REPORT

OF THE

SECOND MEETING

OF THE

AUSTRALASIAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE

HELD AT

MELBOURNE, VICTORIA,

IN

JANUARY, 1890.

EDITED BY

W. BALDWIN SPENCER, M.A.

Published by the Association.

PERMANENT OFFICE OF THE ASSOCIATION:
THE ROYAL SOCIETY'S HOUSE, 5 ELIZABETH STREET,
SYDNEY.

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OBJECTS AND RULES OF THE ASSOCIATION.

OBJECTS.

The Association has been founded upon the same lines as the British Association, and its rules are practically the same. It should be particularly noticed that this Association also "contemplates no interference with the ground occupied by other institutions. Its objects are:—To give a stronger impulse and a more systematic direction to scientific enquiry; to promote the intercourse of those who cultivate Science in different parts of the British Empire, with one another and with foreign philosophers; to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which may impede its progess."

RULES.

1. All persons who signify their intention of attending the first Meeting shall be entitled to become original Members of the Association, upon agreeing to conform to the Rules.

2. The Officers, Members of the Council, Fellows, and Members of the Literary and Philosophical Societies publishing Transactions or Journals in the British Empire, shall be entitled in like manner to become Members of the Association. Persons not belonging to such Institutions shall be elected by the General Committee, or Council, to become Life Members of the Associations, Annual Subscribers, or Associates for the year, subject to the payment of the prescribed Subscription, and the approval of a General Committee.

3. All members who have paid their Subscriptions (£1 per annum) shall be entitled to receive the Publications of the Associations *gratis*.

4. The Association shall meet for one week or longer. The place of meeting shall be appointed by the General Committee two years in advance.

5. There shall be a General Council, having the supreme control, to be composed of Delegates from the different Colonies or Colonial Scientific Societies. The number of Delegates from each Society or Colony shall be proportionate to the number of

Members from the particular Colony or Society—Subscribing or otherwise—taking part in the proceedings (*i.e.* after the preliminary Meetings). Each Colony or Society shall be allowed to nominate a Delegate for each one hundred of its Members.

6. There shall be a General Committee consisting of Members of the Council, Presidents, Vice-Presidents and Secretaries of Sections, Contributors of Papers to the Association, and such others as may be elected.

7. A Local Committee shall be appointed at the place of meeting to make arrangements for the reception and entertainment of the visitors, and to make preparations for the Business of the General Meetings.

8. Sectional Committees shall be appointed for the following Subjects:—

Section A—Astronomy, Mathematics, Physics and Mechanics.

Section B—Chemistry and Mineralogy.

Section C—Geology and Palæontology.

Section D—Biology.

Section E—Geography.

Section F—Economic and Social Science and Statistics.

Section G—Anthropology.

Section H—Sanitary Science and Hygiene.

Section I—Literature and Fine Arts.

Section J—Architecture and Engineering.

9. Ladies are eligible for Membership.

10. The rights and privileges of Membership shall be in the main similar to those afforded by the British Association, subject to revision and alteration after the first Meeting of the Australasian Association for the Advancement of Science.

OFFICERS AND COUNCIL, 1890.

President:

Baron von Mueller, K.C.M.G., F.R.S., M. & Ph. D.

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His Excellency Sir Robert G. C. Hamilton, K.C.B., President of the Royal Society of Tasmania.

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Professor Kernot, M.A., C.E., President of the Royal Society of Victoria.

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G. Gordon, C.E., Victorian Engineers' Association.

G. S. Griffiths, F.G.S., Royal Geographical Society of Australasia, Victorian Branch.

H. W. Hammond, Royal Geographical Society of Australasia, New South Wales Branch.

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K. L. Murray, Victorian Engineers' Association.

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J. Shirley, B.Sc., Royal Society of Queensland.

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Professor Anderson Stuart. M.D., C.M., Royal Society of New South Wales.

J. Sulman, F.R.I.B.A., Royal Society of New South Wales.

R. O. Thompson, Victorian Engineers' Society.

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C. W. De Vis, M.A., Royal Society of Queensland.

Hon. W. A. E. West-Erskine, M.L.C., Zool. and Acclim. Society of South Australia.

C. S. Wilkinson, F.G.S., F.L.S., Royal Society of New South Wales.

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G. S. Griffiths, F.R.G.S.
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Professor W. Baldwin Spencer, M.A. (Secretary).

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E. F. J. Love, M.A.
A. Dendy, M.Sc.
J. Stirling, F.G.S. (Secretary).

Presidents, Vice-Presidents, & Secretaries of the Sections at the Melbourne Meeting, January, 1890.

Presidents.	Vice-Presidents.	Secretaries.
	Section A.—Astronomy, Physics, Mathematics and Mechanics.	
Professor Threlfall, M.A.	Professor Lyle, M.A.	E. F. J. Love, M.A. W. Sutherland, M.A.
	Section B.—Chemistry and Mineralogy.	
Professor Rennie, M.A., D.Sc.	C. R. Blackett, F.C.S.	Professor Orme Masson, M.A., D.Sc.
	Section C.—Geology and Palæontology.	
Professor Hutton, M.A. F.G.S., C.M.Z.S.	Professor McCoy, C.M.G., M.A., D.Sc.	James Stirling
	Section D.—Biology.	
Professor A. P. Thomas, M.A., F.L.S.	P. H. MacGillivray, M.A., M.R.C.S. J. Bracebridge Wilson, M.A., F.L.S.	A. Dendy, M.Sc., F.L.S. C. A. Topp, M.A., LL.B., F.L.S
	Section E.—Geography.	
W. H. Miskin, F.E S.	Commander Crawford Pasco, R.N. A. C. Macdonald, F.R.G.S.	G. S. Griffiths, F.R.G.S.
	Section F.—Economic and Social Science.	
R. M. Johnston, F.L.S.	Professor Elkington, M.A.	H. K. Rusden, F.R.G.S. A. Sutherland, M.A.
	Section G.—Anthropology.	
Hon. J. Forrest, C.M.G., M.L.C.	A. W. Howitt, F.G.S.	Rev. Lorimer Fison, M.A.
	Section H.—Sanitary Science and Hygiene.	
J. Ashburton Thompson, M.D., D.P.H.	A. P. Akehurst G. Gordon. C.E.	G. A. Syme, M.B., F.R.C.S.
	Section I.—Literature and Fine Arts.	
Hon. J. W. Agnew, M.D., M.E.C.	Professor Tucker, M.A. J. Hamilton Clarke, Mus. Bac.	Louis Henry, M.D. Tennyson Smith.
	Section J.—Architecture and Engineering.	
Professor Warren, M.Inst.C.E.	H. C. Mais, M.Inst.C.E. A. Purchas, C.E.	A. O. Sachse, C.E.

GENERAL PROGRAMME FOR THE MEETING.

Tuesday, 7th January.

11 a.m.—General Committee Meeting, in Meeting Room of Section F.
3 p.m.—Garden Party given by Baron von Mueller at the University.
8 p.m.—Presidential Address in Town Hall.

Wednesday, 8th January.

10 a.m.—Sectional Committees meet in Section Rooms.
10.30 a.m. to 1 p.m.—Sections meet for Reading and Discussion of Papers.
10.30 a.m.—The following Presidential Addresses will be delivered:—

Section A.—Astronomy, Mathematics, Physics, and Mechanics, by Professor Threlfall, M.A.

Section C.—Geology and Palæontology, by Professor Hutton, F.G.S.

Section F.—Economic and Social Science and Statistics, by R. M. Johnston, F.L.S.

Luncheon.—1 p.m. to 2 p.m.

2 p.m. to 4 p.m.—Sections meet for Reading and Discussion of Papers.
2 p.m.—The following Presidential Addresses will be delivered:—

Section B.—Chemistry and Mineralogy, by Professor Rennie, M.A., D.Sc.

Section D.—Biology, by Professor Thomas, M.A.

3 p.m.—Visit to Newport Railway Works and to Botanical Gardens.
8 p.m.—Conversazione in the Town Hall, given by the Right Worshipful the Mayor of Melbourne, Matthew Lang, Esq.

Thursday, 9th January.

10 a.m.—Sectional Committees meet.
10.30 a.m. to 1 p.m.—Sections meet for Reading and Discussion of Papers.
10.30 a.m.—The following Presidential Addresses will be delivered:—

Section E.—Geography, by W. H. Miskin, F.E.S.

Section G.—Anthropology, by Hon. John Forrest, C.M.G.

Section J.—Architecture and Engineering, by Professor Warren, M.Inst.C.E.

Luncheon.—1 p.m. to 2 p.m.

2 p.m. to 4 p.m.—Sections meet for Reading and Discussion of Papers.
2 p.m.—The following Presidential Addresses will be delivered:—

Section H. — Sanitary Science and Hygiene, by Ashburton Thompson, M.D.

Section I.—Literature and Fine Arts, by Hon. J. W. Agnew, M.D., M.E.C.

2.20 p.m.—Visit to Royal Mint and Picture Gallery.
3.30 p.m.—Visit to Public Library and Picture Gallery.
4.30. p.m.—Visit to Works of Hydraulic Power Company.
8 p.m.—Invitation Concert, given by the Victorian Orchestra.

Friday, 10th January.

9.30 a.m.—Sectional Committees meet.
10 a.m. to 12 noon.—Sections meet for Reading and Discussion of Papers.
1 p.m.—Special train leaves Spencer Street, taking Members to the Garden Party given by Sir William and Lady Clarke, at Rupertswood, Sunbury.
5.45 p.m.—Train leaves Sunbury.

Saturday, 11th January.

10 a.m.—Sectional Committees meet.
10.30 a.m. to 1 p.m.—Sections meet for Reading and Discussion of Papers.
Luncheon.—1 p.m. to 2 p.m.
2 p.m. to 3.30 p.m.—Sections meet for Reading and Discussion of Papers.
3 p.m.—Visit to Picture Gallery of Robert H. Kinnear, Esq.
4 p.m.—Visit to Tram Sheds.
8 p.m.—Special Concert in the Town Hall.

Monday, 13th January.

Excursion to Ballarat starts.
10 a.m.—Sectional Committees meet.
10.30 a.m. to 1 p.m.—Sections meet for Reading and Discussion of Papers.
Luncheon.—1 p.m. to 2 p.m.
2 p.m. to 3.30 p.m.—Sections meet for Reading and Discussion of Papers, and Sectional work is brought to a close.
3.30 p.m.—Visit to Zoological Society's Gardens, and to the Foundry of Messrs. Langlands.
8 p.m.—Conversazione in University Grounds.

Tuesday, 14th January.

Excursion to Sandhurst starts.
11 a.m.—Meeting of General Committee to appoint Officers and make arrangements for the next meeting to be held in New Zealand, and to settle the place of the next following meeting.

Wednesday, 15th January.

Excursions start for Gippsland Lakes, Australian Alps, and the Black Spur, as detailed in the trip-slips. Each of these will occupy four days, the parties returning to Melbourne on Saturday, 18th January. Leaders—Messrs. J. Stirling, A. Sutherland, and A. W. Howitt.

Thursday, 16th January.

Excursion to Fern Tree Gully, returning to Melbourne the same day. Leader—Mr. C. A. Topp.

MEETING OF THE GENERAL COMMITTEE, TUESDAY, 7TH JANUARY, 1890.

Extracts from the Minutes.

Mr. Ellery, C.M.G., F.R.S., in the chair. About twenty-five members present.

The Minutes of the last meeting held in Sydney, on 3rd September, 1888, were taken as read.

Professor Liversidge presented the Balance-Sheet, showing the receipts and expenditure in Sydney, during the year 1889, which was received and adopted.

The arrangements made for the Melbourne Meeting were ratified, and the thanks of the General Committee were unanimously accorded to Professor W. Baldwin Spencer for having by his untiring exertions brought matters to such a successful issue.

Invitations were received from Auckland and Christchurch for the Meeting of 1891. It was resolved on the motion of Professor Hutton to hold the Meeting in Christchurch.

Professor Kernot proposed that the the Fourth Meeting should be held in Adelaide, seconded by Professor Rennie.

Mr. Barnard proposed and Captain Pascoe seconded a motion to hold the Fourth Meeting in Tasmania. After some discussion it was resolved to postpone the discussion until Saturday, the 11th.

Mr. W. Sutherland moved—"That the asociation add to its sections a special one for the science of education, to be entitled 'Educational,' and denoted by the letter K." He thought educational enthusiam here was more general than in the mother country, and it would be a wise thing to have an educational section.

Professor Tate moved, as an amendment—"That a representive from each section be a committee to determine whether any, and what increase or decrease, there shall be in the number of sections, and to report to the General Meeting of Committee, to be held on Tuesday next."

Mr. Tate's amendment for the appointment of a committee to consider the desirableness of extending or curtailing the number of sections was put as a substantive motion, and was carried.

After some discussion the meeting adjourned until Saturday, 11th January, at 9.30 a.m.

MEETING OF THE GENERAL COMMITTEE, WEDNESDAY, 14TH JANUARY, 1890.

Extracts from the Minutes.

Mr. Ellery in the chair. About thirty-five members present.

The Minutes were taken as read and signed by the Chairman.

The following Reports of Committees of Investigation were presented, received, and ordered to be published as far as funds would permit:—

No. 3.—Australasian Biological Station Committee.

No. 7.—Australasian Mineral Census Committee.

No. 9.—Town Sanitation Committee.

No. 11.—Australasian and Polynesian Races Bibliography Committee.

No. 13.—Australasian Geological Record Committee.

No. 14.—Progress of Chemical Science Committee.

Resolved,—On the motion of Rev. LORIMER FISON, M.A., that the services of Dr. J. FRASER of Sydney in connection with the Report of Committee 11 be placed on record.

Payment of Accounts.—Moved by Mr. GRIFFITHS, seconded by Mr. TOPP, that authority be given to the Council to pay accounts.

Appointment of President for New Zealand Meeting.—Proposed by Mr. F. WRIGHT, seconded by H. H. HAYTER, that Sir JAMES HECTOR be appointed President for the New Zealand Meeting. Carried unanimously.

Appointment of Secretary for New Zealand Meeting.—Proposed by Mr. A. MORTON, seconded by Dr. ALLAN CAMPBELL that Professor HUTTON be appointed Secretary for New Zealand. Carried unanimously.

General Treasurer.—Proposed by Dr. ALLAN CAMPBELL seconded by Professor ANDERSON STUART, that Mr. H. C. RUSSELL be appointed General Treasurer. Carried unanimously.

Local Secretaries.—The following were elected :

Mr. A. MORTON	... ...	Tasmania.
Mr. J. SHIRLEY	... ...	Queensland.
Mr. F. WRIGHT	... ...	South Australia.
Professor PARKER	... ...	Dunedin.
Professor THOMAS	... ...	Auckland.

Secretaries for Wellington, Napier and Nelson to be appointed by New Zealand Council, Secretary for West Australia to be appointed on the recommendation of Hon. JOHN FORREST.

Professor LAURIE gave notice of the following motion :—"That a New Section be added under the head of Mental and Moral Science."

It was decided on the motion of Mr. A. MORTON to hold the Fourth Meeting of the Association in Hobart, Tasmania.

Vote of Thanks were unanimously passed to the following :—(1) Sir William Clarke, (2) Mayor of Melbourne, (3) Mayor of Ballarat, (4) Mayor of Sandhurst, (5) Council of School of Mines, Ballarat, (6) Council of University of Melbourne, (7) Managing Committee of the Victorian Orchestra, (8) Royal Society, (9) Musical Bodies, &c., who assisted at the Concert, (10) Others who have extended hospitality to its members.

A Special Vote of Thanks was accorded to Messrs. G. B. PRITCHARD, T. S. HALL, T. S. HART, J. S. HART, A. W. CRAIG, and W. MACGILLIVRAY, in acknowledgment of the services rendered by them in connection with the meeting.

A Vote of Thanks was passed in acknowledgment of the services of the ex-President, Mr. H. C. RUSSELL.

A Vote of Thanks was passed to Professor SPENCER in acknowledgment of his services in connection with the Meeting.

A Vote of Thanks was passed to Mr. ELLERY for his service in presiding at the Meeting and acting as Chairman of the Local Council.

The following Committees were re-appointed :—

No. 1—Conditions of Labour Committee.

Committee "To inquire into the Question of the Condition of Labour, with special reference to strikes, and to make suggestions for their remedy" :—Mr. W. GARLICK, Major GOLDSTEIN, Mr. H. H. HAYTER, Professor KERNOT, Mr. H. K. RUSDEN, Mr. H. C. RUSSELL, Mr. A. C. WYLIE.

Secretary—*Professor Elkington.*

No. 2—Australasian Meteorology Committee.

Committee "To inquire into the present state of Meteorology in the Australasian Colonies":—Mr. R. L. J. ELLERY, Mr. W. SUTHERLAND, Professor THRELFALL.

Secretary—*Mr. H. C. Russell.*

No. 3—Australasian Biological Station Committee.

Committee "To consider the Establishment and Endowment of a Biological Station for Australasia" :—Mr. A. DENDY, Mr. J. J. FLETCHER, Mr. A. A. S. LUCAS, Mr. MACGILLIVRAY, Professor W. BALDWIN SPENCER, Professor R. TATE.

Secretary—*Professor W. A. Haswell.*

No. 4—Australasian Biological Bibliographical Committee.

Messrs. A. DENDY, Mr. J. J. FLETCHER, Professor F. J. PARKER, Professor W. A. HASWELL, Professor W. B. SPENCER, Professor A. P. THOMAS, Professor R. TATE, Mr. C. A. TOPP, Mr. H. TRYON, Mr. T. WHITELEGGE, Dr. J. T. WILSON, Dr. MACGILLIVRAY, Mr. J. BRACEBRIDGE WILSON.

Secretary—*Mr. A. H. S. Lucas.*

No. 5—Protection of Native Birds and Mammals Committee.

Committee "To consider and investigate the Protection of Native Birds and Mammals":—Mr. A. J. CAMPBELL, Professor W. A. HASWELL, Mr. R. M. JOHNSTON, Professor W. B. SPENCER, Dr. RAMSAY, Professor R. TATE, Mr. H. TRYON, Colonel LEGGE, Professor THOMAS, Mr. S. DIXON, Rev. J. J. HALLEY.

Secretary—*Mr. A. Morton.*

No. 6.—Hygienic Committee.

Committee "To consider certain points in the Construction and Hygienic Requirements of Places of Amusement in Sydney":—Mr. W. E. ROTH, Dr. J. ASHBURTON THOMPSON, Professor WARREN, Dr. WILSON.

Secretary—*Mr. J. Sulman, Sydney.*

No. 8—Australasian Glacial Evidence Committee.

Committee "To investigate and report on Glacial Evidence in Australasia":—Mr. H. Y. L. BROWN, Mr. S. H. COX, Sir JAMES HECTOR, Mr. R. L. JACK, Mr. W. H. RANDS, Mr. J. STIRLING, Professor TATE, Mr. C. S. WILKINSON.

Secretary—*Professor R. Tate.*

No. 10—Australasian Seismological Committee.

Committee "To investigate and report upon the Seismological Phenomena of Australasia":—Mr. A. BIGGS, Mr. R. L. J. ELLERY, Sir JAMES HECTOR, Mr. H. C. RUSSELL, Professor THRELFALL, Mr. C. TODD.

Secretary—*Sir James Hector.*

No. 12—Antarctic Exploration Committee.

Committee "To consider the question of Antarctic Exploration":—Mr. J. BARNARD, Mr. R. L. J. ELLERY, Hon. JOHN FORREST, Mr. G. S. GRIFFITHS, Baron VON MUELLER, Professor SPENCER, Professor STEPHENS.

Secretary—*Mr. Ellery.*

No. 13—Australasian Geological Record Committee.

Committee "For Geological Record during the year":—Mr. R. ETHERIDGE, Professor F. W. HUTTON, Mr. R. L. JACK, Mr. R. M. JOHNSTON, Professor R. TATE.

Secretary—*Mr. J. Stirling.*

The following new Committees were appointed:—

No. 15—Rust in Wheat Committee.

Committee "To investigate the question of Rust in Wheat":—Mr. J. H. MAIDEN, Mr. D. MCALPINE, Mr. C. A. TOPP, Mr. F. WRIGHT, with power to add to their number.

Secretary—*Mr. A. N. Pearson.*

No. 16—Location and Laying-out of Towns Committee.

Committee to consider and report upon the Location and Laying-out of Towns":—Mr. J. M. COANE, Mr. A. W. CRAVEN, Mr. A. M. HENDERSON, Professor KERNOT, Professor WARREN.

