pass over into the copper-bearing schists of the Mount Lyell field.

The Copper-schist Group: This belt of country, made famous by the occurrence therein of the copper-mines of Mount Lyell, lies to the east of the Dundas group. At north Dundas the schists appear to lie conformably upon and even pass over into the slates and claystones of the Dundas group. The observations are not, however, sufficiently satisfactory to enable this point to be regarded as finally settled. The rocks consist largely of argillaceous schists, but a great many of the so-called schists prove on microscopic examination to be in reality schistose porphyries, felsites, keratophyres, syenites, and even granites. The old name "porphyroid" might well be used as a group-name for these rocks. To the east of the porphyroids the true schists appear again, and these finally give place to the more highly crystalline mica-schists of presumably Pre-Cambrian age, or to hard slates and claystones belonging perhaps to the same formation as the Dundas group. This schist belt extends from at least as far south as Macquarie Harbour, northwards through Mounts Darwin, Jukes, Huxley, Owen, Lyell, Sedgewick, Tyndall, Read, Murchison, Black, and Farrell. Quite similar schists and porphyroids are met with also at Bell

Mount, in Middlesex, and in the Forth River Valley to the east of Wilmot.

Upper Silurian.—The rocks of this system are composed largely of slates, sandstones, and limestones, occasionally conglomerates, and in the Zeehan district contemporaneous basic tuffs, with dyke flows of melaphyre. In several localities, notably at Zeehan, Heazlewood, Bell Mount, and the Queen River, the strata are fossiliferous, and their age has been determined by Mr. R. Etheridge, jun., as Upper or Upper Middle Silurian. Over large areas, however, the slates and sandstones contain no fossils, and as the strata are usually highly inclined they may represent a considerable range of geological horizon. The general strike of these rocks is from 35 deg. to 45 deg. west of north, but there are many contradictions. In many places the slates are so crushed and contorted that no strike can be observed over considerable areas. In the Zeehan field the strike is fairly consistently 35 deg. west of north, and the dip 60 deg. to the east, in the eastern portion of the field; but in the western portion the general strike varies from 60 deg. west of north to due west, the dip being to the north from 60 deg. to 90 deg. There is some evidence in the distribution of the interbedded tuffs and melaphyres which seems to point to the presence of a huge anticline in the Zeehan field. If the observations which have been made to date are confirmed, the anticlinal axis has a decided pitch to the south. The axial plane strikes 30 deg. east of north in the southern portion of the field, but in the northern portion it bends round to the west. It would also appear to have a considerable dip to eastward; the strata to the east of the axial plane dips about 60 deg. to the east, while to the west of it the dip is vertical. These Upper and Middle Silurian strata appear to be younger than the Dundas formation, though there is as yet no absolutely conclusive evidence. As already mentioned, the apparent nonconformability of the Upper Silurian strata with rocks of the Dundas group have been observed. At Queenstown, and at Bell Mount also, the Upper Silurian sandstones are probably overlying the rocks of the schist belt uncomformably.

Coarse Red Sandstones and Conglomerates.—These rocks are found capping many of the mountains on the west coast, as, for example, Mounts Murchison, the Red Hills, Tyndall, Sedgewick, Lyell, Owen, Darwin, &c., where they lie unconformably upon the schists and felsites. They are generally tilted at a considerable angle from the horizontal and often form distinct anticlinal and synclinal foldings; they have been faulted to a very large extent, and huge escarpments due to this cause are very common. The age is at present uncertain. They have frequently been referred to as Devonian;

all that can be said in favour of this theory is that they are certainly younger than the schists and felsites, which are probably Lower Silurian, and that none of the eruptive rocks which occur intrusive in, and are therefore younger than, the Upper Silurian strata have so far been found intrusive in the conglomerates. This evidence is of a purely negative character. Nowhere has any positive evidence been found that the conglomerates are younger than the younger intrusive rocks. The conglomerates have not been found lying on the eroded surface of the eruptives, and no boulders or detrital matter has been found which could be supposed to have been derived from their denudation. It does not appear at all impossible that the red conglomerates belong to the Upper Silurian. A few specimens containing obscure and distorted fossils, apparently spirifers, were brought in from the Red Hill by Mr. R. Montgomery. These in all probability came from the conglomerate formation, and would point to their being of Silurian age. Professor Gregory, who has made an examination of the Lyell field, and has had a good opportunity of studying this conglomerate formation, is, I understand, also of this opinion. The conglomerate and coarse red sandstone on Mount Zeehan is not unlike the so-called Devonian conglomerate, and this is undoubtedly conformable with the Zeehan sandstones and slates.

Permo-carboniferous.—These strata occur overlying the older schists and Silurian strata in many places on the west coast. Usually the strata are almost horizontal and capped with a massive covering of columnar Mesozoic diabase. On the whole, they are singularly undisturbed, the only exception to this being a somewhat limited area in the vicinity of the Henty River, where the strata are faulted and contorted to a very considerable extent. This may have been caused by an eruption of Mesozoic diabase, as this rock is believed to occur *in situ* in the vicinity.

Igneous Rocks.—The distribution and relative ages of the various igneous rocks are important factors in the solution of problems in structural geology. It is at least probable that the main periods of upheaval correspond to a greater or lesser extent with the periods of plutonic activity. It will therefore be useful to record such facts as would appear to have a bearing on this question so far as they are known.

The Porphyroids.—Excluding some obscure and highly altered diorites and other probably igneous rocks which have been observed in the Pre-Cambrian schists, the oldest eruptive rocks on the west coast are probably the porphyroids of the schist belt. These consist of granites, quartz porphyries, felsites, quartz keratophyres, keratophyres, syenite porphyries, and syenites, which all appear to be nearly related to one another. They frequently pass over into one another, as in the case of the schistose felsites or porphyries at South Darwin, which pass over gradually into a quartz felspar granite, having a more or less decided schistose structure. The quartz keratophyres and keratophyres of Mount Read also pass over into one another, and these appear to be closely related on the one side to the felsites and quartz porphyries of the White Spur and Red Hills district, and on the other to the syenite porphyries and syenites of West Mount Read and Mount Black. At least, it appears pretty safe to conclude that all of these rocks belong to one period of eruption, and are probably products of differentiation from one and the same magma. These rocks also penetrate the Lower Silurian slates and claystones of the Dundas group. At North Dundas, in the Curtin Davis district, numerous dykes of a dark-coloured fine-grained quartz felspar porphyry occur, closely resembling mineralogically and structurally many of the dykes on the White Spur, Mount Read. These rocks often contain numerous fragments of slate, and are associated with curious crush breccias. The structure is often extremely schistose, and under the microscope they are seen to be much crushed, and exhibit strain and shearing phenomena. So schistose are many of these porphyries that they were taken for sedimentary grits and greywackes prior to micro-examination. These porphyries are believed to have no connection with the tourmaline and tin-bearing granites and porphyries which occur in the same district and in other parts of the west coast. The latter are different in composition, and have not been subjected to the same pressures since consolidation as the older porphyries or porphyroids. At Lynchford, near Queenstown, there is a syenite porphyry, similar in character to those on the eastern slopes of Mount Read and on Mount Black, occurring in what are probably Lower Silurian slates to the west of the schist belt. So far as I know, these rocks never penetrate into the Upper Silurian. As the Lower Silurian strata, including the schists, were upheaved before the Upper Silurian sediments were laid down, it seems not unlikely that this upheaval was connected with the eruption of the porphyroids.

The Melaphyres.—It would appear that next in point of age to the porphyroids come the melaphyres and melaphyre tuffs of the Zeehan district in Upper Silurian times. These are limited in their distribution, and have not played an important part in the structural geology of the coast. They may, however, have been the forerunners of the great eruption of basic plutonic rocks, including—

Gabbros, pyroxenites, serpentines, diabases, &c., which penetrate the rocks of both Lower and Upper Silurian age.

These rocks form another petrological group, and are connected with each other by numerous intermediate types. The diabases of this period are not to be confused with the Mesozoic diabase, which also occurs on the west coast. The older diabases are distinguished from the younger by the large amount of alteration (chloritisation, &c.) which they have undergone, and by the large amount of leucoxene which they contain. It is probable that these rocks occur more abundantly than any other igneous rock of the west coast, and their appearance must have profoundly altered the geological structure of the country. The first great upheaval of the Upper Silurian series probably was contemporaneous with the eruption of the basic rocks. Gabbros and serpentine occur to the south of Humskirk, at Trial Harbour, and in the Comstock district. They are largely developed in the Dundas and North-east Dundas district. In the latter a large dyke or mass some 10 chains in width, consisting of gabbros, pyroxenite, and serpentine, runs nearly due north along the western slopes of the Colebrook Hill, and crosses the Pieman River, where it junctions with other extensive masses of the same rock. Another mass 30 or 40 chains wide runs in a north-easterly direction from the Five-mile along the south end of Commonwealth Hill, and then on towards the Pieman. Numerous smaller dykes of diabase occur in the district; in only two cases, however, was the strike determinable. These were among a number of dykes which cross the Emu Bay line to the west of the Ring River. They vary in width from 12 ft. upwards. The strikes determined were 70 deg. west of north and 50 deg. west of north respectively, the dip in the former case being 80 deg. to the north-east and in the latter 70 deg. to the south-west; several other dykes appeared to strike east of north. North of the Pieman there are very extensive masses of serpentine, gabbros, and pyroxenites. On the track from the Heazlewood to Corinna they continually make their appearance for a distance of about twenty miles. This country is not all serpentine, but certainly a large proportion of it is.

Tourmaline and Tin-bearing Granite.—This rock was erupted subsequently to the basic rocks just described. At Trial Harbour the serpentine is profoundly altered near the contact of the granite, and it is penetrated by small dykes of quartz porphyry issuing from the latter. In the North-east Dundas district also there are dykes of quartz porphyry in the serpentine, and some of the gabbros contain tourmaline near the contact. There appear to be two main lines of outcrop of the granite. One of these runs along the coast from Mount Heemskirk to a point about ten miles north of the Pieman Heads, in a general direction of 30 deg. west of true north. The other strikes 45 deg. east of true north from Mount Heemskirk, and includes the granite of Mount Livingstone and the Parsons Hood, the Meredith Range, Mount Ramsay, Mount Bischoff, and the Blythe River. Besides these main lines of outcrop must be mentioned the tourmaline porphyries of North-east Dundas, the granite of Granite Tor, and several other isolated localities. Concerning the latter, I am not sure whether these outcrops belong to the tourmaline and tin-bearing granite or to the older granites which are connected with the porphyroids.

It is undoubtedly to the intrusion of the granite that we owe the numerous deposits of tin-ore on the west coast, including those of Mount Bischoff, Mount Heemskirk, Mount Livingstone, the Parsons Hood, &c., also the contact deposits of magnetite in the Heemskirk district and elsewhere, and possibly the hæmatite deposit at the Blythe River; also the pyritic zinc-lead deposits of the Comstock district, and almost certainly the pyritic and sideritic deposits of silver lead and associated silver tin (stannite) deposits of the Zeehan field; possibly also the pyritic zinc lead and copper deposits of Mount Read and the copper deposits of Mount Lyell. In fact, there is a considerable amount of evidence in favour of the theory that almost all the metalliferous deposits of the west coast are connected with the granite eruption.

It seems probable that no very great lapse of time intervened between the eruption of the gabbro series and that of the granite. At least, we may say this: that we know of no rock formations which are demonstrably younger than the gabbro and older than the granite. The eruption of the latter must have been accompanied by huge disturbance of previously existing rock, and no doubt these successive periods of eruption will largely account for the exceedingly complex and irregular structure of many districts on the west coast.

Mesozoic Diabase.—The age of this rock has been determined with a considerable amount of certainty in other parts of the States. On the west coast the eruption appears to have been accompanied by no considerable disturbance of older strata. Where it overlies the Permo-carboniferous rocks the latter are lying in almost perfectly horizontal layers, proving that the great mountain-building processes took place prior to Permo-carboniferous times. A possible exception to this is in the Henty district, where the Permo-carboniferous strata have been subjected to a considerable amount of disturbance. It is not yet quite certain, however, that the Mesozoic diabase occurs *in situ* in this district.

Tertiary Basalt.—This rock occurs in numerous localities on the west coast, notably in the northern portion, where it covers large areas in the form of extensive sheets. It occurs in the form of small dykes in the Barn Bluff district and at Mount Dundas (Commonwealth Mine); at Granville Harbour, the St. Dizier River, and Zeehan in the form of sheets or flows. Only in one locality—namely, at the St. Dizier River—can any disturbance of the strata be attributed to this period. The St. Dizier deep lead (tin) is covered by a sheet of basalt. The lead is faulted in several places, and the layers of wash have been so tilted that they now in places occupy vertical positions. It is, however, pretty certain that any disturbance which took place in Tertiary times was local in its distribution, and insignificant as a factor in the mountain-building processes which have been responsible for the present position of the rocks on the west coast of Tasmania.

No. 5.—REPORT OF MAGNETIC COMMITTEE.

The only magnetic work carried on since the 1st January, 1902, has been,—

1. The work done at the Magnetic Observatory in Christchurch by or under the direction of Dr. Farr;
2. The continuation of the magnetic survey of New Zealand by Dr. Farr;
3. The work done at the Melbourne Observatory.

An account of the work done in New Zealand is given by Dr. Farr himself.

At the Melbourne Observatory the continuous photographic registration of the variation of the magnetic elements has been carried on as in former years.

The programme laid out by the International Geographical Congress of Berlin in 1899 in connection with antarctic exploration has been fully carried out, and will terminate next February.

Considerable progress has been made in the measurement of the series of magnetic traces obtained at the Observatory and extending over a period of more than thirty years. The total number of day-curves fully measured and reduced to date is about 28,000, covering the period 1868 - 93. A catalogue of magnetic disturbances for the whole series is now under preparation. It is expected that the work will be completed in two years.

In 1898 the Council of the Association requested the Government of Victoria to supply means to enable me to initiate this work, with the result that a small sum of money has been annually voted since the middle of 1899, with which it has been possible to bring the work to its present stage. It is necessary that this subsidy be continued for a further period of two years, and, although I have no strong reason to fear that it may be stopped, it would be desirable to make a request for this by the Council to the Victorian Government.

REPORT OF THE COMMITTEE ON THE MAGNETIC SURVEY OF NEW ZEALAND.

This survey, which was commenced by the New Zealand Government in February, 1899, has been continued during the past summer. Since its inception the work has been carried on under the direction of Dr. C. Coleridge Farr, Secretary of the Magnetic Committee of this Association.

From February, 1899, to April, 1900, eighty-five magnetic stations were observed at, chiefly round the coast-line of the colony, and five stations were repeated. These stations enabled a choice to be made of the location for the magnetic observatory which was to act as the base station for the survey. Christchurch was the place chosen, since it was both magnetically suitable and would be accessible to the officers of the British National Antarctic Expedition, for which it would act as a base.

During the next summer, from August, 1900, to March, 1901, seventy additional stations were observed at in the western and northern part of the North Island. The next eighteen months were occupied in installing the observatory, which was in operation before the visit of the "Discovery" to Lyttelton in November, 1901. From September, 1902, to March, 1903, sixty new stations were taken in the eastern and central portions of the North Island, over which magnetic stations were now fairly uniformly distributed. Seven stations, in addition, were repeated. During the last summer, from October, 1903, to February, 1904, thirty-three new stations and seven repeat stations have been observed at, the new stations being placed, as uniformly as the mountainous nature of the country would permit, in the interior of that part of the South Island lying to the north of Christchurch.

There is thus a total of 248 magnetic stations up to the present. All the observations made at these have been carefully reduced and checked. There only remains to place about fifty stations in the interior of the southern part of the South Island, and it is expected to commence this in the coming spring.

The field observations have in all cases been carried out either by Dr. Farr or Mr. H. F. Skey, with the assistance of cadets of the Survey Department.

At the beginning of April in this year the "Discovery" returned to Lyttelton from the Antarctic. The expedition was successful beyond all anticipations, both in exploratory and observational work. The international magnetic term days were successfully observed in Victoria Land.

No. 6. PHOTOGRAPHIC WORK IN GEOLOGICAL SURVEYS.

(This report has not come to hand.)

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Walker, Alan—Tasmania.
Walker, J. T.—109, Pitt Street, Sydney (*Life Member*).
Walker, Mrs. Robert L.—Tasmania.
Wallis, The Right Rev. F., D.D., Bishop of Wellington—Bishopscourt, Wellington.
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Ward, W. F.—Hobart.
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Waters, D. B., A.O.S.M.—School of Mines, Dunedin.
Watson, Hon. James, M.L.C.—"Glanworth," Darling Point, Sydney.
Watt, Miss B. M., M.A.—Principal, Girls' High School, Timaru. New Zealand.
Watt, W. C., J.P.—"Knellerpore," Double Bay, Sydney.
Watt, W. S., A.O.S.M.—School of Mines, Zeehan, Tasmania.

Way, Sir S. J., Bart., P.C.—"Montefiore," North Adelaide.
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Webb, Herbert—Elgin Road, Mornington, Dunedin.
Webster, John—Hokianga, New Zealand.
Weigall, A. B., M.A.—The Grammar School, Sydney.
Welch, William—Roto-iti, Palmerston North, New Zealand.
Wellisch, E. M., B.A.—King's College, Goulburn.
Weston, Thomas S.—New Plymouth, New Zealand.
Weston, W. D.—Launceston, Tasmania.
Weston, Mrs. W. D.—Launceston, Tasmania.
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White, Miss R. E. J.—c/o E. J. White, Esq., Melbourne.
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Williams, His Honour Mr. Justice—Anderson's Bay, Dunedin.
Wills, Allen T. P.—Gunnedah, New South Wales.
Wilson, Alexander, M.A.—Rector, Boys' High School, Dunedin.
Wilson, C. A.—1, Elder Street, Dunedin.
Wilson, Professor—The Medical School, University, Sydney.
Wilson, Hon. A. Heron, M.L.C.—Doon Villa, Maryborough, Queensland.
Wilson, Mrs. A. H.—Doon Villa, Maryborough, Queensland.
Wilson, Leslie R.—Mornington, Dunedin.
Wilson, W. D.—Model School, Hobart.
Woodhouse, J. F.—23, Alva Street, Dunedin.
Woods, Miss—60, Carlisle Street, St. Kilda, Dunedin.
Woolcott, W. C.—Manager, Equitable Life Insurance Company, Dunedin.
Wolff, Miss R.—Dixon Street, Masterton, New Zealand.
Woolnough, George, M.A.—Telegraph Newspaper Company, Brisbane.
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Wright, J. Inglis—Spring Hill Road, Mornington, Dunedin.
Wright, Miss M.—36, Stewart Place, Paddington, Sydney.
Wyndham, Miss B.—G.O.P, Brisbane.