Secretary—*Mr. J. Sulman.*

No. 17—Improvement of Museums as a Means of Popular Education Committee.

Committee "To consider and report upon the Improvement of Museums as a Means of Popular Education":—Mr. C. W. DE VIS, Professor HUTTON, Professor MCCOY, Mr. A. MORTON, Dr. RAMSAY, Dr. STIRLING, Professor THOMAS.

Secretary—*Professor Parker.*

No. 18—Fertilisation of Fig in Australasian Colonies Committee.

Committee "To investigate the Fertilisation of the Fig in the Australasian Colonies":—Mr. F. M. BAILEY, Mr. C. FRENCH, Baron VON MUELLER, Mr. A. S. OLIFF, Professor THOMAS.
Secretary—*Mr. C. French.*

No. 19—Unification of Colours and Signs of Geological Maps Committee.

Committee on "The Unification of Colours and Signs of Geological Maps":—Mr. H. Y. L. BROWN, Sir JAMES HECTOR, Mr. R. L. JACK, Mr. R. A. MURRAY, Mr. C. S. WILKINSON, Mr. WOODWARD.
Secretary—*Professor Hutton.*

No. 20—Present State of Knowledge of Australasian Palæontology Committee.

Committee "To investigate and report upon the Present State of Knowledge of Australasian Palæontology":—Sir JAMES HECTOR, Mr. R. M. JOHNSTON, Professor MCCOY, Professor TATE.
Secretary—*Mr. R. Etheridge.*

No. 21—Tides of Australia Committee.

Committee "To investigate and report upon the Tides of Australia": —Professor BRAGG, Professor LYLE.
Secretary—*Mr. R. W. Chapman.*

The following Special Committees were appointed:—

Moved by Professor ANDERSON STUART and seconded by Mr. C. S. WILKINSON—"That the following form the Publication Committee:—Messrs. ELLERY, GRIFFITHS, W. SUTHERLAND, and Professors SPENCER and MASSON."

Professor MASSON moved and Professor TATE seconded—"That a Committee be appointed to draft a revised Code of Laws for the Association, and report at the meeting in Christchurch, the Committee to consist of the following:—The General Secretaries, Mr. ELLERY, Professor RENNIE, Mr. A. MORTON, and the Mover; Professor SPENCER to act as convener."

On the recommendation of Section B., it was resolved "That a Special Committee consisting of the Presidents and Secretaries of Sections B., C. and D. be appointed to formulate a scheme, whereby the assistance of the Governments of the various colonies may be enlisted in procuring material for Special Investigation. Professor RENNIE to be reporter."

SYNOPSIS OF GRANTS OF MONEY APPROPRIATED TO SCIENTIFIC PURPOSES BY THE GENERAL COMMITTEE AT THE MEETING IN 189 .

The names of the members who are entitled to call on the Treasurer for the respective grants are prefixed.

[None.]

TABLE SHOWING THE NUMBER OF MEMBERS PRESENT, RECEIPTS TO, AND GRANTS MADE AT THE ANNUAL MEETINGS OF THE ASSOCIATION.

Date of Meeting.	Place of Meeting.	Presidents.	ATTENDED BY						Amount Received up to and during Meeting.	Sums paid on Account of Grants for Scientific Purposes.
			Old Life Members.	New Life Members.	Annual Members.	Ladies.	Visitors.	Total		
1888—Aug. Sept.	Sydney.	H. C. RUSSELL, B.A., F.R.S.	—	—	805	45	—	850	£858 8s.	—
1890—Jan.	Melbourne.	BARON VON MUELLER, K.C.M.G., F.R.S., M. & Ph.D.	—	—	1081	81	—	—	£2084.	—

The Australasian Association for the Advancement of Science.

Statement of Accounts of Melbourne Meeting: 1st July, 1889, to 1st October, 1890.

RECEIPTS.

	£	s.	d.
Subscriptions	£1084	0	0
Grant from Victorian Government	1000	0	0
Excursions	398	6	0
Sale of Sundries	3	5	0
	£2485	11	0

EXPENDITURE.

	£	s.	d.
Printing to date	£934	15	2
Advertisements	180	9	0
Postages to 4th January	41	7	8
Telegrams to 4th January	10	9	4
Salaries and Assistance to date	176	4	0
Excursions	538	1	0
General Expenses of January Meeting ...	480	6	4½
Retained in Sydney Office	111	0	0
Balance in Bank	59	18	11
Cash in Hand	22	5	0
Sundries	30	14	6½
	£2485	11	0

Audited and found correct,

F. T. J. DICKSON.

31st October, 1890.

ROBT. L. J. ELLERY, *Hon. Treasurer.*

W. BALDWIN SPENCER, *Hon. Secretary for Victoria.*

INAUGURAL ADDRESS

By the PRESIDENT,

BARON FERDINAND VON MUELLER,

K.C.M.G., F.R.S., M. & Ph.D., &c.

The first duty, devolving on me at this auspicious gathering, is to offer on behalf of the present Council of the Australasian Association, and not less from the depth of my own feelings to all, assembled now, the very best of welcome. Patronised by the noble representative of her Majesty, graced from exalted station also by the first lady of the land, generously countenanced by the Premier and the other members of the Ministry, extensively sustained by Melbourne citizenship, and prominently supported by the University, we enter on this second meeting of the Association with every bright prospect. Indeed, our hopes are raised still more by the success, achieved already in the eldest metropolis, since, through the genius and circumspect assiduity of the Sydney University Professor of Chemistry, the great home movement became extended to these southern colonies. Called unexpectedly for this year to the position, which magnanimous impulses and unbounded generosity have assigned to me, I must so far speak of myself, as to assure you, that this mark of consideration will ever be valued by me beyond all expression; that I am conscious of having no claims to this high favour, unless it be by scientific seniority in these colonies, and that I will endeavour to fulfil those expectations, which are justly set on leaderships in a grand festive concourse, such as we are now to celebrate. Before proceeding, it is incumbent on me to express my rejoicing at so large and so splendid an attendance at this meeting, which is even encouraged by the genial smiles of so many ladies; and further, to offer my homage to the distinguished office-bearers, to the kindful hosts and notably also to the accomplished Secretary, through whose united perseverance, graciousness and energy the hopeful aspect of the Melbourne gathering is mainly due. My eminent predecessor, the Government Astronomer of New South Wales, has in a powerful and learned address sketched the origin and objects of the British

Association for the Advancement of Science, the fifty-eighth meeting of which was held in Newcastle during September of last year. Thus the bearings and aspirations of these science-musterings came anew before us here also from the great British home, whose lead and aims we are anxious to follow and to imitate even in these respects. Whoever shared actively or even only passively in the engagements, for which this extensive union has been established, whether in Britain or on the continent of Europe or in America, must have realised how much vitality is infused into science-work by these Associations through whole communities, how immensely inspiring the personal contact with leaders in progressive thought is to individual workers of all ranks and in all directions; how plans are formed and problems submitted, otherwise likely unattended to or left indefinitely postponed, and how powerful and trusty an influence by this widely spreading and annually refreshed organisation can be exercised on the public mind, to speed progress, particularly of utilitarian tendency, in a telling and in an impressive manner. Indeed, with the inauguration of this Association commenced a new era for science in these dominions of the British Crown. It is to us a movement of historic significance of its own. It falls to the share of the greater gatherings, from which ours is an offspring, to review the advance of science throughout its various branches in the older seats of learning; I will therefore not attempt at the youthful stage of the Association here, to lay before you any methodical and connected accounts of more recent events on the walk of knowledge, even should I thereby not anticipate, what my honoured colleagues may wish to explain or record in the respective sections, over which they preside. Indeed, in these distant locations it seems at present more important, to clear away some scruples, which prevent recognition of our purposes, or to render more fully known the wide accessibility, afforded for joining in these periodic gatherings. The destination of this institution is a far wider one, than may be supposed generally by our fellow colonists. The word "science" seems in British communities often to be understood, to apply to researches in the domain of nature exclusively. The acceptance of the word in this sense would exclude from our scope much of the best *éclat* of what we desire to accomplish, whereas really we here would wish to embrace in our range of discussions and operations, whatever was meant by the ancient word "*scire*" and hence "*scientia.*" We would extend this meaning as far as ever the rays of knowledge can illuminate, as far as ever the power of thought can penetrate. Social science, for which at the Exhibition of 1880 a congress was held here, over which our erudite honorary Treasurer presided, can merge readily now into sections of this Association. Though we cannot expect every member, perhaps according to some European standard, to be engaged actively in pursuits of discovery with a strict scientific bearing, I feel sure to express the feelings of all, whom professional positions or amateur-inclination bring together on the path of knowledge, when I affirm, that the Association joyously and gratefully welcomes all who will cheer us in our aspirations, will listen to our discussions, and will support us by that moral influence, which every educated and thoughtful layman can bring to bear. Ours is a kind of scientific federation full of soul. Every one can help. The wide scope of the Association thus being rendered patent, as well as the ease of access, it might next be asked by the uninitiated, what are the more direct objects, what the more immediate tendencies, what the final destinations of this organisation, spread now also to a distant corner of the globe like ours? As you might foretell, we accept on Australian soil this movement—started by an illustrious sage of Edinburgh—in all its bearings, hopes and responsibilities, with perhaps this one preference, that, while we endeavour to follow the cosmopolitan course, as adopted in the northern world, we would cherish some predilection for maintaining a command over the fields of indigenous work in these far southern regions, without any wish however of monopoly, but with that patriotic sense, becoming to us as residents in this particular portion of the British Empire. Irrespective of carrying on original research, worthy of a country of juvenile freshness, it is our duty more especially, to instil the flow of information from so manifold sources near us in such a manner, that new growth for further developments may arise through that limpid course in all possible directions. We should and could arouse anew also all those, who may slacken, by example and by new inspirations. You can carry a spirit of research into the family-homes; you will leave in many an hospitable house, which opens its doors in a year of choice to illustrious participators of these meetings, many reminiscences not less pleasurable than profitable through life. I shall not speak here of the living among leaders in progressive knowledge, of those who yet are shining forth at the British Association also; but I would wish to pay a word of homage to the dead—to those, whom many of you have still met, and on whose busts at solemn moments we would wish, if even in thought only and passive pensiveness, to place also here a laurel wreath. Thus, among Britons, such names come before our memory as those of J. Herschel, James Ross, Faraday, McClure, Sabine, W. Hooker, Lindley, Brewster, Wheatstone, Murchison, Darwin, Speke, Carpenter, Lyell, Brodie, Gould, Livingstone, Sedgwick, Berkeley, G. Bentham, Simpson, Proctor and a host of other luminaries, reminding us likewise of an early Melbourne University professor, who at a meeting of the British Association about the middle of the century, was one of its principal secretaries. To one meeting the greatest lustre was given by the presidency of H.R.H. the Prince Consort. As there is a brotherhood of all nationalities in science, it may be pardonable when from my own bit of career I allude to some experiences of forty-four years ago, while attending as an active member what might be called the German Association for the Advancement of Science. A flight of thought brings vividly before me again such illustrious personages as Schleiden, one of the earliest investigators of the living cellule; D'Alton, one of the founders of embryology; Langenbeck, the great and conservative surgical operator and his long-renowned disciple, Esmarch. There were also the Scandinavians Oersted, Forchammer and Steenstrup, the one the main discoverer of electro-magnetism, the other eminent in northern geology, the third an early expounder of alternative generation. It is as if I hear once more the voice also of Kunze, the pteridologist; of Rammelsberg, a leading expert in analytic chemistry; of Waitz, the horticultural monographer of the Ericeæ; of Volger, one of the great authorities on volcanoes; of Krauss, the zoologic Caffrarian explorer; of Sonder, one of the authors of the Cape-flora, and of Schacht, Roeper and Muenter, the eminent morphologists and physiologists; some of gay communicativeness, others of calmer reservedness—all spreading knowledge in their own way, all happy and elated among their scientific compeers, but also well aware, that their coming together then might be an only one in life! It is, as if I were brought once more face to face with many a hero in science, nearly all now numbering with the dead; some of whom having attended the earliest meetings of the British Association, and thus by their appearance, then grey, among a multitude of junior investigators, linked together in a most fascinating and exalting manner one generation with another in science. A felicitation could then still be sent to Oken, the founder. You can all enter into the feelings of Virchow, who at the Berlin meeting of the German Association in 1886, while unfolding to the 3000 members once more the roll-book of 1828. There were the names of Humboldt, as President, of Berzelius, Ehrenberg, Woehler, Rudolphi, Gauss, Weber, Johannes Mueller, Mitscherlich, Rose, Magnus, of Oersted also, and of many another scientific immortality, each either a founder of a branch of science or a rearer of it into extensive vigour. Well may Virchow have exclaimed, that it was as if life became infused once more into the dead signatures! No doubt many assembled now in this hall experienced similar emotions, when attending meetings of the British Association, where they first of all, and perhaps never again, saw individually some of the coryphæans, of whom they had ever so often heard and read, for whom they cherished an unlimited veneration, and whose memory became thus dearer still. Some of the younger members, now here present, may yet be spared to participate as veterans in the centenary celebrations of Sir David Brewster's founding the parent Association. To some extent and in a vivid manner we shall be able, to measure the onward course of science here by the periodicity of these gatherings from year to year, from decade to decade. Much human faculty is always going to waste; let this Association in its popularity collect all stray forces, especially as here, on new grounds, the very novelty of research must stimulate to more ardent action and keener emulation. Crude empiricism gives way in all directions to scientific ruling; the multitude is awakening more and more to the importance of exact research; a tide has set in to carry knowledge with all accumulating discoveries into every possible application; hence the rapid strides of technic art and rural industries, particularly in young, bustling communities. Yet commerce, as well as handicraft, often still undervalues science-work, while daily benefiting from it, though unseen, unrecognised and unregarded. But this Union can make its influence felt through deliberations and direct recommendations, and perhaps most powerfully so, because its tendencies are so eminently practical and so unselfish. Much in that direction are indeed our efforts, our aspirations, our hopes! We can at measured intervals in this Association connect researches with an extensiveness and universality such as no other organisation can effect; yet we do not enter into rivalry with localised societies or institutions of learning; contrarily, on them we lean mainly for our mental sustenance.

The field of research is ever widening, but the horizon gets clearer; the objects of research become more multitudinous, but the appliances for investigation are constantly enriched; volumes still more instructive supersede one another; methods more facilitous are substituted for those of the past; incontestable observations are daily increasing, the elaboration of systems and records gets more completed, and thus endless difficulties become removed, which beset the path of former workers; by such means an ever-accumulating science-fortune is rendered available without individual freedom being impaired. Yet, while the network of knowledge expands and the width of the meshes decreases, the empty interstices between the threads are proportionately augmented, though the fabric as a whole gains more firmness. The greatest triumph of sciences consists in bringing them into the fullest contact, somewhat in an Aristotelean and Plinian—or speaking of our own epoch—in an Humboldtian spirit.

Discovery has its own rewards, and they are of the sublimest kind. When, as far back as 1817, the founder of the British Association perceived the endless displays of his kaleidoscope, and beheld other before unthought-of marvels, he lifted in pious admiration his eyes to heaven, well recognising that each playful change in the picture or every other result from his optic apparatus was ruled as much by laws, universal and eternal, as the movements in the planetary world. In recent days the great anatomic Professor Hyrtl, after he saw his main work pass through eighteen editions and through many translations, discourses still, though blind, with youthful enthusiasm in classic Latin on the bearings of medicine. Sir Richard Owen, at the venerable age of an octogenarian, evinces still with freshness of mind a keen and joyful interest in comparative zoography, of which he is one of the main originators. A coëtanean of his through the century, George Bentham, continued like Sir William Hooker after four scores of years still brisk in descriptive taxonomy for the plants of the world—engagements of severity, from which many a young worker even would shrink; the watching of discoveries in their speciality were to them a never-ceasing fountain of delight, a necessity for their intellectual existence. When Haydn, the predecessor of Mozart and Beethoven in composing symphonies, heard with great splendour the performance of his oratorio, the "Creation," one of his last works, he burst into tears at the passage, "It became light," and uttered in deepest emotion the words, "It is not from me, it is Divine inspiration." The vibrations of the Eiffel-tower, the new structure, doubly as high as the Strassburg-spire, were attentively studied by Chevreul at an age of his more than that of a centenarian.

Grand and true discoveries, such as may more and more also here be effected, are not, like meteors, flashing brilliantly but ephemerously across the sky; they are like the discerning of new stars of lasting radiancy; and there is one mighty incitation, inasmuch as every achievement through progressive thought stamps on it the name of the discoverer for all times, and as any single new achievement may have numbers of others in its sequence.

Let it be instanced, what since Galvani's time has been brought about, until with lightning's speed electric messages are now dashing in all directions through the world. It would be invidious to single out anyone connected with this glorious progress for special praise, unless the Nestor of electrology, who in co-operation with Gauss fully fifty years ago issued the atlas of terrestrial magnetism, and still some years earlier made one of the first efforts to span electric wires over wide distances.

What long ago was surmised by Faraday, and later on through calculations by Maxwell, has in the course of 1889 been proved by Professor H. Hertz, of Karlsruhe, from real experiments, that the action of the electric current on the medium, through which it is carried, is the same as that produced by light; further, that the generation of both depends on the same laws, and that the propulsion is effected at the same velocity. The objectionable hypothesis of "action into distance," which Weber already wished to avoid with regard to gravitation, is overthrown by these new demonstrations.

In recent days many surprising and momentous discoveries were witnessed, but few can be alluded to here. Among those, which have a practical and extensive bearing on daily requirements, some originated or were evolved through the genius of Edison, from whom, as one yet in the prime of life, still other inventions may be expected. Here I will refer only to that mode of luminosity, which may be regarded as much cosmic as telluric, and which now is brought within wide technical operation through particularly disintegrated coal glowing in absolute vacuum—not without some previous suggestions and experiments by Sidot and Swan.

So also is it startling, to hear the human voice now with telephonic celerity across a whole country, and hardly impaired in intensity. Through the combination of Gray's or Bell's telephone, with Edison's phonograph, messages can be fixed—as you may be aware—in writing; while, by Hughes's microphone, the sound can be heard with extraordinary distinctness.

Nations are now rivalling to possess the largest telescope, Melbourne still carrying the palm for the southern hemisphere. Indeed, the great equatorial instrument here, with its four feet mirror, is surpassed only by that of Lord Rosse, and equalled only by that of Paris. Astronomy became lately in wondrous details connected with astrophysics and astrophotography. The astronomic department here, under our distinguished treasurer, Colonel Ellery's able administration, will extensively share also in the now commencing international photographic charting of the sidereal heavens. A gigantic refractor-telescope has been placed in the clearest of air at one of the culminations, 4600 feet high, of the Californian coast-range by a generous American mining operator and amateur-astronomer, on whom fortune had smiled; and thus within the last year or two were revealed some empyrean marvels, never beheld by mortal eye before; the nebular ring in Lyra presented quite new and complicated features, and additional stars at or near the cyclic aggregations were discovered by the astronomers of Mount Hamilton, Professors Holden and Schaeberle. Here may be alluded to only one other result of these observers, attained under so exceptionally favourable circumstances within their celestial area, namely the elliptic nebula of Draco, with its fulgent hydrogen and nitrogen, is now shown to consist of coiled rings. New planetoids may thus also from thence come within the range of vision, eight having been observed from elsewhere on the northern heaven during 1888 and at the beginning of 1889, thus bringing recorded numbers up to 283. The power, which would be exercised by very large telescopes placed within the tropics at alpine elevations above the frequent course of clouds in air so much rarified, may be beyond all present imagination. More "about the comets, as supposed meteor-swarms, which have entered the solar system," might perhaps be learnt from such positions. Spectroscopic observations by Huggins, Secchi, Vogel, D'Arrest, Finlay, Wiedemann, Schiparelli, Hasselberg and other philosophers lead to additional explanations in this respect.

What photography, an art discovered within the lifetime of many assembled here, in progressive scope may effect in future, is as yet mere conjecture. The producing already, but not the fixing as yet, of three of the principal colours within the present processes of this glorious art holds out some hope, that its faithful pictorial representations may become embellished yet by vividity of colouration emanating directly and thus unerringly from operative processes.