Crompton, Miss Pattie—Stoneyfell, Adelaide.
Gullett, Henry—Wahronga, New South Wales.
Thow, William, M.Inst.C.E.—"Ascot," Dutrue Street, Randwick, Sydney.
Touch, J. Edward, M.Inst.Mech.E.—Throgmorton House, 15, Copthall Avenue, London, E.C.

EXCHANGES AND PRESENTATIONS

MADE BY THE

AUSTRALASIAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The Association's Report for 1902, Vol. ix., has been forwarded to the following Societies and Institutions; should the publication not have arrived, the Institution concerned is requested to communicate with the Permanent Hon. Secretary, the University, Sydney, in order that inquiry may be made.

* *Exchanges of Publications have been received, since Vol. viii. (Melbourne, 1900 Session) was issued, from the Societies and Institutions distinguished by an asterisk.*

Austro-Hungary

Brunn ..	.. *Naturforschender Verein.
Cracow ..	.. *Académie des Sciences.
Prague ..	.. *Königlich Böhmische Gesellschaft der Wissenschaften.
Vienna ..	.. Kaiserliche Akademie der Wissenschaften.
,, ..	.. *Geographische Gesellschaft.
,, ..	.. *K. K. Zoologisch Botanische Gesellschaft.

Belgium.

Brussels ..	.. Académie Royale des Sciences, des Lettres et des Beaux Arts.
Liége ..	.. *Société Royale des Sciences.
Mons ..	.. *Société des Sciences, des Arts et des Lettres du Hainaut.

Brazil.

Rio de Janeiro	.. National Library.

Egypt.

Cairo ..	.. Egyptian Institute.

France.

Dijon ..	.. *Académie des Sciences, Arts, et Belles-Lettres.
Lille ..	.. *Bibliothèque Universitaire.
,, ..	.. Société Géologique du Nord.
Marseilles ..	.. *Faculté des Sciences.
Montpellier	.. *Académie des Sciences et Lettres.
Nantes ..	.. *Société des Sciences Naturelles de l'Ouest de la France.
Paris ..	.. Académie des Sciences de l'Institut de France.
,, ..	.. Bibliothèque de l'Université à la Sorbonne.
,, ..	.. Ecole Nationale des Mines.
,, ..	.. *Museum d'Histoire Naturelle.
,, ..	.. *Société d'Encouragement pour l'Industrie Nationale.
Rennes ..	.. The University.

New Caledonia.

Noumea ..	.. Government Library.

Germany.

Berlin ..	.. Königlich Preussische Akademie der Wissenschaften.
Bremen ..	.. *Naturwissenschaftlicher Verein.
Bonn ..	.. *Naturhistorischer Verein der Preussischen Rheinland.
,, ..	.. *Niederrheinische Gesellschaft für Natur-und-Heilkunde.
Brunswick ..	.. *Verein fur Naturwissenschaft zu Braunschweig.
Carlsruhe ..	.. Naturwissenschaftlicher Verein.
Cassel ..	.. *Verein fur Naturkunde.
Frankfurt a/m	.. Senckenbergische Naturforschende Gesellschaft.
Freiburg (Baden)	.. *Naturforschende Gesellschaft.
Giessen ..	.. Oberhessische Gesellschaft fur Natur-und-Heilkunde.
Görlitz ..	.. *Naturforschende Gesellschaft.
Göttingen ..	.. *Königliche Gesellschaft der Wissenschaften.
Halle, A.S.	.. *Kaiserliche Leopoldina Carolina Akademie der Deutschen Naturforscher.
Hamburg ..	.. *Naturhistorisches Museum.
,, ..	.. *Verein fur Naturwissenschaft.
Hanover ..	.. *Naturhistorisches Gesellschaft.
Königsberg	.. *Königliche Physikalisch-Okonomische Gesellschaft.
Leipzig ..	.. Königliche Sächsische Gesellschaft der Wissenschaften.
,, ..	.. *Verein fur Erdkunde.
Marburg ..	.. *Gesellschaft zur Beförderung der gesammten Naturwissenschaften.
Munich ..	.. Königlich Bayerische Akademie der Wissenschaften.
Würzburg ..	.. *Physikalisch-Medicinische Gesellschaft.

Great Britain and the Colonies.

Birmingham	.. *Midland Institute.
,,	.. *Free Library.
Cambridge ..	.. *Philosophical Society.
,, ..	.. University.
Kew ..	.. Royal Gardens.
,, ..	.. National Physical Laboratory.
Leeds ..	.. *Yorkshire College.
,, ..	.. *Philosophical and Literary Society.
,, ..	.. *Yorkshire Geological and Polytechnic Society.
Liverpool ..	.. *Geographical Society.
London ..	.. Agent-General (2 copies).
,, ..	.. *Anthropological Institute of Great Britain and Ireland.
,, ..	.. British Museum, Bloomsbury.
,, ..	.. ,, South Kensington.
,, ..	.. Chemical Society.
,, ..	.. Colonial Office, Downing Street.
,, ..	.. *Institute of Chemistry.
,, ..	.. Institution of Civil Engineers.
,, ..	.. Iron and Steel Institute.
,, ..	.. Library, South Kensington Museum.
,, ..	.. Linnean Society.
,, ..	.. Lords Commissioners of the Admiralty (the Corporation of Trinity House).
,, ..	.. Museum of Practical Geology.
,, ..	.. *Royal Colonial Institute.
,, ..	.. Royal Geographical Society.
,, ..	.. Royal Institution of Great Britain.

London ..	.. Royal College of Science, and School of Mines.
,, ..	.. Royal Society.
,, ..	.. *Society of Arts.
,, ..	.. University of London.
,, ..	.. War Office (Intelligence Division).
Manchester	.. *Literary and Philosophical Society.
,,	.. *Geological Society.
,,	.. Owens College.
Newcastle-on-Tyne	.. *North of England Institute of Mining and Mechanical Engineers.
,,	.. Society of Chemical Industry.
Oxford ..	.. Bodleian Library.
,, ..	.. Radcliffe Library.
Penzance ..	.. Royal Geologica Society of Cornwall.
York ..	.. Yorkshire Philosophical Society.

AFRICA.

Cape Town	.. *South African Philosophical Society.
,,	.. *Geological Commission.
Pietermaritzburg	.. *Government Geologist (Surveyor-General's Department).

CANADA.

Halifax (Nova Scotia)	*Nova Scotian Institute of Science.
Montreal ..	.. *Natural History Society of Montreal.
,, ..	.. McGill University Medical Library.
Ottawa ..	.. Geological and Natural History Survey of Canada.
Quebec ..	.. Literary and Historical Society.
Toronto ..	.. *Canadian Institute.
,, ..	.. University.
Winnipeg ..	.. Manitoba Historical and Scientific Society.

INDIA.

Aligarh ..	.. Anglo-Oriental College.
Bombay ..	.. Royal Asiatic Society (Bombay Branch).
Calcutta ..	.. Asiatic Society of Bengal.
Madras ..	.. Central Museum.

IRELAND.

Dublin ..	.. National Library of Ireland.
,, ..	.. Trinity College.

MALTA.

Malta ..	.. Public Library.

MAURITIUS.

Port Louis ..	.. Royal Society of Arts and Sciences.

NEW BRUNSWICK.

St. John ..	.. Natural History Society of New Brunswick.

NEW SOUTH WALES.

Sydney ..	.. *Australian Museum.
,, ..	.. Botanic Gardens.
,, ..	.. Department of Mines and Agriculture.
,, ..	.. Department of Public Instruction.
,, ..	.. *Government Statistician.
,, ..	.. Linnean Society of N.S.W.
,, ..	.. N.S.W. Board of International Exchanges.

Sydney	..	.. Parliamentary Library.
,,	..	.. Public Library.
,,	..	.. Royal Society of N.S.W.
,,	..	.. School of Arts.
,,	..	.. Technological Museum.
,,	..	.. University.

NEW ZEALAND.

Auckland	..	.. Auckland Institute.
Christchurch		.. Public Library.
,,		.. Canterbury College.
Dunedin	..	.. Otago Institute.
Wellington		.. *New Zealand Institute.
New Plymouth		.. *Polynesian Society.

QUEENSLAND.

Brisbane	..	.. Parliamentary Library.
,,	..	.. *Royal Society of Queensland.

SCOTLAND.

Aberdeen	..	.. University.
Edinburgh	..	.. Royal Society.
,,	..	.. University.
Glasgow	..	.. *Philosophical Society.
,,	..	.. University.
St. Andrew's		.. University.

SOUTH AUSTRALIA.

Adelaide	..	.. Public Library, Museum, and Art Gallery of S.A.
,,	..	.. *Royal Society of South Australia.
,,	..	.. University.

STRAITS SETTLEMENTS.

Singapore	..	.. Royal Asiatic Society (Straits Branch).

TASMANIA.

Hobart	..	.. Parliamentary Library.
,,	..	.. Royal Society of Tasmania.
Launceston	..	.. Geological Survey of Tasmania.

VICTORIA.

Ballarat	..	.. School of Mines and Industries.
Melbourne	..	.. *Australasian Institute of Mining Engineers.
,,	..	.. Government Statist.
,,	..	.. *Mining Department.
,,	..	.. Parliamentary Library.
,,	..	.. Public Library.
,,	..	.. Royal Society of Victoria.
,,	..	.. University.
,,	..	.. Working-men's College.

WESTERN AUSTRALIA.

Perth	..	.. Parliamentary Library.
,,	..	.. Victoria Public Library.

GREECE.

Athens	..	.. University.

ITALY.

Bologna .. .. *R. Accademia delle Scienze dell' Instituto.
,, ... University.
Catania .. .. *Accademia Gioenia di Scienze Naturali.
Milan .. .. R. Instituto Lombardo di Scienze, Lettere, ed Arti.
Modena .. .. R. Accademia di Scienze, Lettere, ed Arti.
Pisa .. .. *Società Toscana di Scienze Naturali.
Rome .. .. *R. Accademia dei Lincei.
Sassari .. .. *University.

JAPAN.

Tokyo .. .. *Asiatic Society of Japan.
,, ... Imperial University.

JAVA.

Batavia .. .. *K. Natuurkundige Vereeniging in Nederlandsch-Indië.

MEXICO.

Mexico .. .. *Sociedad Cientifica "Antonio Alzate."

NETHERLANDS.

Amsterdam .. Académie Royale des Sciences.
Haarlem .. .. *Bibliothèque du Musée Teyler.
,, ... Colonial Museum.
Leyden .. .. University.

NORWAY.

Christiania .. .. Königelige Norske Fredericks Universitet.

PORTUGAL.

Coimbra .. .. *Universidade.
Lisbon .. .. Academia Royale das Sciencias.

RUSSIA.

Helsingfors .. *Societas Scientiarum Fennica.
Moscow .. .. Société Impériale des Naturalistes.
St. Petersburg .. Académie Impériale des Sciences.
,, .. *Institut des Mines.

SPAIN.

Barcelona .. .. *Real Academia de Ciencias.

SWEDEN.

Stockholm .. .. *K. Svenska Vetenskaps-Akademie.
Upsala .. .. *Université Royale d'Upsala.

SWITZERLAND.

Basel .. .. *Naturforschende Gesellschaft.
Geneva .. .. Schweizerische Naturforschende Gesellschaft.
Lausanne .. .. Société Vaudoise des Sciences Naturelles.
Zurich .. .. Naturforschende Gesellschaft.

UNITED STATES OF AMERICA.

Albany .. .. *New York State Library, Albany.
Baltimore .. .. *Johns Hopkins University.
Boston .. .. American Academy of Arts and Sciences.
Cambridge .. .. *Harvard University.
Chicago .. .. *The John Crerar Library.

Cincinnati ..	..	American Association for the Advancement of Science.
Columbia ..	..	University of Missouri.
Denver ..	..	Colorado Scientific Society.
Indianopolis	..	Indiana Academy of Sciences.
Lawrence ..	..	*Kansas University.
Michigan ..	..	College of Mines.
Madison (Wis.)	..	*Wisconsin Academy of Sciences, Arts, and Letters.
Minneapolis	..	*Minnesota Academy of Natural Sciences.
Missoula ..	..	*University of Montana (Department of Biology).
Montana ..	..	State School of Mines.
Newhaven (Conn.)	..	*Connecticut Academy of Arts and Sciences.
,, ,,	..	Yale University.
New York ..	..	*New York Academy of Sciences.
,, ..	..	School of Mines, Columbia College.
Paolo Alto ..	..	Leland Stanford, jun., University of California.
Philadelphia	..	Academy of Natural Sciences.
,,	..	American Philosophical Society.
Rochester (N.Y.)	..	*Rochester Academy of Sciences.
Salem (Mass.)	..	Essex Institute.
St. Louis ..	..	Academy of Science.
San Francisco	..	*California Academy of Sciences.
Washington	..	Bureau of Education (Department of the Interior)
,,	..	*Bureau of American Ethnology.
,,	..	National Academy of Sciences.
,,	..	*Philosophical Society.
,,	..	*Smithsonian Institution.
,,	..	*U.S. Geological Survey.
,,	..	U.S. National Museum (Department of the Interior).

URUGUAY.

Monte Video	..	National Library and Museum.

JOHN MACKAY, GOVERNMENT PRINTER, WELLINGTON.

APPENDIX.

Section A.—REPORT OF SEISMOLOGICAL COMMITTEE.

Members: Sir Charles Todd, South Australia; Professor David, F.R.S., New South Wales; Professor Gregory, F.R.S., Victoria; W. E. Cook, M.A., West Australia; C. Coleridge Farr, D.Sc., New Zealand; A. Macaulay, M.A., Tasmania; Tarlton Phillips, B.Sc., South Australia; and P. Baracchi, Melbourne, and G. Hogben, M.A., Wellington, Hon. Secretaries.

The most important earthquake in Australasia during the period covered by this report was the South Australian earthquake of the 19th September, 1902. It extended as far west as Streaky Bay, to the north as far as Hawker (about 216 miles in a straight line north of Adelaide), to Gambier in the south-east, and into Victoria. The maximum intensity was shown in southern Yorke's Peninsula. It was exceptionally severe at Warooka, where several buildings were damaged; and at the Troubridge Lighthouse, where several lamps were thrown down and much damage done.

The times were not exact enough for exact determination of the origin, but Sir Charles Todd, by the method of isoseismals, has fixed the principal focus of disturbance in the neighbourhood of Warooka. It is interesting to note that this region lies almost on a continuation of the line to which Mr. G. Hogben referred the origin of the South Australian earthquake of the 10th May, 1897—namely, a line off the coast between Robe and Beachport, and nearly parallel to it.

Other noteworthy shocks were those at Warrnambool in April, 1903, and those that were felt with marked severity at Cheviot, near the east coast of the South Island of New Zealand. The chief shock of the latter series—viz., that on the 19th November, 1901—was very similar in character to that which threw down the top of the Christchurch Cathedral spire in September, 1888, and probably came from a parallel line of fault, the origin being situated ten miles or more below the surface, about twelve miles west-north-west of the Township of Cheviot. One interesting fact about this earthquake was that the seismographic record at Wellington showed that there was a downthrow on the western side of the seismological observatory amounting to 1¾ seconds of arc. Although the tilting thus indicated was not nearly so great as that which took place at the time of the great earthquake of January, 1855, yet it is noteworthy that the axis of movement at that time is collinear with the origin of the 1901 earthquake, and very nearly parallel with the general axis of New Zealand.

In Western Australia a Milne horizontal pendulum seismograph has been installed at the Perth Observatory, under the charge of the Government Astronomer, Mr. W. S. Cook.

A Milne instrument has also been installed at the Sydney Observatory, but it has not yet, it is believed, been started for systematic registration. In Victoria a Milne H.P. seismograph has been continuously at work in one of the underground rooms in the basement of Melbourne University. The records of these instruments, as well as of the similar instruments at Wellington and Christchurch, New Zealand, are published every half-year by the Seismological Committee of the British Association.

South Australia has no instrument, but ordinary records have been kept, and the list printed below has been forwarded to this Committee by Sir Charles Todd.

There are no instruments in Queensland or Tasmania, and no observations appeared to have been recorded. The slight movements of the earth's crust shown to have taken place in New Zealand, and the far more extensive elevation (50 ft. or more) in the New Hebrides within recent years render it very desirable that the number of instruments in or near Australia should be increased, so that it may be ascertained, among other things, whether there is a general rise or fall in the floor of the western Pacific. Much also may be learned by the comparison of the records of the Milne instruments at stations comparatively near together in regard to the speed of the waves of distant earthquakes and their path through the earth's crust, and hence again as to the character of the underlying rocks.

The Committee recommends—

(1.) That one or more competent and influential members be added to the Committee to represent Queensland.

(2.) That the Government of South Australia be asked by the Council of the Association to enable Sir Charles Todd to procure and instal a Milne seismograph at the Adelaide Observatory and a similar one at Port Darwin.

(3.) That the Government of Tasmania be asked to establish a Milne seismograph at the University or at the Weather Office.

(4.) That the Sydney Observatory be requested to start as early as possible the seismograph now installed at the Observatory.

(5.) That it is desirable that seismographs should be installed, if possible, at Norfolk Island and Tonga.

(6.) That the various stations at which seismographs are installed should exchange records and copies of seismograms periodically, especially those of earthquakes occurring in or near Australasia.

Attached to the report are lists of the principal shocks felt in Victoria and South Australia during 1902 and 1903. Those observed in New Zealand are published year by year in the "Transactions of the New Zealand Institute."

P. BARACCHI }
G. HOGBEN } Secretaries.

EARTHQUAKES IN VICTORIA, 1902–1903.