In a very different way other questions come before us. Whether in the organic world a supposed involuntary tendency of striving for higher development and further melioration, whenever circumstances are favourable, arises from uncontrolled impulses, so that nothing is left in a stationary distinctiveness! Whether specific values for clear diagnosis and systematic fixity have in the generality of cases been allotted with adequate scope? Whether fertile hybridity is far more extensive, than we have hitherto been led to suppose? Whether diversity in the physical conditions of nature can explain the vaster development of gigantic mammals and birds in the zoologic ages prior to the present? Whether forced accommodation or spontaneous adaptability to altered circumstances of existence can change gradually and even infinitely structural organisations and specific functions? Whether crowding out, however overwhelming, can extend to absolute annihilation in the free fields of nature, when undisturbed by human action, or whether this combat for space and search for nourishment is limited to mere repression? Whether among specific organisations the most powerful always dominate to the extensive suppression of others more numerous? Whether organisms, which in the present creation-epoch became extinct by the hand of man, could possibly ever be restored, by progressive growth, even after many lengthened periods and with every conduciveness for resuscitation? Whether our present means for research are advanced enough, to distinguish all innate peculiarities, with which distinct types in the organic world are endowed? Whether, if all this could be answered in the affirmative, it would be sufficient to account for the marvels of designs in organic individuality connected with vital processes, as revealed to us from the simplest and minutest to the most complex and huge of living beings, all displaying perfection for their own distinct purposes? Whether all our search for what is knowable can ever lead to a worldly insight into the commencement of all origination? Can we contribute from this Association, by original unbiassed research here in new countries, towards the answering these momentous questions?

The wider the climatic range, the greater the variability, so that for studying specific limitations of organic beings we here are placed in a more advantageous position, than those on whom the first elaboration of Faunas and Floras devolved in the home-countries. When a phyto-palæontologist of first rank and life-long experience, such as Goeppert, doubted whether from that branch of knowledge much support could as yet be obtained for the ascendance-doctrine, we are cautioned also so far, not to be over-hasty in construing ideas and evolving theories with a view of universal applications. The opposite views on organic development, defended respectively by two such eminent among earlier naturalists, as Cuvier and St. Hilaire, deserve profound consideration even now-a-days. We are anywhere and anyhow only at the threshold of the temple of truth, and might thus remain conscious of some of the last humble words of even a Newton!

The dictum, supposed to be reliable, "*natura non facit saltus*," is not universally applicable, not even in palæontology, as demonstrated by the three well-marked stages of the American horse. One of the sublimest of poets, not foreign to natural science, must have been persuaded of a Godly operation in nature, when he wrote—

> "Wohl erkundbar is das Wirken,
> Unerforschlich bleibt die Kraft!"

The world would lose many of its charms to intellectual beholders, if observers sink too much into materialistic explanations and speculative reasonings. We all admire the sagacity, displayed by great leaders in biology, to trace the building up of organic frames, and to follow up observingly what is manifest in respective cycles of vitality; but can we adopt with the evidence attained all the conclusions drawn therefrom? Let us deprecate extending theories beyond what is warranted by trustworthy observations; let us avoid hazarding opinions unsupported by facts; and above all let us distinguish between what is within human grasp and what must ever be concealed to the eyes of mortal beings!

The question has sometimes been raised, what is a billion? but an answer of calculative correctness has but seldom been given, though in some thoughtlessness that enormity of numeric value may be often enough rashly applied. Thus we hear spoken of more than a billion tons of coal deposits in the Chinese province of Shansi; and as the search through carboniferous areas has in this colony also just passed into a momentous stage, it would be well to remember, that in 1884 the actual output of coal came to a total of 409 million tons, two-fifths of this from Britain. From a naturalist's point of view, some fractional approach to the solution of such questions might be arrived at perhaps, when the prodigiosity of nature's displays is considered in estimating, on the basis of some calculation, the total number of spore-caselets on the fronds of our hill-ferntree (*Alsophila australis*) at 400 millions and that of the spores at 4000 millions; when further it fairly can be assumed, that a large tree of our silver-wattle may produce as a total from its copious masses of flower-headlets 25 millions of tiny flowers, 800 millions of stamens, and 8000 millions of the compound pollen-grains; when a red-gum eucylaptus or a manna eucalyptus may exhibit the twenty-fifth part of a billion of stomata in the whole of its foliage.

Let us turn to another subject. Choice areas, not necessarily very extensive, should be reserved in every great country for some maintenance of the original vegetation, and therewith for the preservation of animal life concomitant to peculiar plants. Where the endemic riches are greatest, there also the danger is more imminent of these being swept out of existence, unless timely measures are adopted for the reservation of some sequestered spot, to which rural occupations should never be allowed to have any access with their disturbing influence on primeval harmonies. Such spots should be proclaimed for all times the people's inalienable property, and every inhabitant or visitor of the locality should consider himself the co-preserver of such areas, so as to aid in preventing accidental invasion or casual ignition or intentional spoliation. Furthermore, to such places of security should be transferred plants and animals of exceptional rarity occurring near these seclusions. "Floral commons," thus established, would soon be among the most attractive features, not only for pleasure excursionists, but also for travellers from abroad, and would afford future generations in various territories some idea of the wondrous natural beauty of vegetable and animal life in its once unique loveliness, pristine grace and unimpaired freedom. Measures like these once initiated would earn enduring gratitude, and would find imitation in all countries, and particularly in those, where nature has scattered its floral gifts most prodigiously over the territorial expanse. Under intelligent supervision such places, through restricted concessions, might be made to yield a greater income, than accruable through ordinary rural occupation. Who would not plead in this cause? as our Field Naturalists' Club has indeed so fervently done already. More and more of rarities are commencing to succumb and to be made unrestorable, and scarcely a spot seems safe on the face of the globe against the defacing hand of man! To the Great Auk no longer any existence was allowed on the remotest hiding-place of Iceland, where the last poor pair succumbed, while courageously defending their nest! Will any remnant of the tribe of the gigantic birds, lingering yet in the recesses of far southern latitudes, perhaps share the same fate? At this instance may be called into memory the touching verses by the greatest of German poets, relating how the chamois is driven by the relentless hunter to the utmost pinnacle of its highland-home, and then the Alp-spirit of the legend sallies forth with wrathful voice, "Pause! why do you hurt my herd?" Space is left for all on earth!

May also the forests be pleaded for here in this assembly?

It should be a fixed plan in national economy anywhere, to maintain masses of forest-vegetation near sources of rivers, and to establish some broad arboreous bordering on streams, where it does not extensively exist, as much calculated to reduce sweeping water-volumes by soakage and mechanical retention. For this purpose, nut-trees, cork-oaks, basket-willows and other trees, prominently utilitarian, could be chosen. To what reflections are you led, when a recent flood of the Mississippi not only devastated the adjoining land in its course, but destroyed also, through protracted submersion, much of the existing riparian woods; when property counting by millions of dollars is lost to a Californian railway company through one single flood directly traceable to destruction of forests; when two-thirds of the inhabitants of the populous Connemaugh Valley perished by the dam-disaster; when so recently and so terrifically quite a million of people were drowned in the floods of the Yellow River, and another million of inhabitants died from starvation, epidemics and other miseries as the sequence of such vast calamity. Merely a small fraction of the monetary losses involved would have sufficed to avert all this, if spent in well-regulated forestry. The cooling of temperature in forests under ordinary circumstances means the reduction of much aqueous vapour to liquid humidity, and further the local re-precipitation of gaseous moisture in aqueous density, with proportionate lessening of evaporation. Each of "our friends, the trees," is a factor, however small, in this calculation.

If really it could be demonstrated, that forests exercise no influence whatever on atmospheric precipitation, not even through electricity,—an opinion lately advanced, but about the correctness of which many do yet entertain the gravest doubt—then still remains to be considered whether through forests any country can obtain the fullest benefit from such aerial downpours as do occur. In North-western America the expression seems proverbial, "Rain follows the plough." The principle in both cases would be the same. Though moisture promotes spontaneous forest-growth, we are fortunately not by its absence prevented, even in almost rainless zones, to clothe bare tracts of country with an arborescent mantle of verdure. Should some one in opulence desire to build up for himself one of the most lasting of monuments, it would be by the bequest of an isolated primeval forest, ever untouchable, for the free enjoyment of the orderly portion of the public. The annual "arbor-day," let us trust, will become universal as a legitimate holiday, which will be looked forward to with delight, particularly by the juveniles, who, with a life of hope before them, can await results from pleasurable action and intelligent forethought. Celebrations like these are not without a lesson to the whole community.

The increment to the wood-estate of Victoria would be now already 200,000 trees annually, if some slight tending followed the impulse of planting; even where trees naturally abound, additions can be made by choices from abroad, as anyhow forest culture should nowhere any longer be limited to maintenance and increase of species possessed by the region, but should in amplification be extended to whatever is best and perhaps available as superior from other lands.

Here, where, so to say, we live under eucalyptus-trees, we are apt to undervalue their hygienic importance, or to discard them altogether. Unfortunately also the multitude, notwithstanding many efforts made, is not yet sufficiently informed on sanitary measures; thus a large proportion of the general public does not even yet seem to recognise, that for plantations, such as were with special forethought raised since the last thirty years around this metropolis, pines were purposely chosen on account of the salubrious effect of terebinthine antiseptic exhalations from these particular trees—a momentous consideration, where hundreds of thousands of inhabitants have already crowded closely together, and where zymotic diseases are so frequent and often so severely raging, not to speak of the æsthetic aspect in a zone of evergreen vegetation, where main-masses of trees with deciduous foliage are out of harmony, while a six months' spring prevails against as much winter-time of colder regions; yet, for all that, what thoughtful people have regarded as the vegetative pride of the environs of Melbourne may be in danger of being sacrificed to capricious tastes and transient fashions. Interplantations of palms, bamboos, and other contrasting plants were long since contemplated under the shelter of the pines, to relieve any imaginary or real monotony produced by large masses of coniferous trees, even where they were miscellaneously grouped. Now to another topic.

If merely to a slight extent the treasures of nature have been studied anywhere, with what enthusiasm are visited then new regions in appreciative knowledge or detail conversedness. The child even on its school-walks, the recreation-seeking pedestrian, the travelling tourist,—after some previous glimpses into nature's arcana—involuntarily sees more for rational and elevating enjoyment than the rest of the people, and that uncostly too, and perhaps even with substantial profit.

In whatever direction our glances are cast on organic nature, we perceive marvels of design from the mouse-sized monkey to elephantine giants, living or extinct; from the smallest humming bird, half-a-dozen of them hardly weighing as much as an ordinary letter, to the now byegone Moa of giraffe-tallness; from the towering huge Athrotaxis (or Sequoia) cypress-pine of California to mosses of almost invisible minuteness,—all perfect in organisation for their own special purposes. But endless other considerations press on the trained observer, only one to be touched on here. Can the time approximately be determined when the Diptrodon stamped in gigantic paces our plains, and when the Thylacoleon roared in pursuit of other marsupials, now exterminated?

One of the most remarkable of objects within the whole range of biology is that of Symbiosis, the unexpectedly wide extent of which through the empire of plants having lately been demonstrated by Professor Beccari—the hospes not proving detrimental or often not even injurious to the host. Professor Frank very recently discovered that fungus-growth of quite peculiar kind at the extreme ends of the root fibres in oaks, beeches and trees allied to them, mediates the nutrition of them as a necessity. Could all this be merely casual? The Azolla, nourishing a microscopic alge, is an example near to us, just as in other but similar respects the native evergreen beech.

At the very time, when I left Europe, forty-two years ago, Count Suminski discovered, to the surprise of many of us, the antheridous and archegonous organs on the minute prothallus of ferns; but whether and how genetic relation exists between the primordial and the subsequently-developed sporangious organs on fern-fronds has never yet been traced or explained; and this is all the more mysterious as regards fern-trees, such as abound here, when years intervene between the production of the prothallus and that of the spore-bearing caselets. See further the vast significance of what, at first thought, may appear a mere trifling matter.

A small fly (*Lestophones iceryae*) was not long ago noticed as antagonistic to the coccid-insect *Icerya purchasi*, by the very observant Mr. Fraser Crawford, of Adelaide, though a closely allied fly, *Lastophonus monophlebi*, infests mainly, if not exclusively, another coccid, the *Monophlebus crawfordi*, as shown by Mr. F. A. A. Skuse, so that even in introducing the particular Diptere needed for subduing the Icerya very discriminative entomology must be brought to bear for coping with an evil of quite dreadful dimensions in Californian orchards, not to speak of what with the less powerful Coccinellides can be done. Thus the Agricultural Department of Washington found it necessary to send a professional entomologist purposely to Australia, in order that the Lestophones be established also on the other side of the Pacific Ocean, to restore thus far "the balance of nature;" just as in another remarkable instance the vines of the United States are largely reared in Europe and elsewhere now for their immunity to the *Phylloxera vastatrix*, which from America invaded other countries. Perhaps this parasite could likewise be subdued by other insects, such as would not attack the vines. If so, a question would be solved involving almost the whole interest of rural prosperity in many wide regions. So then a new special field is opened anywhere for entomologic observations, with a prospect held out of high substantial reward.

The described species of living animals, according to a very recent calculation by Drs. Krauss and Lamprecht, largely from the works of Leunis and Bronn, reach in number one quarter of a million! Of these are Mammals 2,300, Birds 11,200, Fishes 9,000, Molluscs 2,300, Insects 167,000 (with 80,000 Beetles). But even in latest days these numbers became considerably augmented, thus that of the Micro-Lepidoptera from this part of the world by the strenuous researches of Meyrick.

The admissible species of described living plants number not less than 200,000 now, as about 120,000 vasculares, taken in a conservative sense, have been fairly well defined, and as Prof. Saccardo has given in his large recent work alone 27,000 diagnoses of fungaceous plants, so that the total number of supposed species already to be dealt with in descriptive Biology cannot fall very much short of half a million species. Mitten enumerated and diagnosticised, twenty years ago, already 1750 sorts of genuine mosses for South-America; the zealous and accomplished two Vice-Presidents of the Biologic Section have, in spare hours, after their professional engagements, recorded respectively 400 species of seaweeds from the littoral regions off and near Port Phillip, and 600 species of Polyzoa from the extratropic shores of Australia, the polyzoic fauna merely of our great Bay here being richer than either that of the British shores or that of the Mediterranean Sea. Over 1000 species of Australian fishes are contained in the Census, which we owe to the Hon. Sir William McLeay, whom, to our regret, illness obliged to relinquish in the Melbourne meeting the position, assigned to him as a veteran of scientific prominence. Mr. Masters's Catalogue of Australian Beetles, largely from collections of the distinguished naturalist just named, and commenced by his renowned uncle, comprises 7200 species; but since that was published considerable augmentations have taken place. Indeed, thousands and thousands of kinds of insects, particularly others than coleoptera, are fluttering and buzzing as yet unrecognised, unclassified and undescribed in Australian air, entomologists throughout Europe and many elsewhere envying those here for the yet easy chances of obtaining novelties.

Let as an instance of rarity of species be adduced the re-discovery of *Amansia mammillaris* through some action of my own within the last few months on the very isolated Abrolhos-rocks, opposite Champion Bay, perhaps the only place of its existence, from whence a solitary specimen of this oceanic alge, as one most exquisite for delicate beauty, structural tenderness and lovely coloration, was brought by Peron during Baudin's expedition of 1802, and described in 1809 by the Caen Professor Lamoruoux, thus tantalising phycologists all the while.

Irrespective of the seven descriptive volumes, mainly by the incomparable Bentham, on the universal vegetation of Australia, special works on the flora of most of the Australian Colonies are now provided, one for Queensland having been published by Mr. Bailey some time ago, and one for South Australia having been just issued by Professor Tate, who also brought geologic and zoologic considerations to bear on the vegetation there. Mr. C. Moore has furnished the manuscript for the Flora of New South Wales, with a prospect of early promulgation in a special volume. Sir Jas. Hooker's Floras of New Zealand and of Tasmania, quite gems, emanated already many years ago as one of the results of Sir James Ross's antarctic expedition.

Though limiting these remarks to achievements of later times, I do not wish to pass the name of Robert Brown, because not only did he lay most extensively and firmly the basis for the system of Australian vegetation, but it was he also, who took up again morphology for plants, after the long interval since the origination of that branch-science by Wolff, just when it was resumed for animals by Doellinger.*

Through gradually increasing facilities for multiplication in iconography now, so far as plants are concerned, about one-fifth of the known species have become depictured. Of illustrated monographies in vegetable natural history the most urgently required is one on Characeae, an opus, which would be of local interest in every part of the world, and particularly here, where this group of waterweeds abounds.

In one particular respect splendid chances for facilitation or acceleration of science-work are not rarely lost at opportune moments, namely, to acquire extensive authentic collections, the accumulation of which may have involved the sacrifices of recreative ordinary pleasures through a whole life, the disbursement of a private fortune and the main-absorption of a brilliant mind in fixed research, whereby treasures may have been got together for material valuation simply unpriceable. Nowhere applies this more than in young colonies, where no opportunity should be missed, whenever such may suddenly arise at long intervals, to complete the working material from abroad by what may be otherwise utterly unobtainable. The securing of the Linnean collections, by the forethought of a British servant to his country, is an instance in point.

The gifted Secretary of the subsection for Music in our gather-

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* A passage from the Address is here omitted, in which the names were given of scientists, prominent in Australia during recent periods and mostly yet active in research; but it proved impossible within the precincts of a general discourse, however propitious the moment, to allude to every one, who had attained celebrity in Australian scientific life. A hope is entertained, that at future meetings of the Association full justice will be done within the special sections to the merits of various and respective individual discoverers, who constitute now already quite a multitude of scientific worthies also in this part of the world. Two deviations from this course will be countenanced by all with due homage—to note especially the superb Decades, largely also palæontologic, issued during the last 30 years by the veteran Professor of the Melbourne University—and to bestow adequate recognition on the brilliant manner in which the first President of the Australian Association maintains the fame of our eldest Observatory.

ing is among those who endeavored to rouse a spirit for beautifying our landscapes as well as our immediate surroundings. Biologists, particularly, could add to the charms of vernal vegetation anywhere by transferring for naturalisation from land to land, at all events, the minutest of flowers, always innocent, such as here the neatest Candolleas ; the snatching up and forwarding of a few grains of seeds, and their being merely scattered on adequate soil in similar climatic regions, would suffice. Peculiarity in the constitution of the fruit enabled the Cocos-palm to transmigrate on its own accord from its home in the Western Hemisphere to the shores of the Eastern ; it requires other means for the French-bean and the gourds to reach the East ; for the last 300 years they were consumed as a frequent table-food of supposed eastern origin ; but now only has it been shown, by archaeologic researches into the Incas-times, that they belong as indigenous to the western world exclusively. This exemplifies how objects of almost daily concerns can still afford means for original inquiry for almost indefinite periods. The munificence of the learned President of the section for Literature and Fine Arts has fostered also this system of translocation, as shown last year by additional very copious distribution of salmon-ova through Tasmanian streams.

Cassino for 1888 recorded 13,500 scientists as holding recognised positions in various countries ; but the respective numbers given seem adequate only for North America—thus far, nearly 5,000 names being given. This, however, shows the extraordinary vividity displayed there for original inventive work, and that very much of a practical kind.

Young Australia has placed hitherto already through its science-societies about 130 volumes into the libraries of the world, and that mostly during the latter half of the century ; a freshness pervades these literary efforts, commensurate with the ampler originality of sources in new countries. An enlightened journalistic press accords here no less than elsewhere its generous support to science. For the world as a whole mental faculty is displayed, never without a scientific touch, in hundreds of thousands of journals, in uncountable periodicals, and in an endless number of spacious volumes. How is a view to be maintained over this ever-increasing flood of literature, if even for each of us in one or few directions only ? At all events, in greater works a resumé of their salient contents should never be wanting, some summing up of the main-substance, some abridged reference to novel elucidations. The idea of constructing an universal linguistic medium of communication, at first promulgated by Leibnitz in 1666, has occupied the minds of many of the learned ever since. Like numerical figures, chemical formulas and musical notes, such a language is to be readable by each nation in its own words, and the name Pasigraphy has been chosen for it. Volapük affords steps towards accomplishing this, but does not solve the problem. Can the principle of stenography be drawn into use for this purpose? Classic languages, grandly developed more than 2,000 years ago, continue to give an antique firmness to international writing; but, after all, England has given its language to already one-fourth of the world, a language of powerful conciseness and flexible expressibility, doubtless destined to become still more and more predominating in the course of time.

There is one publication which concerns Australia much, but is in its value here too scantily recognised—that of the Royal Colonial Institute, a union much brought about by the thoughtful activity of H.R.H. the Prince of Wales, and largely tending, through essays and discussions of leading colonists, to unite the interests of the British Colonies with those of the great home-country for more solidifying the Empire.

Chronologic writings exist for political but not for scientific events; a volume of the History of the British Association would almost be equivalent to a connected record of discoveries effected since its founding, as foreign achievements were never lost sight of. A history of all universities from original local archives would carry authentic and comprehensive records of all sciences also into medieval remoteness, and yet could be held within trenchant briefness—local extra-academic working not likely being passed at the respective seats of universal knowledge. By the co-operation of specialists the prominent points of still earlier discoveries might be readily adduced quite into the dawn of civilisation.

A new principle for facilitating scientific pursuits deserves to be alluded to at this occasion on account of its wide applicability, namely: to afford special convenience for original research in distant countries, as thereby additional inducements are offered for particular studies far abroad. A commencement thus far was made by the establishment of the biologic station at Naples. But to the Dutch belongs the credit of adopting ampler measures in this direction, so far as to fit up local working rooms, and as to lessen the expenditure for a lengthened stay of naturalists in Java, one of the most attractive places, as you are aware, for whoever wishes to study nature in its tropical grandeur. Several leading scientists have availed themselves already of this inducement; and Ceylon—still nearer to Europe—so as to be with sufficient advantage within reach during the long annual professional vacations, is now also resorted to. If Australia could follow this example, we would see oftener on our shores illustrious strangers, who might wish to spend a scientific furlough rather among widely different scenes in nature, and to roam among a vast number of new objects, than to travel within much traversed and scientifically more exhausted areas; and they might perhaps come accredited also as delegates to the Australian Association—

should we not prefer to invite purposely year after year representatives from the older seats of learning to gatherings here, as suggested at the last Medical Congress. What a rich store of recent professional experiences would be shed out before us, and how would we, while offering Australian hospitalities, endeavour to reciprocate from what could be obtained from here as scientifically novel. But this principle has still another bearing. In Java, for instance, pulmonary consumption seems never to become developed. More than that, a fortnight's steamer-voyage can bring, at a moderate cost, the phthisic invalid from England to Central America, for reaching, not too far inland, any chosen elevations with light and pure air of easy respiration. The mountain-regions of extra and intra-tropical Australia, as well as some of the elevated inland downs, come likewise within this hygienic scope, especially for sufferers from a home sufficiently near.

Turning to geography, let here the question be asked, as concerning us most, how can Australian exploration be advanced? Talent, enthusiasm and experience are available at any moment for the purpose. Our first historic century has passed; will the chronologic seculum also close, ere the blanks on the maps are filled up? If so, it would be almost a reproach; and may I be allowed to repeat what, in a geographic address, was said some few months ago: "The main work of Australian land-exploration devolved on nine travellers only; now space seems only left for one more great explorer, to rank with the nine. Who will be the tenth to carry off this last of honors, or will it be divided among several less ambitious competitors?" Well may the eagerness be understood, to set the life on winning such a prize!

What a contrast, when we reflect that Pytheas reached the Shetland Islands, his "Thule," at the time of Alexander the Great; and yet, that it should require more than two thousand years before Socotra became carefully explored, and thereby also its unique floral treasures and other natural riches disclosed, this having only been accomplished through action of the British Association by Professor Bailey Balfour within the last few years, though courses of navigation were close to that island since grey antiquity, its endemic aloe-plant having been famed already to the trading Phœnicians, but remaining through all that time for science purposes utterly unknown.

Manifold attempts have been made, to map out the leading features of the vegetation of various countries on series of charts, and to treat the stationary fauna similarly; if this was done from adequate material for every great region by united efforts of those, locally best initiated, then might be constructed comparatively complete zoo- and phyto-geographic atlases for the whole globe, and these would unfold at a glance the prominent types in a more impressive and instructive manner than any other. Co-operation is needed, to accomplish this, and more particularly so in Australia. Our biologists might devise some feasible plan, to advance this subject from year to year at the Association's meeting.

Capt. Engelhardt Jörgensen's singular enterprise, now under progress, to sail in a lifeboat around the world, arose from ideas encouraged and matured in this metropolis. The boat is decked, divided into water-tight compartments, unsinkable, readily portable, never permanently upset, easily set going in accident, and carries drinking water as ballast; it has stood a furious sea near the Bay of Biscay. We may thus expect the venturesome mariner with his companion, to arrive in due time, whereby a deed will be accomplished as daring and unique, as that of his famous countryman, who lately crossed the south of Greenland.

Dr. Nansen is seemingly to receive munificent support from a compatriot for an effort to approach by land the North-Pole from Greenland; this will likely prove the safest route, notwithstanding immense hindrances, because on that line will at all events be mostly a firm footing, and perhaps some game. If the best is made of a full arctic summer with sailing sleighs, it would be shown, to some extent at least, whether Greenland extends in terrestrial continuity still much further than 83° N., while chances likely would accrue of wide views onward from any high elevation. As one likely result, the northern limits of Greenland would at least be determined. At all events, it has now been shown, that arctic altitudes up to 10,000 feet are traversable.

Instances are too rare, considering the enormous private wealth accumulated in innumerable cases, of calling explorers into the field, such as in our days brought Agassiz to the Amazon-river, Stanley, "the bravest of the brave" among geographers, to Central Africa, Nordenskiold along the whole coast of North Asia.

But Australia is not without its Maecenates! Of this you will be reminded in the Wilson-Hall, in the Clarke and Wyselaskie Institutions, connected with the Melbourne University, while in the eldest city of Australia the main seat of science was endowed by Challis's princely munificence, and the Linnean Society is sustained largely in a permanent home by the foremost of Australian zoologists. In the metropolis, west of us, the University owes some of its principal ramifications to the Hughes and Elder bestowals. Ormond College and that of the Artisans here tell their own tale, whereas a statue at the largest library in the Southern Hemisphere commemorates what well directed energy and untiring perseverance can individually bring about. But let us think also of the liberal support, accorded by successive enlightened Ministries and Parliaments, to early and continued studies, without which high-mindedness many researches here could not have reached their present extent.

Turning to antarctics so far as mere temperature is concerned, that to be encountered on the southernmost tableland of ice, would probably not be lower than that endured by Nansen at elevations very lofty in Greenland, and the ascent of the ice-cliffs near Mount Erebus, from convenient points of sloping shores, would likely also not be more perilous, than the scaling of some ice-crests of the Caucasus by members of the Alpine Club last year. The project of renewed south-polar exploration has been discussed in all its bearings by the Antarctic Committee of the British Association, as well as here. We are not even yet aware, to what circumstances the existence of the only deep gulf towards the South Pole is traceable, whether to volcanic influences, or to terrestrial configuration, or to what other causes. Can the increasing pressure, exercised by the constantly enlarging height of the contiguous immense southern ice-masses, induce perhaps volcanic disturbances through the enormous weight? The breaking away of the crust or melting away from beneath, where not on firm land, seems quite out of proportion to the ever augmenting ponderousness, resulting from all aqueous precipitations ever there at once freezing, even at summer-time. What the effect of mere gravitation may finally be on this land of ice without any relieving open interjacent water-channels, concerns us even at such distance here as physicists and also as mere inhabitants very much indeed; and it is worthy of full discussions in our meetings for years to come, particularly if data could be obtained as to the ratio of increase of the ice. The extensive and so patriotic Australian Natives' Association likewise advocates renewed Antarctic disquisition; and surely these efforts will tend, to maintain also the glorious maritime supremacy of the British Nation, displayed formerly in the most distant of southern waters as much as elsewhere.

Now as to our own Alps. The circumspectness and energy of the Council, aided by public and private liberality, has provided enjoyments, some with us not previously realised. Among these is a tour to our highlands. To most Australians and many of the Europeans here a visit to our Alps, through the steam-locomotive more and more coming within ready and easy reach, will have the charms of novelty. Particularly in early or in late hours you will likely behold a kind of airy ocean, surrounding with gigantic waves, phantastic isles, formed by highland pinnacles visible above the sea of vapours, the sun's rays illuminating the calm or drifting clouds, resplendent in colorations of ever-changing and indescribable magnificence. You will there be in the purest of air of lightly respirable buoyancy. Whilst summer-heat parched already the lowlands, you will have vernal flower-fields of unique ever refreshed beauty, to wander over; close to this may lie never-melting snow. In this, what I would call the Australian Switzerland, pasture- and orchard-plots will soon be the homes of many new highlanders. You will be impressed with the solemnity and almost awe of stillness away from the haunts of man, feelings of human insignificance arising within scenes of nature so incomparably grand; there man is drawing nearer in his thoughts to the Divine Power ruling all.

Science nowhere can stand still! Linguistic science is not foreign to this Association. Thus, then, time-hallowed expressions, though some of them may have come as a glossarian inheritage even from Pythagorean antiquity, and may have continued of daily frequency, will have to give way to wordings in consonance with progressive discoveries. Organography, even in instances of words, to which has been clung with tenacity since the Plinian age, will have yet to undergo some changes for the sake of greater accuracy in definiteness and more clearness in etymology. Commatation in more than one of current languages could be brought better into accord with oscillations of thought. The hyphen might for fuller perspicuity be more drawn into use, and particularly so in organic chemistry, which furnishes, even at the latest of dates, words so unwieldy in reading, and so unpronounceable in length, for its complex-compositions, that one single word may be composed in unbroken array of as many as forty-five letters, not unlike the extensiveness of construction in some Oriental languages; while contrarily, abbreviations to such an extent as "Salol" for the new therapeutic chemical, "Salicylate of Phenol," appear equally deprecable. Speaking of ancient languages, it might passingly here be noted, from researches of Professor Sayce, of Oxford, in most recent days, that a brisk literary intercourse existed in cuneate lettering between all the countries from the Nile to the Euphrates during the fifteenth century before the Christian era. This was shown by unearthing the ruins of the residence-town of Amenophis the Fourth. Contrast with this the still existing stone-age of the Australian Nomades! We here cannot hope, to add much to what has been gathered already of the languages of the Australian aborigines for some further insight into the onward-march of the human races and the history of their progress; but such chances, as may still exist, should not be lost for constructing further vocabularies, ere the remnants of the last tribes are passing away, or abandon their pristine languages, or forget their lore; what can still be secured will be all the more valuable, because it will—at best—be so scanty. Studies of this kind will become more significant, since a Victorian divine, as a missionary in the New Hebrides, traces the language there partly to Semitic origin. Indeed, linguistic research assumes also here now such magnitude, that it might be recommendable to constitute hereafter a division for "science of languages" in the section for literature within this Association. The moment seems an apt one, to pay some homage at this spot also to the bearers of the gospel, who, in their inostentatious yet severe and perilous task, have to a vast extent gathered, fixed and systematised the languages of savage tribes, doubtless primarily in duties of holy call, but thereby collaterally affording means for comparative linguistic studies and the philologic subjects connected therewith. Indeed, the Bible is now translated into more than 300 languages or their diversified dialects. What an incalculable treasure is stored up by these biblic translations also in wordly aspects! Could the Association possibly do some further good in insisting, that by the force of logic, should be suppressed any defectiveness of thought in much of commonplace conversational and perhaps also literary phraseology, ever without reflection reiterated. Some appellations, vernacular or otherwise, are also here and there open to improvement yet; thus, to quote only one familiar instance, "Gumtrees," professionally speaking, would apply here to the Wattle-Acacias, not to the Eucalypts. For the advantage of conversing in several languages, and simultaneously to have disclosed the treasures of literature in originality, to learn two, three or even four, is at early childhood hardly more difficult than one, if facilities in family-life can be offered to the youthful retentive mind. Even to orphan-children, provided for by the State, this benefit could be extended, inasmuch as some juvenile inmates of orphanages might be readily transferred from the institution of one country to that of a neighbouring one without any additional expenditure for support, and with this philanthropic view, that nations, who unhappily nourish mutual sentiments of asperity, would through the rising generation by closer social contract draw nearer to each other also as great communities, would learn more to respect national character, would recognise more individual worth of their adversaries, would gradually be disabused of hostile prejudices, and would abandon supposed or exaggerated notions of their neighbour's faultfulness or enmity. This principle might perhaps be extended to all classes, with domesticities sure to arise out of it with all their happy influences.

It is most pleasing, to see assigned to the highly scientific art of music so distinct a position at this gathering, the division, constituted for it, being moreover enhanced in importance through a renowned composer being identified with it. At all periods of human existence the soul found its sublimest expression in harmonious tones. Emblematically the sacred Scripture seizes on this mode of expression, as conveying to the utmost the ideas of mental loftiness! By nearly a thousand symbols vocal and instrumental sounds were fixed from almost mythologic remoteness down to the olympian festivals; and well might it be wished, that some records of those melodies were left, enchanting as they were even at the dawn of mental culture, to be deciphered or restored at this age. To judge from the poetry of ancient periods, the music must then already have been pervaded by great depth and richness of feeling. A magnificent piece of music surpasses even so far the most splendid of poems, as its sounds are the eloquence of one universal language. Among great operatic composers is one only, with whom word and sound emanated from the same mind and soul, and it is he also who never spent the sublimest of music on inadequate themes; it is he who, with Meyerbeer, in utmost impressiveness gave to his musical effusions historic vividity, it is he who thus far knew to profit from the incomparable Avon-bard. So long as human suceptibilities exist for what is elevating, so long will master-pieces of music, of poetry and indeed also of pictorial and plastic art be imperishable treasures, may they even have come to us from the time even of the Iliad. If we think of the names of the great masters, should then not also with some thankfulness be a remembrance for those, who drew men of high genius into their path or sustained them thereon? What would have been the fate of Beethoven in 1808, had it not been for the aid of the then Arch-Duke Rudolph, of Prince Lobkowitz and Count Kinski at that turbulent time? What would have become of Schiller at his protracted illness without the annuity spontaneously, in the most delicate of terms, bestowed by the Danish Crown-Prince and Count Schimmelpfenning, and that at a period when national and private resources were alike absorbed to a vast extent, because all Europe was in arms, not to speak of numerous other instances, when genius was in danger to be extinguished by worldly narrowness. The sunny sky of Australia seems to kindle a general love for music, and has called forth many a talent already, some celebrating triumphs in the centres of European art, while a youth of this city carried off there among numerous competitors the Mozart-fellowship. But distinctions for this our great land have not only been earned in the glorious cause of music.

Photolithography, if not altogether it did arise in Victoria, became universally adopted in the particular process, elaborated here, and first explained before our Royal Society by one of Liebig's disciples, who too early became alienated from this colony. There also were first enunciated, however briefly, the views of the author of the *Unseen Universe* on the effects of rays, emanating from various substances; and these early studies were followed up by a long series of appertaining researches at the great Home Observatory of Kew. Brennan's torpedo is a Victorian achievement, recognised as highly important by the British Government, and has proved lucrative to the constructor.

It is about a hundred years ago when Galvani led the knowledge of electricity into new courses for unforeboded vast influences through the technic world; when Goethe conceived the first and far-reaching ideas of organic metamorphosis; when Sir James Smith established the first society of just pretensiveness for a special science; when the second Jussieu constructed his natural system of plants, perfect for all points but one, unless in details; when the elder Herschel erected his great telescope at Slough, the discovery of the sixth and seventh satellites of Saturn being among the earliest results obtained; when the elder Gaertner founded carpology; when the Danish Professor Otto Mueller established in taxonomy the genus Bacillaria, he, even as a physician, but little foreseeing, what solid basis he was gaining in one direction for the future extension of pathology; when Roxburgh settled in India, as the first to elucidate in a modern sense the flora of an extensive region by independent extra-European researches; when Lavoisier published his *Traité de Chimie* as the earliest main-pillar of the present system of chemistry, not long before he met his cruel fate; when, amidst other contemporaneous exploits, it fell to the share of Vancouver to cast the first anchor in St. George's Sound for vast extension of the British dominions in this continent.

Australia, although one of the latest of original abodes of man, may yet also be destined perhaps to be the field of some of mankind's greatest achievements. The Biblic words, Matthaeus: "It is good for us to be here; let us build edifices," is significantly applicable to advancing civilized settlement through these fortunate dominions.

We are to enter soon on the last decennium of this century, that secular epoch, which to all human foresight will remain the most expansive for discoveries in the world's history, because it would seem, that in most directions not equal opportunities can re-arise for inventive foundation-research within the same space of time. Shall we be in the proud position, that other ages will say, "The nineteenth century has done its work for science well?" And what can yet be accomplished towards its verge here and elsewhere? There will be some summing-up then of the gain of human thoughts so far. Can the geographic chart of our planet be finished by that time? Can the telegraph-wires be connected throughout all countries? Can the outlines of the geologic map of our globe be completed? Can the systematic records of the faunas and floras be mainly brought everywhere to a close? Can an universal meteorology be evolved? Can chemistry exhaust then already the display of elementary substances and of their principal coalescences? And can all this be helped on locally by this Association, if even only to a small extent?

When probably a decade hence this Union will inaugurally reassemble in our metropolis, perhaps to witness then also again another industrial fair of nations in commemoration of the linking together of two centuries, many whom we are gladdened to see yet among us will have passed away, resting under the sods; but though then you will see them no more, they—like earlier contemporaries of some of us—like Sturt, Mitchell, M. Stuart, Leichhardt, Gould, W. Sharpe, M'Leay, Gunn, Milligan, Sprent, Davy, Jukes, Haast, McKinlay, Clarke, Castleman, Tenison-Woods, Scortechini will have left for future inspiration and due gratitude many science-bequests of enduring value, gained largely on Australian soil; yet some loneliness of its own may perhaps be felt through missing them, for which the contact with a younger generation can perhaps not always fully compensate.

Individual life at best is but short; through "the advancement of science" it can be prolonged, can be rendered capable of much augmented achievement, can be made susceptible to multiplied enjoyments and much increased usefulness. We advance towards a greater future; what would we wish man's destiny in life to be? Can unprosperity be banished through amplest industrial productiveness? Can contentions be abolished by a universal recognition of rights? Can savagedom early be made to cease? Can finally each human being be educated to higher and worthier ideals? Can atheism be made to vanish? Can knowledge with its Baconian password bring its power to bear, to accomplish these most transcendental of objects? Can as interpreters of answers to such cosmopolitan questions all bearers of science throughout the world unite in a mental brotherhood?

And now some few closing words. Though while coming together in this Association we do not engage in political discussions, yet in one aspect we might venture, to diverge from the strict path, marked out for science-votaries—it is in this, to foster also through *our* bonds the "union of the empire," under permanent British supremacy. This must be the ardent wish of every true subject of our gracious Sovereign. Thereto point the grandest traditions, prominence in history, world-wide national influence, immeasurable strength of the realm, irresistible patriotic sentiments; thereto also leads us veneration for the great homeland, with its keen sense of justice, philanthropic clemency, practical tendencies and indomitable energy. May the reflex rays of that national greatness fall ever unobscured on us also here! What are we, whether in science or in any other consideration, without Britain in all its prototypic bearings and glory? Take this away, sever us from this, then the best of impulses, the greater confidence in our purposes, as well as our main guidance and security, would be lost! And where would be our gratitude? Britain bestowed on us a whole continent, with oceanic boundaries, within salubrious zones, exempt from autochthonic complications, with resources uncountable—all as a free gift, as an unencumbered patrimony. The solidity of a great empire will also be a guarantee for the best-connected and most luminous of science-progress in all dominions, over which its sceptre sways; it will ever signalise a power, by which knowledge and enlightenment and indeed religious reverence also, will be carried with the widest permanency through the world not only for the welfare of the greatest of nations, but also for the tranquillity and happiness of all mankind!

"What guides man in his high pursuit,
Opens, illumes and cheers his way?
Discerns immortals from the brute,
God's image from the moulds of clay?
'Tis knowledge! and *that* to the soul
Is power, is liberty and peace;
And, while celestial ages roll,
The light of *knowledge* shall increase!"

PRESIDENTIAL ADDRESS IN SECTION A

(*Astronomy, Mathematics, Physics and Mechanics*).

THE PRESENT STATE OF ELECTRICAL KNOWLEDGE;

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A DISCUSSION of the present state of electrical knowledge naturally involves an apology. It is not without a certain amount of trepidation that I venture to address you on the most profound of physical subjects, nor should I have done so unless it had been suggested to me by the Secretary of the Association. Anyone with any knowledge of the matter will, I think, bear me out when I say that the difficulty of turning the results of mathematical reasoning into a form in any way suitable for an address is exceedingly grave, and should really be only attempted by those who have a special knowledge, to which I in no way pretend. I hope, however, that any account, however feeble, will not be altogether useless, since the mathematical thicket must have appeared impenetrable to many who would otherwise have taken an interest in the subject. A knowledge of the elementary facts of the subject will be assumed. Coming to the point with all convenient speed, I will give a sketch of Maxwell's theory, because it has recently received what must be regarded as a great deal of striking confirmation. I will then go on to develop some of the arguments in favour of the theory, and will finally try to bring it up to date with respect to several points that have been more or less passed over in the general discussion.