Greenwich Mean Civil Time.		Place.	Lat. S.	Long. E.	Description of Phenomena.
1902.			° ′	° ′	
Jan. 12	10.30 p.m. ..	Perth	31 57	115 51	Largest earthquake shock yet recorded.—W. E. COOKE.
Feb. 2	3.15 p.m. ..	Adelong ..	35 17	148 5	About 30 secs. rumbling. Most people awakened by the shock.
" 2	..	Tumut ..	35 17	148 13	Tremors. N. to S.
Mar. 7	Abt. 12 noon ..	Bundanoon ..	34 25	150 26	Shock. Buildings trembled. Rumbling.
" 7	" ..	Camden ..	34 4	150 46	" " "
" 7	" ..	Sutherland ..	34 0	151 0	" " "
" 7	6 p.m. ..	Greta	32 40	151 36	" " "
" 8	Abt. 10.30 a.m.	Maldon ..	37 0	144 5	Slight shock, lasting few seconds. Lamps and crockery shaken. Men in mines rushed to surface.
8	"	Castlemaine ..	37 4	144 14	Slight shock. Duration about 10 secs. Most severely felt on higher portions of town.
" 8	"	Campbell's Creek	37 4	144 12	Slight shock.
" 8	"	Harcourt ..	37 0	144 17	Houses shaken. Inmates greatly alarmed.
" 8	"	Barker's Creek ..	37 2	144 17	Slight shock.
May 8	1 p.m. ..	Camberwell ..	37 51	145 7	Suspected earthquake.
" 16	Early afternoon	Deepwater ..	29 30	151 52	Shock felt.
" 16	Abt. 8 p.m. ..	St. Kilda ..	37 52	145 0	Suspected earthquake. Windows rattled. Rumbling.
" 27	1.50 a.m. ..	Jenolan Caves ..	33 50	150 4	Two distinct shocks. Rumbling.
July 7	p.m. ..	Young ..	34 18	148 21	Two shocks felt.
" 8	7.23 a.m. ..	" ..	34 18	148 21	Sharp shock. Buildings shaken. People rushed into streets. W. to E.
" 11	..	Walhalla ..	37 57	146 27	Shock felt.
" 20	7.50 a.m. ..	Cape Everard ..	37 48	149 16	"
" 21	8.51 a.m. ..	Yea	37 12	145 25	Distinct shock. Articles in houses shaken. Loud rumbling. N. to S.
" 21	8.58 a.m. ..	Wild Dog Gully	37 13	145 13	Slight earth-tremor. Noise like distant thunder. W. to E.
Aug. 2	..	Mount Buckrabanyule	36 13	143 33	Rumbling noises from interior of hill, resembling thunder or passage of trains underground, and at times like discharge of cannon.

EARTHQUAKES IN VICTORIA, 1902-1903—*continued*

Greenwich Mean Civil Time.			Place.	Lat S.	Long. E.	Description of Phenomena
1902.				° ′	° ′	
Aug.	2	..	Marmal ..	36 5	143 32	Three parallel fissures. E. and W., about 80 yards long and 6 ft. deep.
	13	Morning ..	Young ..	34 18	148 21	Severe shock.
	13	Early afternoon	" ..	34 18	148 21	"
	14	..	Granite Flat ..	36 10	143 15	Two distinct shocks
	16	1 a.m. ..	Mount Buckrabanyule	36 13	143 33	Slight earth-tremor. Sound like distant thunder coming apparently from deep underground.
Sept.	17	Abt. 6 p.m. ..	Cooktown ..	15 28	145 17	Probable earthquake. Loud detonation. Houses shaken. Direction, N.E. to N.W.
	19	10.40 a.m. ..	Nhill	36 20	141 40	Distinct shock. About 15 secs.
	19	10.31 a.m. ..	Melbourne ..	..	..	Seismograph record. About 13 secs.
	19	10.38 a.m. ..	" ..	..	..	Seismograph record. About 14 secs. (See South Australian records.)
	19	Morning ..	Serviceton ..	36 23	141 0	Slight earth-tremor.
	19	Abt. 10.25 a.m.	Jeparit ..	36 13	141 59	Buildings vibrated strongly. Rumbling.
	19	10.40 a.m. ..	Mt. Tareena ..	33 57	141 0	Severe shock.
	19	Abt. 10.45 a.m.	Natimuk ..	36 41	141 57	Slight shocks. About 30 secs.
	19	Morning ..	Goroke ..	36 45	141 31	Slight shock.
"	2[illegible]	11.30 a.m. ..	Ballarat ..	37 33	143 52	Suspected earth-tremor.
Oct.	5	..	Lake Eacham ..	17 24	145 26	Volcanic disturbance reported. Water in centre of lake bubbling.
"	19	Shortly after 3 p.m.	Young ..	34 18	148 21	Severe earth-tremor. N.E. Beds and furniture shaken.
"	19	Shortly after 8 p.m.	" ..	34 18	148 21	Shock. Not so severe as last.
"	21	8.30 p.m. ..	Glen Allan ..	37 55	146 17	Shock felt.
"	22	Abt. 9.30 p.m.	Moondarra ..	38 0	146 22	Shock. Duration about 3 mins. Crockery rattled. Bucket of milk standing on tree-stump capsized.
"	22	9 p.m. ..	Walhalla ..	37 57	146 27	Distinct shock. Houses shook. 10 secs. Preceded by rumbling.

Oct. 27	9.30 p.m. ..	Hurdle Creek ..	36 34	146 36	Distinct shock, accompanied by rumbling. Crockery shook violently. S. to N. Duration 40 secs.
Dec. 17	10 a.m. ..	Cape Schanck ..	38 29	144 53	Shock felt. E. and W.
" 22	12.45 p.m. ..	Sunbary ..	37 35	144 44	Shock felt. Windows and doors violently shaken. Rumbling noise. 30 secs.
" 22	1 p.m. ..	Ballark ..	37 45	144 9	Distinct shock. House vibrated.
" 22	Between 1.45 and 1.50 p.m.	Upper Hawthorn	37 51	145 7	Distinct shock. Bed moved.
" 22	12.45 p.m. ..	Dandenong ..	37 59	145 13	Earth-tremor, accompanied by slight rumbling. N. to S.
" 22	12.50 p.m. ..	Cape Schanck ..	38 29	144 53	Sharp shock. E. and W.
" 22	12.45 p.m. ..	Queenscliff ..	38 16	144 40	Slight earth-tremors. Rumbling. About 10 secs.
" 22	12.50 p.m. ..	Mornington ..	38 18	145 2	Shock felt, accompanied by loud rumbling. About 7 secs.
" 22	12.45 p.m. ..	Flinders ..	38 34	145 1	Distinct tremor. Windows violently shaken. Corrugated iron on roofs grated.
1903.					
Feb. 26	Abt. 12.30 p.m.	Wallerawang ..	33 20	150 7	Distinct shock. Buildings shaken. Rumbling. Direction S.E.
April 6	11.52 p.m. ..	Warrnambool ..	38 23	142 30	Very severe. Considerable damage. Slight tremor followed quickly by a severe shock, accompanied by almost deafening noise resembling the discharge of heavy cannon. All the stone buildings suffered to some extent. Wall in Town Hall cracked for several feet from the roof towards the ground, and plaster fell from ceilings. One of four spires of Presbyterian Church tower fell through roof. Tombstones in cemetery dislodged. Scarcely a shop or residence escaped injury. Numerous chimneys fell and cottages partially wrecked. A steamer anchored at breakwater pier received two distinct shocks. [Effects of this shock examined by Professor Gregory and the Secretary, Mr. P. Baracchi ; and a detailed survey of damages made by Town Engineer, Mr. Ross, assisted by the Shire Engineer. (See special report by Professor Gregory and P. Baracchi.)]
" 6	..	Framlingham ..	38 14	142 43	The above disturbance was also severely felt at these places.
" 6	..	Garvoc ..	38 18	142 49	
" 6	..	Allansford ..	38 22	142 37	
" 6	..	Grasmere ..	38 14	142 35	

Earthquakes in Victoria, 1902–1903—*continued*.

Greenwich Mean Civil Time.		Place	Lat. S.	Long. E.	Description of Phenomena.
1903			° ′	° ′	
April 6	Few minutes before midn't	Koroit	38 18	142 22	Three distinct shocks, accompanied by rumbling. Crockery dislodged from shelves. About 30 secs.
„ 6	11.53 p.m.	Killarney	38 20	142 13	Severe shock. Duration about 15 secs. Buildings shook, and bottles fell from shelves.
„ 6	Abt. midnight	Port Fairy	38 23	142 14	Shock. Heavy bluestone buildings shaken. N.W. to S.E. Most severe in south part of town, towards sea.
„ 8	Abt. 9.30 a.m.	Warrnambool	38 23	142 30	Slight tremor. Windows rattled. Buildings shook. Rumbling.
„ 26	12.25 a.m.	Glen Allan	37 55	146 17	Slight shock from S.W.
„ 26	12.25 a.m.	Walhalla	37 57	146 27	„
„ 30	8.25 a.m.	Euriowie	31 26	141 37	Shock.
„ 30	Morning	Silverton	31 55	141 17	Severe vibration. Walls of old gaol severely strained and cracked.
„ 30	8.22 a.m.	Broken Hill	31 57	141 28	Severe shock, accompanied by loud rumbling. Duration about 20 secs. Direction S. to N. Houses shook. Shock felt in mines, but only as deep as 400 ft. level.
June 2	Noon	„	31 57	141 28	Slight tremor. About 5 secs. S.W. to N.E.
„ 5	7.30 p.m.	Portland	38 21	141 36	Two distinct shocks.
July 10	3.56 a.m.	Maldon	37 0	144 5	Rather severe shock. Appeared to travel S.W. Fully 25 secs.
„ 10	3.57 a.m.	Castlemaine	37 4	144 14	Shock. N. to S. Accompanied by rumbling. Windows and crockery rattled. Walls shook. Most severe. Felt at north of town.
„ 10	Shortly before 4 a.m.	Tarnagulla	36 46	143 50	Smart shock. Buildings shaken. Heavy rumbling. Direction S.W.
„ 10	Ditto	Newstead	37 16	144 4	Smart shock. Buildings rocked. N. to. S. Tremor felt in mines.
„ 10	Just before 4 a.m.	Bendigo	36 46	144 16	Slight shock on high ground, and also deep down in mines (as low as 3,500 ft.). Windows rattled. Crockery disturbed.
„ 10	..	Eaglehawk	36 43	144 16	Shock.
„ 10	..	Quarry Hill	36 48	144 18	„