It is to Faraday that we owe the experimental foundation of the theory, as well as the fundamental step of the theory itself, the direction of attention to the properties of the space surrounding charged or conducting bodies, rather than to the bodies themselves. The ideas of Faraday were first put in a precise manner by Maxwell, and then extended so as to give rise to a theory of optics known as the electro-magnetic theory—one of the most brilliant concepts of physical science. An immense amount of detail was also added by Maxwell, both with respect to phenomena falling clearly within the limits of the theory, and also with respect to certain outstanding phenomena which were not so clearly accounted for. The exact description of the theory of many of the instruments, and processes of electrical research was also first given by Clerk Maxwell. The oldest and most familiar facts of electral science are those of the attraction of electrified bodies and of magnets. Faraday pointed out that the action between such bodies depends on the kind of substance surrounding them, and gave precision to his ideas by his re-discovery of specific inductive capacity, and of specific inductive magnetic capacity, or permeability as we now call it. The question how does a magnet or electrically charged body at a point A manage to act or produce a force on another magnet or charged body situated somewhere away, say at a point B? A similar question was asked by Newton long ago with respect to gravitation, and in his letter to Bentley he gives an answer which I think worth quoting at length in spite of its being so well known: "You sometimes speak of gravity as essential and inherent to matter. Pray do not ascribe that notion to me; for the cause of gravity is what I do not pretend to know, and therefore would take more time to consider of it." "It is inconceivable that inanimate brute matter should, without the mediation of something else which is not material, operate on and affect other matter without mutual contact, as it must do if gravitation in the sense of Epicurus be essential and inherent in it." "That gravity should be innate, inherent, and essential to matter, so that one body may act upon another at a distance through a vacuum, without the mediation of anything else, by and through which their action may be conveyed from one to another, is to me so great an absurdity that I believe no man who has in philosophical matters a competent faculty of thinking can ever fall into it. Gravity must be caused by an agent acting constantly according to certain laws; but whether this agent be material or immaterial, I have left to the consideration of my readers."

Since Newton's time evidence has accumulated. We have first of all the phenomenon of the energy of light and heat which reaches us from the sun. This energy is a real thing, in fact it can be bought and sold, and so I presume must be admitted to exist, though similar considerations applied to gold or silver mines might not necessarily have supreme weight. The question is, what becomes of this energy between the instant when it leaves the sun and the instant when it arrives at the surface of the earth. I premise that it is admitted that Newton's idea of the emanation of particles is proved to be in non-accordance with the facts as far as we know them, and that light really does take a fixed time—some eight minutes to get from the sun to the earth. We must admit, also, that the velocity of light is practically the same between the sun and the earth as it is at the earth's surface, and moreover, that it is the same at least as far as Jupiter. Since no other differences have been detected in the light coming from the other heavenly bodies, except those which we know do not influence the velocity in any experiments we have been able to make, we consider it likely that the velocity of light is the same throughout the whole universe—which, be it noted, is only known to us from the light which comes to us from the stars. As a consequence, it seems fair to assume that whatever the agent which—if we may use such a term—carries the energy from Jupiter to the earth, it is the same as the agent which carries it throughout space as we know it. That this carriage is not due to the actual motion of some substance we may be certain, since we can assure ourselves that the stars are visible in all directions at once, and it is unlikely that there should be a convergence of anything from all points of space towards our very insignificant earth. We will also note that the velocity of light through transparent substances at the earth's surface is not the same as a rule as it is through air—while in our so-called vacua, the velocity is very nearly the same as it is through air. Turning to electric and magnetic action, we note that the attractions and repulsions we observe are not the same in degree through all substances, but depend on the nature of the substances, and finally in the induction of currents on one another, where we have energy transferred from one circuit to another—the circuits not being in any conducting connection—we have evidence both as to the storing of energy in the space surrounding the circuits, and the transferring of it from one circuit to another depending on changes taking place in the currents themselves, and being independent of the nature of the conductors in which the currents exist. And these facts lead us to imagine that space is filled with something or other by and through which the aforesaid actions take place. There may be more than one kind of substance for all we know to the contrary, but one at least there certainly must be. We are led to this conclusion by reasoning based on the interpretation of our sensations, and thus come to know of the existence of the ether—or medium—as we shall call it, in a manner completely analogous to the manner in which we know of the existence of matter. The evidence in the latter case is rather more complete—as we have an additional confirming sense, that of touch—to appeal to. The point which I wish to make however, is that the evidence in both cases is of the same kind, and open to exactly the same philosophical criticism in one case as in the other. In what follows I shall assume the action of a medium in order to account for electrical and magnetical effects. This is the first great point in Maxwell's theory. We can reach the point at which we aim most quickly by considering the case of a Leyden jar, or of any condenser, whose plates we will suppose are separated by a layer of dielectric which we will not further particularise. If we electrify the plates of the condenser, a point will be reached beyond which we cannot go, for a spark will take place between the plates, and the condenser will return more or less nearly to its uncharged condition. Faraday found that when different dielectrics are placed between the metallic plates of the condenser, the sparks occurring on discharge differ in intensity according to the nature of the dielectric. A simple experiment will also show that the energy appearing at discharge is stored in the dielectric itself. Consequently we must admit that different dielectrics will, under corresponding electrical circumstances, store different amounts of energy. A vacuum seems to be a dielectric and so the power of storing energy is equally possessed by it, and that, by the way, to a degree hardly inferior to that possessed by air and other gases. If the dielectric is a fluid like benzene or turpentine, and one of the condenser-plates is fixed while the other is hung from the arm of a balance, the plates being charged to a given potential, we shall find that very different sets of weights are necessary to overcome the corresponding attraction in different dielectrics. Since the power of preventing the passage of sparks is very different in different media, we will suppose that our plates have an attachment whereby the sparks are made always to occur in air. The distances at which sparks will occur between surfaces of a given form in air are practically proportional to a quantity perfectly defined in the mathematical theory and called the electromotive force.

Now, let us charge our condenser-plates and then connect them by a wire; we shall find that the plates are discharged and that the phenomena of a current, as it is called, are exhibited in the wire during the discharge. If the wire encircles a magnetic needle, for instance, the needle will be deflected; or, if a voltameter be included, decomposition, say of water, will take place in it. Before the discharge the dielectric is said to suffer "polarisation," or, as Maxwell called it, "electric displacement." The former term is the better, because all that was meant by Maxwell, at all events in his later work, was that the dielectric suffered a vector or directed change of some sort; while the term he used is apt to connote the actual transference of something—an idea totally at variance with the theory. Since, as I said, a vacuum acts as well, or nearly so, as anything else, we must assume that the ether is the vehicle in which the polarisation occurs, and that in dielectrics other than vacua the properties of this ether are so modified as to account for the comparatively slight differences of effect observed. The second point of Maxwell's theory is that the dielectric polarisation is precisely proportional to the electromotive force. This is not all, however, Maxwell made a further assumption, immensely facilitating mathematical computation, and justified as we shall see by the consistency of the results to which it leads, and by their concordance with experiment. He supposed that the polarisation between the plates is not only proportional to the electric intensity, but is numerically equal to the product of the electric intensity by the factor $\frac{K}{4\pi}$ where K is the specific inductive capacity of the medium. In order to examine the nature of this supposition, we will for a moment take up another point of view and consider, as was formerly done, that there is a substance called electricity, and that plates are electrified when this substance is distributed over them. Maxwell's assumption amounts—in the language of this theory—to making the charge on the plates exactly equal to the loss of electricity by the dielectric, or, in other words, makes electricity incompressible. This point is important, because it distinguishes Maxwell's theory from the theory of Helmholtz, and from other theories in which the action of the medium is taken into account. Reverting to the theory proper, let us see what Maxwell's views are as to discharge. The dielectric returns to its normal condition, and we have a current in the wire, and, moreover, says Maxwell, there is a falling back of the polarisation to its neutral state. If we differentiate the polarisation with respect to time, we have a quantity which may be expressed in words as the time rate of change of the polarisation, and this, according to Maxwell, forms a polarisation current, and produces just exactly similar magnetic effects to the magnetic effects produced by the conduction current in the wire. I say similar, for in any condenser discharge these effects are on a much smaller scale. Thus during a discharge the energy available to produce magnetic effects due to the rate of change of polarisation in the dielectric will be about a thousand million million million times less than the corresponding magnetic energy of the current in the wire. Such small effects have hitherto escaped direct detection, and the proof of their existence must therefore, for the time being, remain indirect. There is such a proof, however, and that of a most satisfactory character, as we shall see when we consider the meaning of some recent experiments, of first-rate importance, due to Hertz. I may mention that I, as well as others, have calculated the possibility of obtaining evidence of these polarisation currents—or rather, and this is the essential point of the theory—of their magnetic action, and find that, thanks to the properties of quartz threads, there is just a possibility of their detection. The difficulty lies not so much in obtaining evidence of the existence of the minute couple we should have to observe, but in seperating the action we are in search of from others due to real conduction in the dielectric or, most of all, to small magnetic effects.

The real current, then, in Maxwell's theory is made up of the conduction current in the wire and the small current due to change of polarisation in the dielectric. It will be observed that this small current is to be taken into account in order to avoid discontinuity in the circuit—to close the circuit, as mathematicians say—which is the very essence of Maxwell's theory. Poynting has recently shown that this theory requires us to imagine that the energy stowed between the condenser-plates moves out into the wire sideways, not through the armature-plates, as one would be apt to fancy. The formal proof of this is obtained on mathematical grounds based on certain consequences and further principles adopted in the theory; but we can see in a kind of way that it must be so. Imagine the conducting wires to be thick and long, but interrupted at their middle point by a short wire of high resistance. If the condenser is big enough the short wire will get appreciably heated by the passage of the current through it. Energy therefore has left the dielectric near the plates, and has converged on the short wire—at least for the most part. That very instructive experiment of the skeleton Leyden jar shows that the energy there, at all events, is in the dielectric. Moreover, we know that if we have a current in a wire energy is dissipated—while, from experiments on the induction of electric currents, we know that energy of *current* is stored to some extent in the dielectric. And further, currents flow in wires either as if they had no inertia —or are caused by "side" pull, not end thrust—and nobody has yet detected anything like inertia in the phenomena of currents. Moreover, we can show that energy stored in a dielectric which is undergoing rapid variation is propogated outward without any conductors at all, and consequently we are at least entitled to admit that there is no inherent improbability in Poynting's deduction. It is verified of course, along with other results of the theory, in many ways, and more particularly has formed the subject of an experimental investigation by Hertz, the results of which are confirmatory in a very definite and striking manner. To render our ideas more precise it will be well to consider here the meaning of the phrase "quantity of electricity" in the light of the theory we are considering. To do this it is most convenient to commence with the conception of lines and tubes of force—an idea we owe in the first place to Faraday. The idea is simplicity itself. A line of force is any line drawn in the electric field in such a direction that a particle carrying a charge of electricity will move along the line if free to do so. Since the electric force at different points in the field will in general have different values, the further stipulation is made that in mapping a field we must draw lines in such a way that the number crossing unit area at any point will be proportional to the electrical force at that point. The lines are to be drawn close together where the field is strong, and far apart where the field is weak, and any small elementary space bounded as to its sides by lines of force we shall call a tube of force. Now it follows from the experiments of Faraday (and indeed these experiments gave rise to the theory we are discussing) that every tube of force must start at a positively charged surface and end at a negatively charged surface. A property of such tubes is that the product of electric force by area of section is constant throughout the tube. Now we may define unit quantity of electricity as the electrification which causes the sum of the above products for all the tubes drawn in connection with it to have the value 4π. Looking at it in a different way, we may say that a tube for which the above product is 4π is a unit tube and corresponds to a unit amount of electrification. From what has been said, however, it is clear that since a dielectric, such as sulphur say, has rather more pronounced electrical properties than air, we shall have rather to extend our definition if it is to fit the case of a condenser, between whose plates there is a layer of sulphur as well as a layer of air. The electric force must abruptly change at the boundary of the media, and consequently what was a unit tube in air will no longer remain a unit tube in sulphur. All the tubes, however, will suffer alike, and since the forces, other things being equal, depend on the specific inductive capacity of the dielectric, we will amend our definition to the extent of introducing the factor K, so that our unit tube must be one in which the product area of section by electric force by specific inductive capacity is equal to 4π. Now the value of K for air is taken nearly as 1, and consequently the amount of energy of electrification required to set up a unit tube will really be a sort of absolute measure of that electrical property, which, reckoned with respect to a vacuum, is denoted by a value nearly unity. Looking at it in another way, as it is important we should see the matter clearly, let us suppose that two insulated particles are immersed in a medium at unit distance apart, and electrified till they exert unit force on one another. If we imagine the particles held in position by elastic springs, and then displace the air in which the particles have been immersed by benzene or any other dielectric, the springs will be observed to relax, shewing that the force is not so great as it was. If we wish to get the springs back to their original state of strain we shall have to work our electrical machine again to increase the electrification. Hence it is clear that the amount of electrification indicated by one unit depends on the specific inductive capacity of the medium in which the experiment is supposed to be made. Returning to Poynting's statement of the mode in which the energy of a charged condenser gets into a wire, we see that it is equivalent to the statement that the tubes of force move out from the dielectric near the plates and converge on the wire where they give off their energy. This, of course, involves what may be called an assumption, namely, that energy is transferred continuously, and is not destroyed at one point and re-created at another. That this is really the case will be shown later on. The next great principle of Maxwell's theory refers to the induction of currents, and is really an extension of Faraday's law. It is that the line integral of the electric intensity round any closed curve is equal to the rate of decrease of the total magnetic induction through the curve. The line integral of electric intensity taken round a conducting circuit is what we are generally accustomed to call the electromotive force acting in the circuit. The above principle has been established in many ways, in so far as it refers to conductors—but Maxwell supposes that it is generally true, whether there be conductors in the field or not. This amounts to saying that change of magnetic induction can produce electric polarisation without the presence of charged bodies at all, and moreover, states the amount of polarisation which will be produced in any case. As a matter of fact, the principle just enunciated is in a sense the converse of the principle of the magnetic action of polarisation currents, and may be deduced from that principle by the method of Lagrange, and so is not really an independent principle at all. Before we go any further it will perhaps be as well to give some idea of Maxwell's views as to magnetism; this is a subject which as far as I know has not been much treated by reviewers. The first fact which Maxwell always seems to have had before him—at all events from the time he considered he discovered that the energy of a magnetic field is kinetic—is that the energy in a magnetic field is due to a rotational motion of some kind around the lines of magnetic force. This idea he obtained from a consideration of the action of magnetic forces on a beam of polarised light. The next point was to explain the action between magnets, and this was accomplished by imagining a stress in the medium analogous to the electric stress in a medium of unit specific inductive capacity. In the case of a homogeneous isotropic solid or of a liquid which is non-magnetisable in the ordinary sense, the stress is to amount to a hydrostatic pressure of $\frac{1}{8\pi}\mathsf{H}^2$ across the lines of force combined with a longitudinal tension of the same amount along these lines, H being the magnetic force. If the substance which is permeated by the medium is magnetic, a distinction arises between the magnetic force in the medium and the force in the substance, and we have to take the magnetic induction instead of the magnetic force. The expressions, too, are complicated, but exact for any medium, magnetisable or not. In some speculations as to the cause of the energy and stress in the medium, Maxwell considers that the rotatory motion referred to is due to the action of ether vortices and the stresses to their centrifugal action. Electric currents produce magnetic action as well as magnets, consequently we must imagine that current action is probably the expression of ether vortex motion, if it be admitted that magnetic action is so. Though it would be improper to ignore the action of conductors to the extent that I have done, it would be still more improper to ignore the action of the material of magnets. Hopkinson has found that the magnetisation of iron is so nearly destroyed by a trace of manganese, that no hypothesis that we can frame of the distribution of the manganese as such through the iron, will account for the effect observed. Chemists will admit that in manganese iron there is probably some combination between the iron and manganese, and I think Hopkinson's experiments prove not only that such must be the case, but that an amount of chemical combination, which may be described as very moderate, will entirely alter the magnetic behaviour of the iron. Consequently I think we may say that whatever be the cause of magnetisation, assuming it to be an ether phenomenon—that phenomenon is immensely influenced by small chemical change—a change for which the ether usually gets little credit. Hopkinson's experiments seem to force on us the conviction that if magnetic phenomena depend on the ether, then at least in iron the relation of the ether to the matter of the iron must be extremely close. We are almost driven to think that magnetism may be produced by some peculiar mode of motion of iron molecules which is shared to only a slight extent by the molecules of other materials. If we take this view, it seems to follow that the particular mode of molecular motion which enables the ether to give rise to magnetic effects must be very nicely balanced since it takes so little to upset it.

We are now in a position to return to the final principle of Maxwell's theory, which may be stated in a theorem analogous to that relating to the electromotive force produced by change of magnetic induction. It is that "the line integral of the magnetic intensity round any closed curve is equal to 4π times the current through the curve." It need hardly be pointed out that this is experimentally true when the current is in a wire, and indeed it is the principle on which dynamos are designed. Maxwell's extension amounts to assuming that it is also true, when the current is due to change of electric induction. It is obvious that there is a close reciprocal relation between this principle and that last discussed, and this is exceedingly well brought out by Poynting in his so-called modification of the principle. As has been said, it follows from the theory in general that the energy keeping a current going moves in sideways. Part of this energy may be considered to be carried by the tubes of electric induction, and an equal part by the motion of the tubes of magnetic induction, which by the principle just stated must accompany them. If we look on the tubes of electric induction as being in motion, then the principle may be stated as follows: Giving the name "magnetomotive force" to the line integral of magnetic intensity in accordance with a suggestion made by Bosanquet and adopted by Poynting, then

"Whenever magnetomotive force is produced by change in the electric field, or by motion of matter through the field, the magnetomotive force per unit length is equal to $4\pi \times$ the number of tubes of electric induction cutting or cut by unit length per second, the magnetomotive force tending to produce induction in the direction in which a right-handed screw would move if turned round from the direction of the electric induction towards the direction of motion of the unit length relatively to the tubes of induction." This in most cases may be simplified to the less general statement that "The magnetomotive force round any curve is equal to $4\pi \times$ number of tubes of electric induction passing in or out through the curve per second." A certain amount of experimental verification has been given to this principle by the well-known experiment of Rowland. The experiment consisted in rotating a charged disc, and observing that this produced the same effect as would have been produced by an equivalent current.

From these principles Maxwell developes certain consequences which we will now discuss briefly. The first and most important consequence is that an electromagnetic disturbance will be propagated with a certain velocity through dielectrics, but will only be propagated in a secondary manner, so to speak, through conductors. This comes about because (1) as has been shown the energy travels through the dielectric, and (2) because, according to the views of Faraday, a conductor is a body in which permanent electric induction or polarisation is impossible. When an electromotive force acts on a conductor we conceive it as first causing electric induction; the nature of a conductor, however, must be such that it cannot support such a state permanently, and consequently there is something equivalent to a yielding, the field becomes discharged, and we have the phenomena of a current. Now the magnetic effect of a current is, I think, generally imagined as being in some way due to the process of yielding by the conductor, at least it is so in a model suggested by Maxwell, and elaborated by Oliver Lodge. It seems, however, that this view is at least unnecessary. The essence of the theory is that in dielectrics change of polarisation produces magnetic effects and consequently by analogy it is to the alternate setting up and breaking down of the field, or rather to the change of polarisation accompanying it, that we ought to look for an explanation of the magnetic action of the current. This involves, however, the assumption that it is only during either the setting up or the breaking down of the field that magnetic action is produced, so that the breaking down can not be a mere reversal of the setting up. It may be noted that to account for all the current magnetic effects in this way involves making the specific inductive capacity of conductors very high. A very instructive view of the phenomena of conduction has been explained by J. J. Thomson. We may regard an apparently continuous phenomenon such as a steady current as being really discontinuous if the discontinuous changes take place so rapidly that we are unable to follow them in detail. For instance, imagine a charged sphere supported by a fused quartz stand—fused quartz is by all odds the best insulator in practice known to us. Let the sphere be placed close to a plate connected to earth and let it be tested from time to time by an infinitesimal proof plane. We know chiefly from German researches that the dust particles in the air will under such circumstances become the chief agents in discharging the sphere; they are first attracted to its surface, then charged, then repelled to the earth plate, again attracted, and so on.

However fast in practice we could work our proof plane, the fall of potential of the sphere would appear regular—if it were possible, however, to work the plane in a period less than the time elapsing between the arrival of successive dust particles, we should find that the phenomenon of discharge was really discontinuous. In a similar way our continuous steady current may, if it is convenient to us and sanctioned by our general knowledge of what is likely to happen, be regarded as the time average effect of the alternate establishment and breaking down of the electric field. On this view our tubes conveying the electric and magnetic energy would also move by jumps, and if we had fine enough instruments we could detect this intermittence. Let us imagine a Leyden jar charged, and having terminals attached to its armatures. Let the terminals be immersed in some substance whose electric strength is infinite, so that we get no spark on joining the said terminals. Then, possibly, an instrumental eye affected by intermittency of electric state placed between the jar and the wire might see a flash of light during the discharge of the jar, though there would be no spark. Our eyes, however, do not lend themselves to such experiments, because they are affected by states differing as to sign, we must have electric and magnetic forces following each other alternately in opposite directions to produce any effect. I do not know of any fundamental physiological reason for this, though it is doubtless an advantage, so that we might possibly find some animal whose sense organs would respond. The experiment is not possible, however, because we are in practice sure to get a spark discharge, and then we may have changes of electric state differing as to sign. If we did not, it would probably place the conductivity too low, the most promising sort of conductivity would be that of a cubic centimeter of mercury. I have however been assuming more information than has yet been given, so that I will now return at once to the electromagnetic theory of light. I intend to adopt Poynting's method of calculating the velocity of electromagnetic disturbances. This method is analogous to Rankin's solution in the case of sound, and proceeds from another consequence of the theory—that the energy per unit volume of a field traversed by electromagnetic disturbances is $\frac{K\,E^2}{8\,\pi} + \frac{\mu\,H^2}{8\,\pi}$ if the intensities may be taken as uniform through the small volume considered. Now, if the waves pass on unchanged in form with uniform velocity, then the energy in any part of the system may also be considered to pass on unchanged with the same velocity. Let the velocity be V, then the energy contained in a unit volume of cubical form with a face in the wave front will all pass through that face in one V^{th} of a second. Now the directions of the electric and magnetic intensities are by the principles of the theory at right angles to one another in a homogeneous non-magnetisable medium, and the direction of both must be normal to the direction of propagation, both from what has been said as to the sideway motion of the energy, and from a direct calculation by Maxwell (Vol. II., p. 400). Let us suppose that the direction of propogation is parallel to the axes of z; the electric polarisation will be, say, up and down, while the magnetic intensity is right and left. The rate at which energy may move in a magnetic field has been shown from Maxwell's equations to be $\frac{E\,H}{4\,\pi}$ per second. This statement is a *précis* of Poynting's deduction, and is a possible solution whether we are considering the energy of a wave motion or the passage of the energy of a strained dielectric into a wire. The proof is to be found in Poynting's paper, *Phil. Trans. 1884;* it is too long to reproduce here, and, though sufficient for our purpose, has met with criticism. The quantity of energy, therefore, which passes out through the side of the cube in 1/V seconds must be $\frac{E\,H}{4\,\pi\,V}$ and this must be the whole energy of the cube: so we have $\frac{E\,H}{4\,\pi\,V} = \frac{K\,E^2}{8\,\pi} + \frac{\mu\,H^2}{8\,\pi}$ Taking a face of the cube perpendicular to the direction of the polarisation, and hence containing the magnetic intensity, we know by one of the principles of the theory that the magnetomotive force round the face must be equal to $4\,\pi\,\times$ current through the face.

Now this may be written in terms of the distance from some fixed plane along the direction of propagation, as a function of z in fact, so the magneto-motive force round the face may be put $-\frac{d\,H}{d\,z}$, while the current is $\frac{K}{4\pi}\frac{d\,E}{d\,t}$ so that $-\frac{d\,H}{d\,z} = K\,\frac{d\,E}{dt}$ But since the displacement is propagated onward with velocity V: after a time dt the displacement at any point will become replaced by one which was at a distance dz or Vdt behind, so that $\frac{d\,E}{dt} = -V\,\frac{d\,E}{d\,z}$ substituting for $\frac{d\,E}{dt}$ above we get $\frac{d\,H}{d\,z} =$

$K V \frac{d\mathsf{E}}{dz}$ or $\mathsf{H} = KV\mathsf{E}$ the function of the time being zero. Repeating the process for the line integral of electromotive force round the perpendicular face of the cube by the corresponding theorem, that this is equal to the decrease of magnetic induction through the face, we obtain $\mathsf{E} = \mu \ V \mathsf{H}$. Multiplying these values for E and H together, and dividing out by $\mathsf{E}\ \mathsf{H}$, we get $1 = \mu K V^2$ or $V = 1/\sqrt{\mu K}$. The energy cannot be propagated faster than at this rate, which is its maximum velocity. When the intensities are perpendicular to each other, as they must be in a homogeneous isotropic non-magnetisable medium, if light is an electro-magnetic disturbance this then must be its velocity. Consequently, if we know the values of μ and K, and not their nominal values only, we can calculate the velocity of light. The matter is perhaps best approached indirectly. Suppose we adopt the electrostatic system of measurement, then if the medium is air we have $K = 1$ and $\mu = 1/v^2$, where v is the ratio of the units, so that the velocity of light will, if the hypothesis be correct, be equal to the number of electrostatic units of electricity in one electro-magnetic unit. Without explaining in detail why μ should $= 1/v^2$ one may get an idea very simply. We have already seen that on the electrostatic system the quantity of electrification chosen as unity depends on the value of K. Again, in a precisely analagous manner we can show that the same quantity on the electro-magnetic system will depend on the quantity μ. We should require merely to start with lines of magnetic instead of lines of electric force. Since the electro-magnetic unity of quantity is derived from the unit of current, and this again defined from its action on a unit magnetic pole, it is clear that the magnitude of the unit will depend on μ since the force does so. But the force will be greater the greater the value of μ, and hence the magnitude of the quantity of electricity making up the unit will be inversely as μ. If we measure the same quantity of electricity electrostatically and electro-magnetically, it is clear that the ratio of the two numbers expressing the result of the measurement in terms of the respective units will involve μ and K as product. Moreover, if the dimensions of K and μ are ignored, as is done by Maxwell, the resulting ratio will not be merely numerical, but will have the dimensions of length $^x \times$ Time ^{y}, or, in other words, of some power of a velocity or slowness according to the nature of the quantity we select for comparison. In any case, if we measure any electrical quantity, be it really quantity, capacity, current, electromotive force or resistance, both electrostatically and magnetically, and compare the numerical values, we shall have a number from which which we can calculate the ratio of the units. This has been done by many observers, and it is found that the number is really the same as it ought to be if the electro-magnetic theory is true. In other words, the number expressing the ratio of the units and involving length and time as dimensions is the same as the velocity of light within the limits of experimental error. It is, in fact, almost a question as to whether the velocity of light can be got most accurately from direct measurement or from a comparison of the units.

Turning now to the velocity of light in media, other than air, we can obtain an expression for the velocity in terms of μ and K. By the principles of the undulatory theory, and in certain cases as the direct result of experiment, we consider that the velocity of light in any medium is inversely as the refractive index of the medium. But the velocity on the electromagnetic theory is inversely as the square root of the product of the specific inductive capacity and the permeability. Consequently, if the theory is true, the refractive index of any transparent substance should be equal to $\sqrt{\mu K}$. Now, for most transparent substances, μ is nearly the same as it is for air, and consequently the chief part of the effect will depend on K. To a first approximation we will write: Refractive index = root of specific inductive capacity, and see how far this is borne out by experiment. It turns out that for some substances, hydrocarbons for instance, the equation is true, especially if we take the index by refraction for very great wave lengths, but for others the agreement is not so good. Again, it is clear that transmission can only take place to a sensible extent through insulators—conductors must be opaque. What are the facts? The facts are that while it is generally true that conductors are opaque and insulators transparent, it is not always so. Ebonite is an apparently good example of an opaque insulator, and most electrolytes are examples of transparent conductors. These facts seem at first as if they dealt the theory a severe blow, but I think we shall see that this is not necessarily the case. Taking J. J. Thomson's view of the way in which conduction goes on, we may suppose that in a conductor a certain time has to elapse after the field is established before it is weakened to a certain fraction of its maximum value. Now, the waves of light which chiefly affect the eye have a period of about 10^{-15} seconds, consequently if with a given electric force it takes longer than this to establish a field and break it down, the conductor in which this occurs will behave as an insulator for forces of a frequency greater than this. An estimate of the frequency which the electric forces can have may be made from the known specific conductivities, and such a calculation has actually been made by J. J. Thomson. The result seems to me entirely satisfactory, and the apparent discrepancy as to the opacity of some insulators and transparency of some electrolytes need no longer trouble us. We are still, however, left partly in the dark as to the transparency of gold leaf, which is possibly greater than it ought to be, even when we estimate the rate of breaking down of the field that can occur in it. With respect to the deviation of the calculated index of refraction from the true index, as in vegetable oils, it is fair to observe that the value of K is measured by steady electric force, or at all events for electric forces of periods much greater than 10^{-15} seconds. If we had means of estimating the value of K for these rapid reversals, it is just possible that all might turn out right. Again, on the other hand, our knowledge of refractive index for so-called infinite wave length depends on some assumption as to the relation between wave length and index of refraction. Now the researches of Langley have lately given what may be called an unexpected relation, for these qualities in the case of rock-salt, and they at least warn us that any deductions based on formulæ derived from observations in the visible or ultra-violet spectrum only must be received with great caution. Again, the deviations from the law connecting refractive index and specific inductive capacity all seem to be pretty much on one side. K is greater than the square root of the refractive index. In other words, the velocity calculated on the electromagnetic theory is too small for these exceptional cases. We must remember, however, that the velocity given by $V = 1/\sqrt{\mu K}$ is a maximum velocity and only occurs when the medium is practically unmagnetisable, and the polarisation in the direction of the electric force. If by any peculiar action of matter on ether, either of these conditions is not fulfilled, which may well be the case, we ought not to be surprised to find such instances of less velocity as are afforded apparently by the vegetable oils. Of course such excuse-making as this would be absurd unless we had very real evidence in support of our theory—to use Maxwell's phrase, we may only have the first terms of the theory—and we must admit that we are in fact brought round again to our old question of the relation between matter and ether.

Since Maxwell's time, however, a great deal of work has been done, and the result of it all must be regarded as confirming the theory in a very remarkable manner. The most important work in this direction has been accomplished by Hertz, and we will deal in the first instance with it. We shall then be in a better position to discuss a variety of facts which allow us to discriminate between Maxwell's and more general theories. The first suggestion as to Leyden jar discharge being oscillatory under some circumstances appears to have been made by Henry, in 1842, with the object of explaining certain anomalies in the observed magnetisation of needles by the jar discharge. Faraday, also, in discussing what happens in an open circuit under induction, imagines that on the removal of the electromotive force there is a surging back of electricity in the wire. In 1847 Helmholtz predicted, on theoretical grounds, that a Leyden jar discharge through a circuit of small dissipation might be oscillatory in

character. In 1858 this suggestion was worked out in all its details by Sir William Thomson, and Feddersen Schiller and others verified Sir William Thomson's formulæ in cases where the oscillations were not unmanageably rapid. From the point of view which we have adopted, it does not require much imagination to enable us to see that since the charge of a condenser corresponds to a distribution of stress in the dielectric, that stress may be reversed if discharge is very rapid, at all events if we regard the stress as produced by a mechanism of any sort. This sort of guessing, however, clearly is out of place unless we are prepared to grant the mechanism something like inertia. I do not know that we ought to go so far, and consequently the above considerations are only justified because they lead us to a known experimental result. As a matter of fact, Sir William Thomson's calculation was exceedingly general, and only involved the principle of the conservation of energy and known experimental electrical relations. The result of the theory is simplicity itself. If the resistance in the discharge circuit is greater than a certain quantity depending on the capacity and self-induction of the jar and circuit, the discharge will not be oscillatory at all, but the plates will fall back to zero-potential by jumps; in other words, the discharge will be intermittent. It is not difficult to see the reason of this by considering the induction tubes. When a discharge once begins, the resistance of the spark-gap enormously diminishes, the slope of electric and magnetic intensities in the neighbourhood gets very big, and the corresponding flow of energy which is proportional to them enormously increases, consequently, that part of the field gets discharged; and if the resistance in the other part of the circuit is sufficiently great, the discharge may have disappeared and the dielectric healed up before sufficient energy has again accumulated to break down the dielectric. If, on the other hand, the resistance is below a certain critical value, the discharge will be oscillatory. The critical resistance is $\sqrt{\dfrac{4 \times \text{self-induction}}{\text{capacity}}}$,
and when the circuit has exactly this resistance, the discharge will be dead beat, as it is ordinarly assumed to be in the elementary theory. We must recollect that as soon as the oscillations are set up, both the self-induction and resistance of the circuit are vastly different from what they are for steady currents. Lord Rayleigh has shown that as the frequency increases the resistance will, as a rule, increase, and the self-induction diminish. Returning to our concept of tubes of electric induction, we must imagine that at first the tubes coverge on the wire faster than they can be broken up, and consequently produce a state of induction which reverses the direction of the intensities; and consequently of the current, when a short time afterwards the tubes do actually move in. This process may be repeated several times, or we may have an oscillatory discharge of several oscillations before equilibrium

is attained. The period of oscillation is fixed by the electro-magnetic properties of the system, and is approximately—when the resistance is very small—$T = 2\ \pi \div \sqrt{\frac{1}{L\ C}}$ seconds, when L is self-induction and C is capacity. This is the time that elapses between consecutive similar electric states. The full expression is $T = 2\ \pi \div \sqrt{\frac{4\ L—C\ R^2}{4\ L^2\ C}}$ which is homogeneous. Consequently the frequency of a Leyden jar discharge comes to be $p = \sqrt{\frac{1}{L\ C}}$ when the dissipation is small.

Now L and C as a rule are very small quantities, so that the frequency is very high. At each oscillation, as has been said, we have tubes of induction moving once backward and once forward across the field. Now, there is nothing to prevent these tubes from radiating into space—if we are dealing with a medium we shall have an electro-magnetic disturbance which will continually propagate itself outward if there is no dissipation, and its velocity will be comparable probably with the velocity of light. The wave length will be the distance moved by the tubes during one oscillation, and consequently will be given by dividing the velocity by the frequency, in fact $\lambda = \frac{2\pi\ V}{p}$ Now the velocity is very high, so that though the frequency is very great the waves may still be extremely long. If we use Maxwell's theory, then the velocity is actually given by $1 / \sqrt{\mu\ K}$ as has already been pointed out, and our expression of the wave length becomes $\lambda = 2\pi \sqrt{\frac{L\ C}{\mu\ K}}$ Clearly, then, a good way of testing Maxwell's theory will be to get oscillations, and then measure the wave length by the disturbance propagated outward from them. The usual plan of estimating wave lengths is to produce a state of stationary vibration, and then measure the distance between nodes or planes of null effect. The distance from one node to another is always half a wave length, so that the measurement of the distance from node to node gives us a wave length on multiplication by two. The usual way of setting up a state of stationary vibration is to take advantage of the principles by interference. Every musical instrument is an illustration of this. The simplest way, of course, to set up a reflector and get interference between direct and reflected waves. It must always be borne in mind that no interference phenomena are possible at all unless waves take some time, however short it may be, to travel a finite distance, and consequently no instantaneous propagation theory could lead us to expect to observe this phenomenon. If, however, waves can be shown to interfere, we know that they must be propagated with a finite velocity; and this means they must occupy space for a finite time. But waves involve the motion of energy, so that we must admit that energy can be located in space, and as a consequence of this we are, I think, just as certainly led to imagine a "plenum" of some kind as if we could touch it with our hands, or smell it with our noses, or taste it with our tongues. The first deduction to be made from our interference experiment then is that space is filled with a medium of some kind—unless we are prepared to admit that energy may exist *per se*—which amounts to filling space with an idea merely. Experiments of the kind suggested have been actually performed by Hertz. In order to get waves of a manageable length, Sir William Thomson's calculation shows that we must have the capacity and self-induction of the circuit small. Hertz's first discovery was the means of getting this. Conductors were constructed either of plates or cylinders and were made symmetrical about a certain point. This point is the gap where the discharge occurs. To take a real case. In a repetition of Hertz's earlier experiments by Trouton, a "vibrator" was used consisting of two brass plates about 40 cm. square. These plates were suspended by silk threads, so that their plates were vertical and identical, and their edges 60 cm. apart. From each plate there ran a stout brass wire toward the other. Each wire carried a brass knob—presumably four or five centimetres in diameter—and the distance between the knobs was about three millimetres, the terminals of an induction coil were brought respectively to each plate and the coil was set in action. At each break of the primary circuit of the coil, one of the plates becomes positively the other negatively charged. As soon as the charging has progressed to a certain point the dielectric breaks down between the knobs and a spark occurs. If the resistance of the spark-path is not too great, we have the condition necessary for the setting up of oscillations. The frequency then depends on the self-induction and capacity of the plates, as has been said several times, and is in general so high that the connection of the plates through the coil becomes of no moment, the immense "impedance" of the coil making it practically non-conducting for currents of this frequency. Some attention has to be paid to the condition of the surfaces between which the spark occurs. If the balls are not finely polished, or if the negative one is illuminated by ultra-violet rays, the spark will not be sudden enough, compared with the period of an oscillation, to enable the oscillatory motion to become established. Lenard and Wolf have lately shown that ultra-violet light causes the knobs (especially when negatively charged) to give off dust which is torn from their surfaces—thus causing glow discharge. When everything is well arranged there is a series of straight, bright, white sparks between the knobs at every discharge—very recognisable after they have once been attended to. The next step is to find some means of detecting the electromagnetic waves which, according to our theory, are propagated outwards from the vibrator. This Hertz accomplished by taking advantage of a property borrowed from acoustics. It is well known that if any vibrating system is subject to accelerating forces of the same period as its own period of vibration, when vibrating freely, the effect will be cumulative, and the system will be caused to vibrate strongly, though any individual impulse might be quite incapable of producing an observable effect. The same principle may be extended to the action of electric oscillations on conductors. We must have a "resonator" or conductor where natural period of electrical oscillation calculated from Sir William Thomson's formulæ coincides with that of the vibrator. In practice, the length of wire most appropriate to the resonator is found by experiment. The wire is bent into a circle and the ends brought close together by a fine screw attachment. If electric forces act on such a resonator in such a way as to produce a cumulative effect the electrical disturbance will become sufficient to cause sparks to pass between the ends of the wire. We have therefore both a means of setting up disturbances of the required character and of detecting them at a considerable distance away. A vibrator of the dimensions given above completes an oscillation in one-thirty-millionth of a second, and if the disturbance is propagated with the velocity of light will consequently yield waves of about ten meters wave length. The resonator for such waves as these was found to require two hundred and ten centimetres of No. 17 wire when bent into a circle. Without going into many very interesting questions as to the best relative positions of the planes of vibrator and resonator it will be sufficient to state that in one position of the resonator the most effective component is the electric, and in the perpendicular position the most effective component is the magnetic intensity. Perhaps the most important experiment one may make with this apparatus is the demonstration of nodes and loops between the vibrator and a large sheet-zinc reflector. The length of the waves roughly confirms the theory that the velocity of propagation is the velocity of light, while the existence of loops and nodes demonstrates the truth of the more important preliminary assumption as to the existence of a medium. The apparatus itself may be modified and for some purposes improved by using two cylinders tipped with balls for the vibrator and placing them in the focus of a large parabolic cylindrical mirror so as to render the electric rays parallel. The receiver in this arrangement consists of a lengthy wire placed on the focal line of another mirror and interrupted by a spark gap in the usual manner. With this apparatus Hertz has imitated most optical effects. He has shown that the ordinary laws of reflexion of light are obeyed by these electric or "etheric" waves, and by constructing a large prism of pitch has found the index of refraction of that substance for long waves to which it is of course transparent. These measurements are all in as close accordance with Maxwell's theory as could be expected, seeing the difficulty there is in making exact measurements of the position of so large a body as a resonator. It may be questioned whether greater accuracy might not be obtained by the use of Geissler tubes, coupled with some system of photography. These tubes have already been successfully applied in Dr. Lodge's laboratory, and if it be permissible to prophesy wildly, we may see in this observation the germ of a great future development. Signalling, for instance, might be accomplished secretly by means of a sort of electric ray flasher, the signals being invisible to anyone not provided with a properly turned tube. An important point in optical theory has been settled lately by the use of Hertz's apparatus in the hands of Fitzgerald and Trouton. Assuming the truth of the electro-magnetic theory for a moment, we have to answer the old question as to the relation of the planes of the intensities to the plane of polarisation. The answer is definite and decisive, and is to the effect that the magnetic intensity is in the plane of polarisation, and the electric intensity as a consequence in the perpendicular plane. Hertz, again, has himself constructed a very interesting model of a tourmaline crystal by means of wires stretched side by side on a frame. This may be considered to form a system in two dimensions, with conductivity along one axis, and much less conductivity in the perpendicular direction. The behaviour of such a frame to Hertz's polarised rays is exactly equivalent to the action of a plate of tourmaline, such as is generally sold for the purpose, on a beam of polarised light. This suggests the apparently inevitable conclusion that unless energy can be dissipated in some other way than by conduction the crystals of tourmaline must have a one-sided conductivity. This action must take place in a manner depending on the minute structure of the crystal, the variation of conductivities along and perpendicular to the axes of crystals as a whole being a well-known and corresponding phenomenon. We turn now to some very interesting experiments made by Hertz on the way in which the velocity of propagation is influenced by the placing of a wire in the field and applying the periodic electric forces to one of its ends. For this purpose the flat plate apparatus previously described is furnished with an additional plate placed immediately behind, and parallel to one of the flat plates in the original apparatus. A wire is led out in front from this plate, and the experiment consists in obtaining interference between the radiation from the wire and the direct radiation from the plates; as a result of these experiments Hertz was led to believe that the velocity of propagation is different in a wire from what it is in space. Another, and perhaps a better way, is to measure directly the wave length in a wire, as has been done by J. J. Thomson, and compare this with the wave length in air. By this method Thomson concludes that the velocity of propagation is the same in both cases in direct contradiction to the results obtained by Hertz. This is a point of considerable importance, as Maxwell's theory clearly indicates that the velocity should be the same in both cases. Before we pursue the matter further, it will be convenient here to give some slight comparative account of the different theories which are at our disposal if we abandon the theory of Maxwell. We shall then be in a better position to estimate the value of the evidence which is before us. Assuming that Hertz's experiments have placed the existence of a medium beyond doubt, we need not devote any attention to those theories which depend on the assumption of action at a distance, and take no notice of intermediate effects. A good account will be found of them in a report of the British Association, 1885, by Professor Thomson. There are at least two theories besides Maxwell's which claim our attention; both of them take the action of a medium into account. One of them is due to Helmholtz, and the other—which is really the most general theory that can be framed from the experimental data—is due to J. J. Thomson. To come to the point at once, Helmholtz's theory differs from Maxwell's in making a rather more general assumption as to the relation between electric force and dielectric polarisation than is made by Maxwell. This leads to the polarisation currents being regarded as "incompressible," while in Maxwell's theory it is the "total" current made up of the conduction, and polarisation current which is mathematically so. Among other results to which the theory leads is that in some of the resonators used by Hertz, slight changes of capacity —as by adding or cutting off tinfoil—should not make much difference to the period, while the facts are that Hertz found that considerable difference was thereby produced; on no theory but Maxwell's is this accounted for. It may be mentioned that, as a working theory, Helmholtz's is far more complicated than Maxwell's, so that unless it proved to possess any great superiority it could not be so serviceable. The general theory due to J. J. Thomson proceeds from the assumption that the dielectric polarisation currents are proportional to the rate of charge of electromotive force—we may say are equal to η times the electromotive force. Now, if $\eta = K/4\pi$ we have Maxwell's theory, and if $\eta = k K$ we have Helmholtz's. The differences between this theory and Maxwell's are summed up by Thomson as follows:—