July	10	Abt. 4 a.m. ..	Dunolly ..	36 52	143 44	Very distinct tremor. Few seconds. Crockery and windows rattled. N. to S.
„	10	Shortly before 4 a.m.	Maryborough ..	37 3	143 44	Shock.
„	10	Abt. 4 a.m. ..	Talbot ..	37 10	143 42	Slight shock.
„	10	Abt. 4 a.m. ..	Campbelltown ..	37 12	143 56	„
„	14	10.27½ a.m. ..	Warrnambool ..	38 23	142 30	Most severe shock. Widespread damage to property. N.E. and S.W. Accompanied by terrifying noise resembling rolling thunder. Community thrown into state of great alarm. Duration of shock about 4 secs. Six massive cement crosses fell from tower of Presbyterian Church. The steeple of the Roman Catholic Church was twisted at a spot 20 ft. from the top. Many other buildings injured considerably by walls cracking and chimneys falling or being twisted, and plaster coming down. Plate-glass windows in shops smashed. The suspension bridge which spans the Merri River at the approach of the breakwater twisted into grotesque shapes. Crack opened across the breakwater. Severe on banks of Hopkins River for several miles up. Stone wall thrown down. Numerous cracks opened in ground. An extensive landslip six or seven miles to east of Warrnambool; and at several spots masses of cliffs fell into the sea. [The above report is from local Press. Professor Gregory and P. Baracchi made an inspection after this earthquake. (See their special report elsewhere.)]
„	14	Abt. 10.32 a.m.	Cape Nelson ..	38 26	141 32	Earth-tremor. About 12 secs.
„	14	10.30 a.m. ..	Portland ..	38 21	141 36	Earth-tremor. Doors and windows shaken. Crockery displaced. Duration only momentary.
„	14	10 a.m. ..	Muntham ..	37 34	141 36	Distinct shock.
„	14	10.45 a.m. ..	Carapook ..	37 33	141 35	„
„	14	10.30 a.m. ..	Casterton ..	37 35	141 26	Slight shock.
„	14	10.30 a.m. ..	Sandford ..	37 37	141 29	„
„	14	10.30 a.m. ..	Coleraine ..	37 36	141 48	Distinct shock. Travelled easterly. 7 or 8 secs. Furniture moved.
„	14	10.30 a.m. ..	Hamilton ..	37 44	142 1	Slight earthquake. Furniture swayed, and doors and windows rattled.

EARTHQUAKES IN VICTORIA, 1902–1903 *continued.*

Greenwich Mean Civil Time.		Place.	Lat. S.	Long. E.	Description of Phenomena.
1903.			° ′	° ′	
July 14	10.30 a.m. ..	Penshurst ..	37 52	142 18	Slight shock. 10 secs. Accompanied by rumbling. Houses trembled. Travelling southward.
" 14	..	Tower Hill Lake	38 19	142 20	Earthquake.
" 14	Abt. 10.30 a.m.	Koroit ..	38 18	142 22	Severe shock. Houses rocked. Windows rattled. Hanging lamps swayed violently. Articles on shelves fell. 5 or 6 secs. From N.W.
" 14	10.30 a.m. ..	Port Fairy ..	38 23	142 14	Severe shock. Travelling S.E. About 15 secs. Most strongly built structures shaken. Clocks stopped Crockery shaken. Rumbling.
" 14	..	Framlingham ..	38 14	142 43	Shock.
" 14	..	Cudgee ..	38 20	142 40	"
" 14	Abt. 10.30 a.m.	Nirranda ..	38 29	142 45	"
" 14	10.30 a.m. ..	Hexham ..	38 0	142 42	Shock. Buildings shaken, and plaster fell.
" 14	10.30 a.m. ..	Illowa ..	38 20	142 25	Severe shock. Buildings violently shaken. Several seconds. N.W. to S W. (? S.E.)
" 14	..	Garvoc ..	38 18	142 49	Shock. Houses swayed
" 14	..	Allansford ..	38 22	142 37	Shock.
" 14	10.30 a.m. ..	Terang ..	38 14	142 55	Sharp shock. Buildings rocked and crockery rattled.
" 14	..	Grasmere ..	38 14	142 35	Shock.
" 14	10.30 a.m. ..	Peterborough ..	38 36	142 54	Distinct shock. W. to E.
" 14	10.30 a.m. ..	Newfield ..	38 34	142 58	Distinct shock.
" 14	..	Ararat ..	37 17	142 57	Distinct shock. About 3 secs. Movable articles on shelves rattled.
" 14	10.30 a.m. ..	Scott's Creek ..	38 24	143 3	Distinct shock.
" 14	10.30 a.m. ..	Princetown ..	38 41	143 9	"
" 14	10.30 a.m. ..	Rivernook ..	38 42	143 11	"
" 14	Abt. 10.30 a.m.	Camperdown ..	38 14	143 9	Tremor. Doors rattled.
" 14	10.29 a.m. ..	Cape Otway ..	38 51	143 30	Shock. Direction W. to E. About 10 secs.

July	14	10.40 a.m. ..	Cape Patton ..	38 41	143 49	Shock. About 10 secs.
„	14	10.28 a.m. ..	Cobden ..	38 19	143 5	Sharp shock. Houses rocked. Water in tanks spilt. Clocks stopped. About 9 secs.
„	14	..	Beech Forest ..	38 37	143 35	Two strong shocks.
„	14	..	Gellibrand River	38 29	143 36	„
„	14	10.30 a.m. ..	Colac	38 20	143 36	Doors shook. Windows rattled loudly. Shock repeated after 2 secs.
„	14	10.28 a.m.* ..	Ballarat ..	37 33	143 52	Sharp tremor. S.W. to N.E. Rumbling. About 5 to 10 secs. Statuettes on shelves rocked. * 10.28 postal time.
„	14	..	Ballarat East ..	37 33	143 56	Earth-tremor Subsidence of roadway in street.
„	14	10.30 a.m. ..	Clunes ..	37 18	143 47	Shock. Windows rattled.
„	14	10.30 a.m. ..	Buninyong ..	37 39	143 53	Slight shock. Houses shook. Windows and doors rattled.
„	14	10.35 a.m. ..	Split Point ..	38 28	144 6	Shock. Lighthouse vibrated.
„	14	10.25 a.m. ..	Ballark ..	37 45	144 9	Shock.
„	14	10.30 a.m. ..	Belmont ..	38 10	144 20	Earth-tremor.
„	14	11 50 a.m. ..	Warrnambool ..	38 23	142 30	Slight shock.
„	14	11.50 a.m. ..	Koroit ..	38 18	142 22	„
„	20	Abt. 1.30 p.m.	Maldon ..	37 0	144 5	Slight shock, accompanied by rumbling. About 5 secs.
„	22	Abt. 7.30 p.m.	Moe	38 10	146 15	Shock. Buildings rocked. Bottles thrown from shelves. Several seconds. N. to S.
„	22	7.30 p.m. ..	Tyers	38 10	146 28	Shock.
Aug.	4	9.32 a.m. ..	Foster ..	38 39	146 13	Sharp shock. N.E. to S.W. Houses shaken.
„	4	..	Yanakie ..	38 51	146 13	Shock.
„	4	10 a.m. ..	Leongatha ..	38 34	145 57	Slight shock.
„	4	Early afternoon	Foster ..	38 39	146 13	„
„	17	12.55 p.m. ..	Penshurst ..	37 52	142 18	Distinct shock, accompanied by rumbling.
„	17	..	Hamilton ..	37 44	142 1	Shock.
„	17	..	Murtoa ..	36 37	142 28	„
„	18	Abt. 12.54 p.m.	Penshurst ..	37 52	142 18	Supposed earthquake. Rumbling.
„	18	Abt 1 p.m ..	„ ..	37 52	142 18	„ „
Sept.	4	Abt. 10.45 a.m.	Dunolly ..	36 52	143 44	Shock. Crockery shaken violently. Felt in mines.
„	4	3.10 p.m. ..	Yea	37 12	145 25	Shock, accompanied by loud rumbling, and travelling S.E. Ornaments rattled.
„	23	11.20 a.m. ..	Mansfield ..	37 3	146 5	Slight shock.

Earthquakes in South Australia, 1902–1903.

Date.	Name of Place.	Time of Beginning of Shock. Adelaide S.T. (9 h. 30 m. E. of Greenwich.)	Apparent Direction.	Apparent Duration.	Effects—Remarks.
1902.				Secs.	
Feb. 14	Caltowie ..	2.1 a.m. ..	SSW to NNE	30	Rumbling several seconds before tremor. Direction uncertain.
„ 14	Georgetown ..	2 a.m. ..	Not known	*	Houses shook. Crockery rattled. Beds rocked.
May 7	Laura	2.40 p.m. ..	..	..	Crockery rattled. Walls and ceilings shook.
„ 7	Hammond ..	2.38 p.m. ..	NW to SE	30	
„ 7	Bruce	2.38 p.m. ..	NW to SE	20	Crockery rattled. Accompanied by rumbling.
„ 7	Carrieton ..	2.38 p.m. ..	SE to NW	7	Articles thrown from mantelpiece. Some plaster shaken down. No previous tremors or rumblings.
„ 7	Black Rock ..	2.40 p.m. ..	W to E	20	Crockery rattled.
„ 7	Eurelia ..	2.38 p.m. ..	NW to SE	30	Buildings shaken. Sudden. Crockery rattled.
„ 7	Wirrabara ..	2.40 p.m. ..	N to S	3	Sharp.
„ 7	Appila Yarrowie	2.37 p.m. ..	NW to SE	5	Loud rumbling. General vibration.
„ 7	Operating-room	2.38 p.m. ..	..	..	Gas-pendants oscillated.
„ 7	Yongala ..	2.38 p.m. ..	..	10	Windows rattled. Crockery rocked.
„ 7	Benelleby ..	2.30 p.m. .. (approx.)	NW to SE	15	Buildings swayed. No previous rumbling.
„ 7	Georgetown ..	2.38 p.m. ..	NW to SE	40	Buildings badly shaken.
„ 7	Hallet ..	2.39½ p.m. ..	..	10	Windows rattled.
„ 7	Mitcham ..	2.47 p.m. ..	NW to SE	30	Stopped clock. Severe tremor. Plaster fell in one house
„ 7	Orroroo ..	2.38 p.m. ..	NW to SE	20	Some plaster shaken from ceiling.
„ 7	Port Germein ..	2.39 p.m. ..	NE to SW	20	
„ 7	Port Pirie ..	2.45 p.m. .. (approx.)	NE to SW	10	Very slight.
„ 7	Quorn ..	2.38 p.m. ..	NW to SE	2	Windows shaken.
„ 7	Wilson ..	2.39 p.m. ..	SE to NW	45	Windows loudly rattled, and floor shook.
„ 7	Wilmington ..	2.40 p.m. ..	..	5	Windows rattled slightly.

May	7	Whyte Yarcowie	2.39 p.m.	..	20	Windows rattled.
"	7	Willowie E.	2.38 p.m.	NW to SE	30	Damage to interior of school.
"	8	Bruce	7.26½ a.m.	NW to SE	10	Movable objects slightly shaken. Accompanied by rumbling.
"	14	Marrabel	4.20 a.m.	SW to NE	20	Beds rocked. Crockery rattled. No damage.
"	14	Eudunda	4.16 a.m.	SE to NW	2	Doors and windows rattled. Very loud rumbling accompanied shock.
"	19	Petherton	1.45 a.m.	SE to NW	10	
June	3	Beltana	11.17 p.m.	..	3	Slight rumble.
"	4	Barossa	4.50½ p.m.	NNE to SSW	5	Windows rattled. Buildings creaked. Accompanied by loud rumbling.
"	4	Williamstown	4.30 p.m.	..	..	Simply a rumble, with a vibration sufficient to be plainly felt.
"	6	Caltowie	8.5 a.m.	W to E	30	Windows and crockery rattled violently. Accompanied by a rumbling noise as of heavy vehicle.
"	6	Gladstone	8.4 a.m.	SE to NW	10	
"	6	Wirrabara	8.5 a.m.	NW to SE	60	Windows shook. Rumbling.
"	6	Laura	8.5 a.m.	SW to NE	..	No damage.
"	6	Appila Yarrowie	8.5 a.m.	..	5	Loud rumbling, house shaken, and crockery rattled. Worst shock ever felt.
"	16	Hawker	2.18 a.m.	..	8	Windows shook. Rumbling like thunder.
"	16	"	3.52 a.m.	..	5	Rumbling like thunder.
"	18	"	8.51 p.m.	..	5	Shook windows. Rumbling like thunder.
†Oct.	30	Beltana	8.43 a.m.	NW to SE	5	Rumbling. Windows rattled.
Dec.	8	Hallet	6.36 p.m.	S to N	10	Gate and building rattled.
"	21	Laura	4.20 p.m.	NE to SW	..	Furniture rattled. Plaster fell. Slight rumbling. No damage.
"	23	Port Germein	4.30 p.m.	..	..	
1903.						
Jan.	31	Port Wakefield	3.25 p.m.	SW to NE	6	
Feb.	6	Hammond	8.10 p.m.	NW to SE	4	
"	6	Bruce	8.11 p.m.	..	6	Windows rattled.
"	7	"	2.23 a.m.	SW to NE	10	
"	28	Nairne	11.52 p.m.	NE to SW	60	Doors ajar swung open. Rumbling as of heavy wagon.
Mar.	10	Cape Banks	2.5 p.m.	..	4	

* Not known. † For earthquakes of September, 1902, see Supplementary List.

Earthquakes in South Australia, 1902–1903—*continued.*

Date.	Place.	Time of Beginning of Shock. Adelaide S.T. (9 h. 30 m. E. of Greenwich.)	Apparent Direction.	Apparent Duration.	Effects—Remarks.
1903.				Secs.	
April 7	Appila Yarrowie	10.31 a.m. ..	..	15	Windows and crockery rattled.
„ 7	Gladstone ..	10.30 a.m. ..	SW to NE	1	
May 17	Clarendon ..	10.37 ..	..	4	
Aug. 14	Clare	9.10 p m. ..	..	2	Noise as of explosion. Windows rattled. Rumbling noise.
„ 14	Port Wakefield ..	9.10 p.m. ..	N to S	5	Slight.
„ 14	Blyth	9.10 p.m. ..	N to S	..	„
„ 14	Brinkworth ..	9.10 p.m. ..	..	20	Sharp.
„ 14	Balaklava ..	9.10 p.m. ..	..	..	Slight
„ 14	Hoyleton ..	9.10 p.m. ..	..	..	„
Nov. 16	Hamley Bridge ..	11.32 a.m. ..	NE to SW	3	
„ 16	Freeling ..	11.35 a.m. ..	..	1	Report and concussion as of heavy guns. Not accompanied by usual rumbling.
„ 16	Eudunda ..	11.36 a.m. ..	..	..	Sharp.

Supplementary List of Earthquakes in South Australia, September, 1902.

1902.					
Sept. 19	Jamestown ..	6.35 a.m. ..	SE to NW	5	Slight.
„ 19	Gladstone ..	6.38 a.m. ..	NW to SE	10	Windows and crockery rattled. No rumbling.
„ 19	Georgetown ..	6.37 a.m. ..	NW to SE	4	Rumbling noise. Shaking of houses.
„ 19	Canowie ..	6.35 a.m. ..	NW to SE	7–10	General rattling of windows and crockery. Perceptible swaying of buildings.
„ 19	Red Hill ..	6.35 a.m. ..	S to N	10	Low rumbling as of heavy wagon. Slight rattle of windows
„ 19	Kooringa ..	6.30 a.m. ..	SE to NW	..	Windows shaken.
„ 19	Clare	..	..	10–15	Windows rattled violently.
„ 19	Auburn ..	6.38 a.m. ..	N to S	10	Crockery and bed shaken. Windows rattled. Loud rumbling.
„ 19	Riverton ..	6.37 a.m. ..	NE to SW	20	Doors and windows rattled violently. Accompanied by deep rumbling.