1. The existence of a normal wave in the general theory, but not in Maxwell's.
2. A difference in the velocity of propagation of the transverse wave.
3. A difference in the relation between electric currents and magnetic force.

4. Forces arising from discontinuity in the currents (in the general theory, but not in Maxwell's).

We next turn to the means that have been discovered of discriminating, experimentally, between the theories.

Let us take in order the points of difference that have been enumerated above.

With respect to (1), all we can say is that in Hertz's experiments no trace of a normal wave has been discovered.

As to (2), I have already stated that as far as the limited accuracy of the experiments can prove it, the velocity of propagation is that which is or may be given by Maxwell's theory.

With respect to (3), there is, I think, no direct evidence, and forces indicated in (4) have not been observed, either through dearth of experiment, imperfection of apparatus, or because they do not exist. Several indirect means have been discovered by Thomson of testing the theories. The first is that in the case of a wire connected to the third plate of a vibrator system, the rate of decay of the energy of the waves in the wire should, by Maxwell's theory, be nearly proportional to the specific resistance of the wires when the frequency is high enough. An experiment has been made by Thomson by which this is shown to be really the case. On Helmholtz's or the general theory, and with the frequencies of vibration used, the conductivity should not have made much difference. All the evidence therefore points in one direction. There remains but the outstanding difference discovered by Hertz in the wave length of the oscillations in wire and in air. With respect to this Thomson has suggested what may very likely turn out to be the cause of the discrepancy between his observations and Hertz's. It is that if the third plate is accidentally displaced in any way during the course of the experiments then there will probably result a change of capacity, due to the presence of other conductors (say a wall) which would account for the difference observed. To sum up, it is perhaps not too much to say that the evidence in favour of Maxwell's theory is overwhelming, and that for the future it must be our guide in all electrical investigation. I ought not to leave this part of the subject without referring to the mathematical work of Heaviside, who restates Maxwell's theory, and whose mathematical discoveries of the detailed behaviour of electro-magnetic waves has far outrun any knowledge of them deduced from experiment. The sideway motion of energy insisted on by Poynting was also indicated on rather different grounds by Heaviside. It remains for me to make some remarks concerning the ultimate nature of the mechanism by which Maxwell's stresses are produced. The thing which, perhaps, strikes one most strongly about the theory is that it offers no suggestion as to the way in which electrification is brought about. Why should the ether in the neighbourhood of a bit of sealing-wax that has been rubbed be brought into this curious polarised state? Ought we to imagine that gravity is caused by ether stresses? The answer to this last question was given long ago, and is to the effect that of course we can represent the actual state of gravitation on the earth's surface by a distribution of stresses, but they would require to be very great, no less than a pressure of 37,000 tons weight per square inch in a vertical direction, combined with an equal tension in all horizontal directions—this is about 3,000 times the breaking strength of steel. (Tait's "Properties of Matter.")

Before we push our enquiry as to the mechanism of electrification any further, it is necessary for us to glance rapidly at the more prominent features of the relations generally summed up under the title of electro-chemistry. Modern researches have only served to strengthen Faraday's position, that when a current passes through an electrolyte the amount of decomposition brought about is strictly and exactly proportional to the time integral of the current. This quantity will for the future be referred to as a "quantity of electricity," and must not be imagined in any way to connote that electricity is a substance—or even that it is a state of motion of ether—though much might be said for both of these views. If we extend the definition so as to discriminate between those substances, which, under certain circumstances, travel in the nominal direction of the current, and those which travel in the reverse direction, we may say that during electrolysis one ion carries a certain positive quantity of electricity, while the other carries an equal negative quantity. Adopting the ordinary atomic theory of chemistry, the results of experiment may be summed up in the statement that all monovalent atoms require the same quantity of electricity to free them on the electrodes, and the quantity of electricity required to pass a divalent atom is twice the quantity required for a monovalent atom; for a trivalent atom, three times, and so on. Further, I think it may be considered as established that the apparent decomposition of an electrolyte into its ions by a current is really merely a process of direction, and is not a real process of decomposition. Taking the case of a solution of copper-sulphate, for instance, it is probably not true to say that the ions are forced apart by the current, or rather by the electric force, but that continuous dissociation is a normal state of such a solution, and that all the electric force does is to cause a congregation of ions at the two electrodes. This conclusion is deduced from the fact that electrolytes appear to obey Ohms' law very exactly, which would be a very unlikely or even impossible thing to happen if work were required to produce dissociation as well as to make the ions give up their charges. Some philosophers have regarded the facts of electrolysis as showing that there must be a real difference between a positive quantity of electricity and a negative quantity of electricity beyond the difference of sign which is included in our definition. This idea is familiar to everyone from the very terms "positive electricity" and "negative electricity." The phrase, "Positive Quantity of Electricity" thus connotes much less than the by-no-means equivalent phrase, "Quantity of Positive Electricity." If the latter phrase is legitimate, we must admit that we think we know more about electricity than is actually the case. For instance, in hydrogen chloride (possibly only in the presence of water), we find that the direction of motion of the hydrogen coincides with the nominal direction of the current, or in our notation each hydrogen atom carries a positive quantity of electricity. In hydrogen sulphate the case is the same, and in silver chloride and silver sulphate it is the silver which carries the positive quantity. Thus, so far, all is well, and if we like to suppose that silver carries positive electricity nothing can be said against it. If we take the cases of Iodide of Potassium and Iodide of Bromine however, we notice that in one case the iodine goes one way, and that in the other it goes in the opposite way—consequently if we talk of iodine carrying a positive charge in one case, we must admit it carries a negative charge in the other. The chemical theory of Berzelius was destroyed by this and similar facts (not very many, by the way), but it need not influence us with respect to the question in hand. The only point we have to note is that the hypothesis of positive and negative electricity at once forces us to make the additional hypothesis that a given atom may sometimes carry one and sometimes the other.

Now, from the extraordinary quantitative fixity of the charges, it is very difficult to escape the impression that electrification, regarded as a state of the ether, is a consequence of the same cause, whatever it may be that conditions the distinction between element and element. If there be anything in this view, it becomes difficult to understand how iodine can sometimes carry positive and sometimes negative electricity and be still iodine. The view that free atoms (at least when they are ions) are associated with an ether state which we call electrification has, I consider, been somewhat strengthened recently by the researches of Ostwald. According to the Clausius-Williamson hypothesis (which we have tacitly assumed above in order to account for electrolytes obeying Ohm's Law), every liquid is in a steady state of dissociation. The influence which any such liquid—say a solution of hydrochloric acid—has in bringing about such chemical change as the inversion of sugar is supposed by Ostwald, on very strong grounds, to depend on the amount of this dissociation. But on our view of electrolytic conduction, the number of free ions must be proportional to the conductivity, since it is only by them that conduction takes place. Ostwald has shown experimentally that when different acids are compared together the velocities of reaction which they induce in the inversion of cane sugar are proportional to their conductivities. Assuming that the Clausius-Williamson hypothesis is established on grounds other than electrolytic—and Ostwald gives strong reasons for this view—then we are, I think, compelled by the resistance law to believe that each atom is necessarily accompanied by that ether state which we call electrification. Further, Helmholtz has shown that it is only when these states or charges are given up at the electrodes that any considerable proportion of the energy required for electrolysis is required. Should we be justified, then, in giving each atom its corresponding equivalent of tubes of induction? I hold not. I conceive that it is only where the work has been done—the work required to transfer (and probably modify) the ether state from the atoms to the electrodes that we get electrification as we know it. I prefer to think that a free atom may possibly have properties much more analogous to those of free ether than to those of matter as we know it. In other words, a free atom does not carry a "charge" at all, but something which becomes a charge when it is transferred to an electrode. As a wild speculation, is it the "free atoms" in a dielectric that are "polarised" by electro-motive force, and is the "vector change" which we have called polarisation related simply to the average position vector of the system? In order to illustrate some consequences of this view, let us look a little more closely at such a reaction as occurs when chloride of silver is electrolysed. This is about the simplest case that can be found. According to my view, we have atoms of chlorine and atoms of silver existing in the fused salt. These atoms are not "free," *i.e*, before they can be so free as to combine into molecules at the electrodes work has to be done on them, resulting in the electrodes becoming charged. The electral state of the wandering atoms is not at all the same as the electral state of the anodes when they become charged. Neither is it neutral, but it is such that by the application of work electrification results. As to the manner of this I suppose nothing can be said till we know the exact relation of free atoms to ether. Whether to imagine that the energy is required to cause combination of atoms—from the reactions of whose associated ether, charge results—or whether the combination is merely an expression of the transference of the state to the electrodes by the doing of work, I leave to the curious to discover. Suppose now we start with silver or chlorine molecules, and force them to part into atoms by methods other than electrical, the question arises as to what the state of these atoms will be. Will it be the same as when they are wandering in a fused mass of silver chloride? To bring them to that state there would be required (by the transference of energy) to be exhibited somewhere the phenomena of charge. If they finally reach that state, as I imagine they must, then the phenomena of charge must appear. Let us take two plates of platinum and place the silver or chlorine, or even the chloride of silver, between the plates, and by some means persuade the chloride to decompose into atoms of chlorine and silver, or the molecules of silver into atoms of silver, or the molecules of chlorine into atoms of chlorine. Then I consider that if the layer of substance is thin, the platinum plates will be found to be charged—if work has had to be done in forcing the decomposition. In fact, just as in electrolysis, or by the application of electric force atoms in the "third" state—if I may so express it—cannot be got into molecules without producing the phenomena of charge, so if once in molecules they cannot be brought to "third" state atoms without suffering a defect of something—which becomes sensible by the charging of the plates. Let some silver chloride placed between platinum plates be electrolysed into silver and chlorine, then small layers of these substances (really free) will appear on the plates. Then remove the undecomposed silver chloride entirely and bring the plates together with pressure. Suppose that recombination into silver chloride results from this pressure, Then between the time when there were molecules of silver and molecules of chlorine, and the time when there were molecules of silver chloride, there will have been by all chemical experience atoms of silver and atoms of chlorine. During this separation they will have (by the application of external work) to undo from the electrodes what was done during electrolysis—if one of the plates retained the charge (say positive) which it got during electrolysis, that charge will disappear. If the charge has been lost beforehand, then the plate will appear negatively charged. A corresponding charge will appear at the other elecrode. Both electrodes will thus be charged. I was led to these speculations by attempting to find an explanation of the ultimate course of the effects produced by rubbing bodies together, or, in other words, the ultimate course of action of a frictional electric machine. I was struck in the first place by the fact that most substances, which we know from hereditary experience, to lend themselves best to the construction of electric machines are very complex molecularly. Probably much more so than the general run of so-called chemical compounds. Some, like sulphur, are capable of allotropic modifications; some, like sealing wax, defy precise chemical description; some, like metals, are in a transition state of combination with gases condensed on their surfaces; others, like silica, are in unknown combination with water, as in quartz crystals—our old friend "electrical amalgam" is as indefinite as most amalgams. Fused quartz, I find, is not particularly easily electrified, but even it must have its gas layer.

Now, there are many cases in chemistry of actual and undoubted chemical change being brought about, directly or indirectly, by the application of pressure. Professor Liversidge, to whom I mentioned this matter, has informed me that dry alum and dry lead acetate become liquid on rubbing together in a mortar; hydrate of chloral and camphor do the same. It is a question as to the combination produced by strongly pressing together powdered metals, or corresponding salts. I have made some experiments on solid paraffine, and believe, though I desire to repeat the experiments before being absolutely sure, that paraffine melting normally at about 53° C, may be caused to begin to melt some two degrees lower by having undergone intense pressure. The melting point also seems to be less definite. Again, the electric charges produced by compressing crystals are well known, and since on this theory such charges are the sign of forced chemical change, since the amount of charging occurring in any crystal is associated with the relation of the compression to the crystallographic axes, it is suggested that the state of chemical combination (of the higher order—generally called physical) is different along different axes. Again, Strouhal and Barus have given good reason for thinking that the molecular grouping of steel alters under stress; and, in fact, explain viscosity—after Maxwell—in this manner. Taking these and other facts into account, my position is that if chemical change (including the reconstruction of so-called "physical compounds") is accompanied by the freeing of atoms, even if they be afterwards combined in another way, only this freeing, if requiring the expenditure of energy, will be accompanied by the phenomena of charge. Applying this reasoning, in connection with Helmholtz's important views as to "boundary layers" to the case of an ordinary frictional machine, I regard the first electrification as due to actual chemical change occurring in the boundary layers between the rubber and the glass plates. This change need not be large. Thus I have calculated roughly that if a large Holtz machine, which charged about ten jars to such a potential in about a hundred seconds as would allow them to give a spark two or three inches long, had been replaced by an equivalent plate machine, with a layer of water vapour on the plate surface, then an amount of decomposition corresponding to about a millionth of a gramme per second would account for the effects observed. I had no reason for taking a layer of water on the glass surface, except to enable me to make a rough calculation. Nothing can be better than a colloid like glass itself. A very small surface change would account for all the results, especially as it might undo itself while the machine was not working, and particularly if it got reversed; and would, I think, be so small as to escape detection by a balance, or rather discrimination from the effects of abrasion. That the glass surface gets more or less changed is well known to everyone. I have ventured to put forward these views—not because they are free from objections, but because I think that the time has come for a beginning to be made in an enquiry as to this portion of the subject. I ought not to close this address without drawing attention to the very fruitful field for speculation as to the relation between ether and matter indicated by Rowland's experiment. Briefly, it seems to me to indicate that the magnetic effects produced by a current in an electrolyte have this analogy with the magnetic effects produced by Rowland's disc—that in both cases we must imagine some "slip" to occur. It matters not whether the slip is produced between the polarised ether-enwrapped atoms of the disc, or whether it occurs at the boundary of atoms in the third state in an electrolyte, where they are directed by other means into an average path. This, however, is too big a subject to be dealt with in such a sketchy manner; and, as I have already taken up too much time, I will close this address with the customary thanks and apologies to the members of the section.

PRESIDENTIAL ADDRESS IN SECTION B.

CHEMISTRY AND MINERALOGY.

By PROFESSOR E. H. RENNIE, M.A., D.Sc.

University of Adelaide.

In assuming the presidency of Section B of the Australasian Association for the Advancement of Science, it is my first duty to thank those who have done me the honour to elect me to the office, and to say that it will be my earnest desire to deserve the distinction by doing all in my power to forward the interests of the sciences which this section represents. While thoroughly appreciating the honour conferred upon me, I feel also a grave sense of responsibility—a responsibility to say something which may help to further the interests not only of this section, but also of the Association, and, therefore, of Australasia.

The benefits to be derived from a meeting of this kind are doubtless, in a large measure, those which arise from conversation and social intercourse between men of like pursuits, and, in fact, we are often twitted with the preponderance of the social element. It will, however, be a great pity if those portions of the proceedings devoted to pleasure and relaxation are allowed to entirely eclipse the scientific objects of the gathering—if, in fact, by means of papers and discussions, we do not get some stimulus to more earnest work in the future.

In common with many others occupying somewhat similar positions, I have felt considerable difficulty in choosing a subject on which to address you. It has been customary in past years in the British Association for sectional presidents to give a general *resumé* of the more important researches and discoveries of the year immediately preceding; but, latterly, men in such positions have found themselves obliged by the ever-increasing rapidity of scientific discovery, and the consequent massing together of material, either to choose some educational theme, or to discourse on those aspects of the science to which they have themselves devoted special attention.

It will, I think, be granted that to the members of our Association any aspects or results of our science which have special reference to Australasia should be of peculiar interest, and I propose therefore to-day, in the course of a very brief address, first to inquire into some of the more important results which have been obtained by examination of Australasian products, and then shortly to touch upon some of those great chemical questions which are being more and more forced upon our notice by the far-reaching generalisations to which they point.

There are, of course, two lines on which an inquiry as regards Australasian products might proceed, viz., the purely utilitarian and the purely scientific. If, in this address, preference is given to the latter, it is not from any desire to undervalue the former, but partly because I have elsewhere given prominence to the importance of the application of science to practice, and because, as I believe, the greatest discoveries in chemical science in recent years, which have also been of great practical importance, have not been the result of accident, but the outcome of long and patient investigation in realms of work at one time most unpromising as regards useful issues, and, moreover, because one object of this Association, as I understand it, is the prosecution of scientific knowledge for its own sake, quite irrespective of the question whether it will immediately yield payable results or not. The perpetual cry, "*Cui bono?*" which would never be uttered if those who make use of it had any real idea of the history of the discoveries of the past, is most discouraging to those of us who are endeavouring to prosecute scientific work in these colonies, where it is exceedingly difficult to rouse interest in anything which does not immediately lead to material profit in one shape or another. May I not, in this connection, take the opportunity of urging upon all scientific teachers to use every endeavour to impress upon their students the historical developments of such discoveries as I have referred to?

Entering now upon the consideration of the chemistry of plant products, I am sure you will, in the first place, join with me in paying a hearty tribute of praise to the very valuable preliminary work which has been accomplished in the region of plant chemistry by our President and his collaborateurs, and to that more recent and most valuable bibliography of the subject contained in the "Useful Native Plants of Australia," lately compiled by Mr. Maiden, curator of the Technological Museum of New South Wales.