Sept.	19	Kapunda ..	6.36 a.m. ..	S to N	10	Distinct low rumbling. Very little vibration.
"	19	Balaklava ..	6.38 a.m. ..	..	4	No previous tremors or rumbling.
"	19	Eudunda ..	6.34 a.m. ..	S to N	2	Rumbling noise accompanied shock.
"	19	Morgan ..	6.34 a.m. ..	N to S	4	" "
"	19	Yardea ..	8.7 p.m. ..	SE to NW	..	Rumbling for 1½ minutes. No damage. Buildings shook.
"	19	Port Germein ..	8.4 p.m. ..	S to N	15–20	No damage.
"	19	Port Pirie ..	8.9 p.m. ..	SE to NW	120 (approx.)	No damage. Gentle rocking sensation. Light rumbling sound.
"	19	Port Broughton	8.5 p.m. ..	SW to NE	30–60	Clocks stopped. Several buildings cracked.
"	19	Crystal Brook ..	8.6 p.m. ..	NE to SW	30	Clocks stopped. Windows and doors shook.
"	19	Hammond ..	8.0 p.m. (approx.) ..	NE to SW	10	Rattling of crockery, windows, and doors.
"	19	Bruce ..	8.0 p.m. (approx.) ..	NE to SW	10	Windows, crockery, &c., rattled. Accompanied by loud rumbling.
"	19	Melrose ..	8.7 p.m. ..	N to S	30	A few walls and ceilings cracked, and a little crockery broken. Loud rumbling. Windows rattled violently. Buildings rocked.
"	19	Wirrabara ..	8.4 p.m. ..	SE to NW	30	Clocks stopped.
"	19	Laura ..	8.6 p.m. ..	SW to NE	36	Plaster shaken from cracked walls, &c.
"	19	Jamestown ..	8.7 p.m. ..	SE to NW	30	Crockery broken. Ceilings cracked. Number of people rushed out of houses.
"	19	Gladstone ..	8.5 p.m. ..	NW to SE	30	Some houses slightly cracked. Windows, &c., rattled. Crockery thrown from shelves. Rumbling previous to shock.
"	19	Georgetown ..	8.7 p.m. ..	NW to SE	90 (approx.)	Loud rumbling. Houses shook and windows rattled violently. The walls of some wells badly cracked.
"	19	Red Hill ..	8.5 p.m. ..	W to E	30	Crockery and windows rattled. No damage.
"	19	Orroroo ..	8.4 p.m. ..	NE to SW	20	
"	19	Hallet ..	8.5 p.m. ..	E to W	45	
"	19	Kooringa ..	8.5 p.m. ..	SE to NW	..	Less severe than morning.
"	19	Clare ..	8.5 p.m. ..	SSE to NNW	15–20	Hanging bells rang.
"	19	Auburn ..	8.7 p.m ..	E to W	90	Floors, furniture, crockery, doors, &c., violently shaken; and utensils fell off shelves. No previous warning.

Supplementary List of Earthquakes in South Australia, September, 1902—*continued.*

Date.	Name of Place.	Time of Beginning of Shock. Adelaide S.T. (9h. 30m. E. of Greenwich.)	Apparent Direction.	Apparent Duration.	Effects Remarks.
1902. Sept. 19	Balaklava ..	8.6 p.m. ..	S to N	Secs. 12	Office clock on E. and W. wall stopped at 8.6. Four or five other clocks stopped. Shook doors and windows; made hanging lamps swing; cracked several houses; and made plaster fall. Previous rumbling shocks; double; second half being severe; rumbling sound going away to the N.
„ 19	Port Wakefield ..	8.5 p.m. ..	SE to NW	100	
„ 19	Kadina ..	8.5 p.m. ..	E to W	105	Windows rattled and telegraph bell rang slightly.
„ 19	Moonta ..	8.5 p.m. ..	WSW to ENE	60	Houses rocked. Masonry fell. Walls cracked. Crockery broken. Preceded by noise similar to severe hurricane.
„ 19	Maitland ..	8.5 p.m. ..	NW to SE	50	Doors and windows violently shaken. Ornaments on mantelpiece shaken off.
„ 19	Edithburg ..	8.5 p.m. ..	W to E	4	Few clocks stopped, more especially pendulums swinging N. and S. Some ceilings and walls slightly cracked.
„ 19	Warooka ..	8.5 p.m. ..	N to S	210	Chinaware and furniture thrown and broken. Chimneys twisted from 2½ in. to 5½ in.; several fell. Wells cracked, large holes in walls from N. to S. Every building damaged. Water dashed from two iron tanks standing N. and S. No landslips.
„ 19	Yorketown ..	8.5 p.m. ..	NW to SE	45	Three clocks stopped. Crockery broken. Three chimneys cracked.
„ 19	Riverton ..	8.4 p.m. ..	E to W	95	Buildings severely shaken. Clocks stopped. Bells rung.
„ 19	Hamley Bridge ..	8.6 p.m. ..	N to S	50	Some clocks stopped. Crockery thrown from shelves.
„ 19	Kapunda ..	8.5 p.m. ..	S to N	120 (approx.)	Bells rung; crockery broken; and chimneys damaged. Bottles on shelves moved from N. to S.
„ 19	Eudunda ..	8.5 p.m. ..	S to N	120	Pendulum of clock facing E. thrown against the glass. Buildings violently shaken. No damage.

Sept. 19	Freeling	8.10 p.m.	NW to SE	60	General swaying of articles hanging. Fall of light objects. Slight damage to crockery. Slight cracks in walls. No serious damage.
" 19	Tanunda	8.7 p.m.	SW to NE	60	Houses rocked. Crockery broken.
" 19	Gawler	8.5 p.m.	SW to NE	60	Town-clock bell rang. Windows broken. Ceilings damaged.
" 19	Largs Bay	..	..	..	Stopped clock.
" 19	Port Adelaide	8.5 p.m.	NW to SE	40	Buildings trembled. Shutters in telephone exchange fell down. Furniture rocked.
" 19	Glenelg	8.6 p.m.	SW to NE	30	Several chimneys thrown down, and walls cracked on W. side. Gas-chandeliers swaying from E. to W.
" 19	Parkside	8.4¾ p.m.	N to S	10	Bells rung. Crockery broken. Walls cracked.
" 19	North Adelaide	..	..	..	Ornaments fell.
" 19	Hindmarsh	8.5½ p.m	NW	20	Rumbling. Ceilings cracked.
" 19	Normanville	8.4 p.m.	NW to SE	10	
" 19	Yankalilla	8.4 p.m.	SW to NE	30	Windows, crockery, and chimneys broken. Building cracked.
" 19	Hindmarsh Valley	8.4½ p.m.	..	..	
" 19	Cape Jervis	8.4 p.m.	NW to SE	10	Shook doors and windows.
" 19	Mount Barker	8.5 or 8.7 p.m.	N to S	15	Rumbling. Clock stopped. Ceiling cracked.
" 19	Nairiu	8.8 p.m. (uncertain)	NE to SW	30	
" 19	Blakiston	8.6 p.m	to SW	6	Great noise. Slight vibration.
" 19	Strathalbyn	8.3 p.m.	E to W	60	
" 19	Milang	8.3 p.m.	W to E	60	Crockery broken.
" 19	Wellington E.	8.5 p.m.	SW to NE	90	Buildings shaken. Windows and crockery rattled.
" 19	Murray Bridge	8.5 p.m.	W to E	60	
" 19	Mannum	8.5 p.m.	W to E	120	Severe tremors.
" 19	Cape Borda	8.0 p.m.	SW to NE	3	Rumbling. Shook tanks, spilt water.
" 19	Port Lincoln	8.5 p.m.	NW to SE	20	Walls and ceilings cracked.
" 19	Renmark	8.7 p.m.	SE to NW	30	Clocks stopped.
" 19	Naracoorti	8.6 p.m.	NW to SE	10	Rumbling.
" 19	Robe	8.6 p.m.	..	10	Slight.
" 19	Beachport	8.7 p.m.	NW to SE	10	Doors and windows shaken.
" 20	Kapunda	7.9 p.m.	Not noted	5	
" 20	Riverton	7.9 p.m.	ENE to W	7	Rumbling. Windows and doors rattled.

Supplementary List of Earthquakes in South Australia, September, 1902—*continued.*

Date.	Name of Place.	Time of Beginning of Shock Adelaide S.T. 9½ hrs. E. of Greenwich.	Apparent Direction.	Apparent Duration.	Effects—Remarks.
1902.				Secs.	
Sept. 20	Freeling ..	7.10 p.m. ..	NW to SE	10	Slight rattle of windows.
" 20	Balaklava	7.10 p.m. ..	E to W	5	Rumbling sound. Water in bore rose.
" 20	Tanunda .	7.11 p.m. ..	SW to NE	15	Tremors.
" 20	Eudunda ..	7.9 p.m. ..	S to N	30	Loud noise. Buildings, doors, &c., rattled.
" 20	Port Wakefield	6.55 p.m. ..	..	..	Slight shock.
" 20	"	7.9 p.m. ..	..	10	
" 20	Kadina .	7.15 p.m. .	..	10	Very slight.
" 20	Moonta ..	6.55 p.m. ..	..	..	
" 20	" ..	7.7 p.m. ..	..	.	
" 20	Auburn ..	7.5 p.m. ..	E to W	5	Slight noises and tremors.
" 20	" ..	7.10 p.m. ..	E to W	10	"
" 20	Hallet ..	1.41 p.m. ..	..	..	Slight.
" 20	Glenelg ..	7.10 p.m. ..	SW to NE	10	Rumbling noise.
" 20	Strathalbyn ..	7.10 p.m. .	..	..	Very slight.
" 20	Milang .	7.10 p.m. ..	..	20	
" 21	Port Wakefield ..	Abt 1.40 p.m.	..	..	Slight.
" 21	Auburn ..	1.42 p.m. ..	N to S	5	Slight. Slight rumble. Rumbling of windows.
" 21	Jamestown .	1.43 p.m.	SE to NW	5	Slight. No effects.
" 21	Balaklava ..	1.42 p.m. ..	..	..	Very slight.
" 24	Port Wakefield ..	1.30 a.m. ..	..	..	Sharp. About thirty other shocks were recorded between the 19th September and the 7th October, mostly slight. The times given are only approximate, generally to nearest quarter-hour.
Oct. 17	Echunga ..	6.50 p.m. ..	..	4	Sharp.
" 22	Hallet ..	8.50 p.m. ..	NE to SW	3	Slight.

Note.—Returns were also received from 106 other places, the times from which were obviously rough, and vary from 8 p.m. to 8.15 p.m.