Among the more important products, those obtained from the "everlasting gum-tree" first claim our attention. In a remarkable series of researches carried out in the laboratory of the University of Bonn, Wallach has succeeded in reducing to something like order and system the confusion which has hitherto existed in our knowledge of that class of hydrocarbons known as the terpenes, and has revealed some most interesting facts about the relationships of these substances to one another, especially with reference to their optical properties. He has shown that some of these substances exist in what may be termed pairs, one of each pair dextro-rotatory, the other lævo-rotatory, in its effect on polarised light. Thus he has found two pinenes, two phellandrenes, and two limonenes, the only difference between the two members of each pair being the effect on polarised light just referred to; but each set of two is characterised by the formation of derivatives distinct from those of any other two, and also from those of other hydrocarbons belonging to the terpene group. In the case of the two limonenes, however, there is a special and most peculiar characteristic. When simply mixed in equal proportions these two hydrocarbons unite directly to form another hydrocarbon, called dipentene, which is very different from either of the originals. This reminds one, of course, of the relationships between dextro and lævo tartaric and racemic acids. There is, however, this distinction, that dipentene differs much more widely from the limonenes than does racemic acid from the tartaric acids, and moreover, there seems to be at present no known means of regenerating the original hydrocarbons from the product. My object in referring to these researches, however, is to point out that the oil of *Eucalyptus amygdalina* has supplied one of the missing links in the chain of discovery, Wallach having found that it contains lævo-rotatory phellandrene (this is at present the only source of this hydrocarbon), the dextro-rotatory variety occurring in the oil of *Phellandrium aquaticum*, and also in the oil of the bitter fennel in the south of France. The oil of *Eucalyptus globulus*, on the other hand, contains no phellandrene, but dextro-rotatory pinene, the two varieties of which are found in turpentines from different sources. The common constituent of both these oils is an oxygen containing liquid called *cineol* of formula $C_{10}H_{18}O$, and boiling point about 176° C, which is the chief constituent of oil of wormseed, oil of cajeput, and is also found in oil of rosemary and other essential oils. This substance is identical with the so-called "Eucalyptol," about the presence or absence of which in oils produced by different firms there has, I understand, been a good deal of dispute. Wallach himself had at first some difficulty in isolating this substance from the oil of one of these (*Eucalyptus amygdalina*), apparently owing to the presence of some disturbing impurity. The fact that it appears to be more easily isolated from the oil of one variety than from that of the other may probably have caused the dispute referred to; at any rate there can be no doubt whatever of its presence in considerable quantities in the oils from both the varieties of eucalyptus I have named, and probably it exists in the oils from other species also. It is a very interesting fact, however, that there should be a considerable difference between the constituents of the oils from these two trees, and there are indications of still wider differences between the oils from other species. The oil from *Eucalyptus Staigeriana*, for example, according to a report by Messrs. Schimmel and Co., of Dresden, contains an oxygenated substance (a ketone $C_{10}H_{16}O$?) which imparts to it its pleasant lemon-like odour, and several other species of eucalyptus yield oils of a similar odour, probably due to the presence of similar substances. References to these will be found in Mr. Maiden's book, to which I have already referred. It is obvious that there is still abundant room for investigation in the direction indicated, an investigation too which has the additional merit of possibly leading to important practical results, some of the substances obtained having been highly spoken of as perfumes, while some, we know, possess considerable disinfecting power.

There are many other Australasian plants, besides the eucalyptus, the leaves of which yield essential oils, but scarcely any of these have received more than an imperfect examination, and here again is a wide field for work.

I may mention also here that some years ago I succeeded in getting a hydrocarbon, apparently a terpene of boiling point 156° C., from New Zealand kauri gum by passing steam over the roughly-powdered gum heated in a copper vessel. It would be interesting, perhaps, to re-examine this in the light of Wallach's researches, but up to the present time I have had no opportunity.

Leaving the essential oils, and passing to other classes of products, we find that *Eucalyptus viminalis* yields the well-known "manna." This has been lately shown by Tollens to contain over 50 per cent. of *raffinose*, or *melitose*, one of the more recently investigated, and from a scientific point of view, more interesting sugars, containing as it does at least eighteen atoms of carbon, and yielding a mixture of lævulose and galactose on treatment with dilute acids. I believe, though on this point I am not quite certain, that "manna" has also been found on other species of eucalyptus; if so, it would be well worth examining.

The alkaloids afford us a field almost untouched, so far as exact chemical investigation is concerned. So far as I know the only substances belonging to this class, which have been at all carefully examined, are those to be found in the bark of *Alstonia constricta* and the "*pituri*." Of the former several have been isolated and partially described by different observers, but especially by Hesse, who describes at least four; but all of them need further examination, especially as some, at any rate, possess very marked physiological activity. The alkaloid to which the peculiar effects of "*pituri*" are due has been isolated by Professor Liversidge, who describes it as a volatile liquid possessing characteristics closely allied to but distinct from those of nicotine. and having the formula C_6H_8N. This also needs further examination, but sufficient quantities of material are very difficult to obtain, and I understand Professor Liversidge has not had an opportunity to continue the investigation. There are numbers of plants which seem to contain principles of more or less poisonous nature, notably two natives of New Zealand, the Coriaria *ruscifolia* and *Corynocarpus levigata*. The former is said to be excessively poisonous to sheep feeding upon it, and extraordinary stories are told of the powerful physiological effects produced by eating the nuts of the latter unless they are first pounded and washed with water, a practice always observed by the natives. Mr. Skey, who examined these nuts, states that he succeeded in isolating a crystalline poisonous substance which, however, appeared to him to be more closely related to the glucosides than to the alkaloids.

It is scarcely necessary to say that the complete isolation and thorough chemical investigation of physiologically active principles, whether of the nature of alkaloids or not, is of the greatest importance, if such principles are to be usefully applied to medicinal purposes. The scientific world owes a debt of gratitude to Dr. Bancroft, of Brisbane, for the valuable results he has obtained by physiological experiments with a variety of Australian plants, but the statement will bear repetition that from a chemical point of view a great deal still remains to be done.

As an instance of a glucoside, we have the active principle of *Smilax glycyphylla*, which is asserted by some to have considerable medicinal value, but which has not yet, so far as I am aware, been tried medicinally in the pure state and in larger doses than can be conveniently administered in the state of infusion. It is a crystalline substance closely allied to phlorizin. By the action of dilute acids it yields phloretin and isodulcite, the latter, I need scarcely tell you, a substance of considerable interest and importance in connection with the question of the constitution of the sugars, and hitherto obtainable with difficulty from a few rare sources.

Colouring matters are not wanting as products of the Australasian flora, and many of these would, without doubt, yield results of great interest, if not always of great practical importance, were they subjected to close examination. You may be interested in examining these specimens of colouring matters from *Drosera whittakeri*, a South Australian species. These materials are capable of being used as dyes, and appear to bear much the same relationship to one of the methyl-naphthalenes as alizarin and its congeners do to anthracene.

My attention has been recently drawn to the fluorescent infusion yielded by the leaves of *Bursaria spinosa*; the fluorescence proves, on examination, to be due to the presence of considerable quantities of *æsculin*, which, you will remember, is found in the horse-chesnut and, as is stated, in the root of one other plant, the wild jasmine. This may prove to be an important source of this substance, should it ever prove to be of practical value.

Many of our gums and resins would doubtless repay close examination, and Mr. Maiden has done a great deal in collecting, classifying, and partially examining a large number of them, especially with reference to the quantities of tannin which they contain. One of the most closely examined of the resins is that obtained from the various species of *Xanthorrhœa*, which was at one time largely used as a source of picric acid. Its products of distillation, under different conditions, have not been thoroughly investigated, and might yield results of importance; and besides, the resin, originally examined by Stenhouse, appears to have been the product of one species only.

A great deal more might be said on this part of my subject, but I think I have said enough to show that there is still a wide field open if we can only find workers, but herein lies the difficulty. It has often occurred to me that outsiders may wonder why, in this land of great advantages, and with such an extensive field, there is not more original investigation. Why is there not an abundance of scientific papers, on all sorts of subjects, to be found in the proceedings of our scientific societies? It is true there are plenty of papers dealing with matters of Natural History, Geology, and kindred subjects, but very few involving long, accurate, and painstaking investigation in other branches of science. The reason is plain enough, viz., that those who have the will have either not the time or the means. Those of us who are most favourably situated as regards appliances have our hands full with the teaching, organising, and all sorts of outside work which is inevitable in colonies in a state of growth, and we have not, as yet, numbers of advanced students, such as we find in older countries, who are only too glad to be entrusted with new lines of research. May we not hope that one effect of this Association will be to so interest young and old alike in the cause of scientific investigation, that such of the younger members as have time and means will come to our aid, and such of the older members as have sons, and can afford it, will endeavour to give us a chance of showing what Australians can do in this direction by sending us their sons to be trained in some branch of scientific work.

Besides this difficulty of obtaining hands to work, there is often difficulty in obtaining material to work with; and here I have a suggestion to make, which may, perhaps, commend itself to you, and which, in case it is approved, will, I hope, be taken up by this section at a later stage in our proceedings. It is the custom in these colonies to apply to a paternal Government for assistance in almost everything, and this meeting owes its hearty thanks to the Government of Victoria for very valuable assistance rendered. Now, there are in most of the colonies government organisations which specially deal with matters bordering upon purely scientific territory—geological, mineralogical, entomological, agricultural, and sanitary departments—not to mention others; and these departments have at their command men who could in many cases, at very slight expense, collect from time to time valuable material. Could it not be so managed that an individual, or individuals, thoroughly capable of dealing with some special investigation, and desirous of following it up, should apply to this Association, or to a specially-appointed committee, for assistance; and might not such assistance take the form of accrediting such individual or individuals to the government of that colony from which he wishes to obtain material in such a way that the authorities would be induced to take steps for obtaining a supply of such material? In most cases the cost involved would be very small. The plan seems to me to be feasible, and it might, to some extent, prevent duplication of work, for it would become generally known that certain persons were carrying out such and such investigations. Of course, such applications would need to be governed by regulations; but should the suggestion meet with your approval, it will be easy to discuss the details at a later period.

If we enquire now what has been done in the region of mineral chemistry (I am speaking, remember, chiefly from a purely scientific point of view), we shall find, I think, that in this department even less has been accomplished. It is true we have a large number of analyses in official reports of one kind and another, but these have, for the most part, been undertaken and published purely from a commercial point of view, and there has been very little careful and systematic analysis of the less common and less useful minerals, of which many varieties are to be found. So far as I have been able to ascertain there is scarcely any record of the discovery of the rarer elements. The only instance I have came across is the analysis of a sample of *monazite*, which was examined by Mr. Dixon, of the Technical College, N.S.W., and which he found to contain Cerium, Lanthanum, Thorium, and Didymium. In one or two instances some of the less rare elements have been discovered; for example, Mr. Mingaye, at the first meeting of this Association, proved the presence of considerable quantities of tellurium in some bismuth ores from Captain's Flat, N.S.W., and some years ago I showed that the appearance of brilliant yellow, reddish, and green colourations on white bricks made in the neighbourhood of Sydney were due to the presence of vanadium. I have found small quantities of vanadium widely distributed in many clays in the neighbourhood of Sydney. But is it not, to say the least of it, highly probable that in the large areas of mineral country which exist in so many parts of Australasia there are waiting to be found many minerals, possibly many new ones, containing either considerable quantities of rare but already known substances, or perhaps even new elements. That they have not been found I attribute to the fact that the search for minerals has been almost entirely directed to the finding of gold or other payable metals. We have heard a good deal of Broken Hill, perhaps there are some listening to me who are fortunate or unfortunate enough to know more about it than by mere hearsay, but it is scarcely to be doubted that a careful scientific search for and examination of minerals from the great silver field would yield results of great interest. Professor Masson and Mr. Kirkland have, I understand, examined a considerable number of zinc ores from that district for gallium, but so far without success. I have roughly examined the flue dust from the Dry Creek Smelting Works for germanium, but so far without finding any, but these negative results need not discourage us. You may be reminded in this connection that the Government assayer of N.S.W. reports the discovery of platinum, and probably therefore some of the associated metals in some minerals from somewhere in the Broken Hill region.

This department of chemical science—I mean the search for new or imperfectly known elements—has acquired great interest and importance in view of the great impulse recently given to the study of the periodic law of Newlands and Mendeléeff by various chemists in Europe and the brilliant researches of Crookes on the nature of several of these so-called elements. It may not be out of place before bringing this address to a conclusion to review very briefly the more important results obtained in this direction during the past few years, the questions involved being of all-absorbing interest to both chemists and physicists. It is evident that, whether justified by facts or not, there is a growing disbelief in the elementary character of the so-called elements, and this disbelief has arisen from results obtained in two different lines of research, namely, a more thorough study of the periodic law, and the spectroscopic investigations of Crookes and others.

One of the most important papers on the periodic law was that read before the British Association at Aberdeen, in 1886, by Carnelley. He brought out very clearly the analogies between the elements so called when arranged according to the periodic law and series of hydrocarbon radicles and their derivatives, and showed that it is possible to build up a series of compounds of two primary elements corresponding in many respects to the known series of elements, and he advances the speculation that all of the latter, except hydrogen, may be compounds of two substances, one with atomic weight 20, and the other with atomic weight -2, the latter being identical with the *ether* which exists all through space and matter as the medium of transmission of heat and light. Dr. Carnelley puts this forward merely as a speculation, and though the idea of a substance with negative atomic weight may be to others, as to myself, very difficult to grasp, there can be no doubt that his paper is a very valuable contribution to the study of the causes underlying the periodic law.

By the adoption of a form of zigzag curve Emerson Reynolds succeeded in indicating much more clearly than by the ordinary tabular system, the relations and contrasts between the various members of the different periods, bringing into prominence especially the following noteworthy points:—(1) The possibility that hydrogen is not the *first* member of Mendeléeff's first period, but the *last*—in other words, that there is still room for elements of lighter atomic weight than hydrogen. (2) The possible non-existence of Mendeléeff's ninth period, which includes at present only the metal *Erbium*; and (3) the interperiodic character of the triplet groups Fe. Ni. Co., Rh. Ru. Pd., and Ir. Os. Pt.

Crookes, in his lecture on the "Genesis of the Elements," adopted a slightly modified form of the curve proposed by Reynolds, and of it he says, "The more I ponder over the arrangement of this zigzag curve the more I become convinced that he who fully grasps its meaning holds the key to unlock some of the deepest mysteries of creation." Using it as an illustration, he sketches out a possible evolution of the substances known to us as elements from an original or primordial matter, which he calls *protyle*, and in this sketch he explains the possible formation of such groups as the three triplets already referred to, and that of the Cerium metals, the characteristics of which he has done so much to elucidate. While on this subject of the graphic representation of the periodic law, attention should be drawn to a curious paper by the Rev. Dr. Haughton, read before the Royal Irish Academy in 1888, in which, by a geometrical representation of the law, he brings out some interesting and hitherto unnoticed points, and indicates in a very graphic manner the isolation of hydrogen and the points at which, in his opinion, there are still to be found missing elements.

The other line of investigation, which has led to serious doubt as to the accuracy of the hitherto generally accepted notions of the nature of the so-called elements, is the purely experimental, as developed by Crookes and others in researches on the rare-earth metals. By long and tedious experiments Crookes has succeeded in splitting up *yttrium*, for example, into several substances, which are, at any rate, spectroscopically distinct, but which are so closely related chemically that they are indistinguishable by ordinary methods. He believes it will be possible to obtain similar results with other substances, if only the right methods can be found; in fact, he has actually found indications of the commencement of a like separation in other cases than that of *yttrium*. Reasoning on these facts he has modified his views as to the character of the elements, and is now inclined to regard them, not as made up of a number of atoms of rigorously the same weight, but as consisting of groups of atoms of which the *mean* atomic weight is practically constant, but which differ in weight among themselves to a small but finite extent. This, in his view, would be the natural consequence of the generation of the elements from a primordial matter, and if I understand him aright, he believes that in such groups as that of the cerium metals, and others of which the members closely resemble one another, we have traces remaining of an imperfect differentiation into the distinct substances we have been accustomed to call elements.

In his Faraday lecture, delivered last year before the Chemical Society of London, Mendeléeff criticises somewhat severely these views as to the character and origin of the elements. He objects to the representation of the periodic law in the form of curves as used by Reynolds, Crookes and Haughton, on the ground that a curve as ordinarily used indicates a continuous and unbroken series of points, and that, therefore, at any and every point of such a curve, there should be a corresponding element—in other words, this method of representation implies an infinite number of elements—so at least I understand his objection. It would appear, however, that this criticism is based upon a misconception of the real object of these so-called curves, which, I take it, are not intended to be understood in a purely mathematical sense, but simply as graphic representations of the periodic law, which enable us to see more clearly its prominent features. He points out further that the analogy between the series of elements and hydrocarbon radicles, worked out by Carnelley (though previously indicated by Pelopidas) is weak in this respect, that whereas the series of natural elements involves an increase of mass as we pass from one member to another the series of hydrocarbon radicles involves a decrease, and that therefore there is no true identity of periodicity in the two cases. This statement, is of course, involved in Carnelley's assumption of a negative atomic weight. As regards the existence of *helium*, an element supposed by Lockyer to exist in the sun, he points out that no attention is paid to the fact that the helium line is seen only in the spectrum of the solar protuberances, nor to the fact that the same line is wanting among the Fraunhofer lines of the solar spectrum, and therefore does not answer to the fundamental conception of spectrum analysis, and he further criticises other statements regarding the alleged spectroscopic indications of the decomposition of the elements. He does not, however, attempt to controvert Crookes' results, but says:—"From the foregoing as well as from the failures of so many attempts at finding in experiment and speculation a proof of the compound character of the elements and of the existence of primordial matter, it is evident, in my opinion, that this theory must be classed among mere utopias."

The supposition of Carnelley that the ether may be one of the forms of the primordial matter has been already alluded to.

Recent physical investigations have thrown wonderful light on the nature and functions of the ether, for a simple account of which I refer you to that fascinating book by Professor Lodge, entitled "Modern Views of Electricity." In his preface to the work he says "the evidence for (the existence of) ether is as strong and direct as the evidence for (the existence of) air," and he regards it as "a perfectly continuous, subtle, incompressible substance pervading all space, and penetrating between the molecules of all ordinary matter, which are embedded in it and connected with one another by its means." If there be such an all-permeating form of *matter*, does it not seem improbable that this substance should exist separate, distinct and different from all other forms of matter, and having no share in their composition? Is it not more likely that it forms an essential part of all forms of matter known to us, and is it not possible that the known effects of heat, light and electricity, for all of which this ether is undoubtedly the means of transmission, are either due to, or at least would be greatly aided by, its presence as a constituent part of the matter upon which the effects are produced? You are doubtless well aware that Sir W. Thompson has elaborated what is known as the vortex theory of matter, which represents the atoms as vortex rings formed of the substance of the ether, he having demonstrated that vortex motion is capable of conferring upon a fluid such as the ether the necessary rigidity. In speaking of this, Professor Lodge says:—"The atoms of matter are not so much foreign particles imbedded in the all-pervading ether, as portions of it differentiated off from the rest by reason of their vortex motion, thus becoming virtually solid particles, yet with no transition of substance: atoms indestructible and not able to be manufactured, not mere hard rigid specks, but each composed of whirling ether—elastic, capable of definite vibration, of free movement, of collision."

Whatever opinions we may hold on these subjects, there is not one of us but must feel, I think, that the scientific atmosphere is pregnant with coming discoveries, though the boldest prophet may well hesitate to predict what they will be. In a few years chemistry, perhaps, will be reduced to a mere branch of the all-embracing science of physics, to be studied by differential equations and other mathematical processes yet to be invented. Already it is becoming more and more necessary for scientific chemists to be, not mere chemists, but also physicists and mathematicians. Let those of us who are not able to plunge into the more abstruse reasonings upon which some of the recently obtained results depend, content ourselves with doing our utmost to discover such new facts as lie within our reach, to aim at generalising these facts as far as possible, and so add to that storehouse of knowledge, by means of which those possessed of greater powers of analytical investigation than ourselves may be able to elucidate the greater problems of nature: and let all of us who are members of this Association strive to make it such an influence in these colonies that Australasia may not be behind the rest of the world in its eagerness for scientific investigation and ambition to produce men who may rank among the great discoverers of future years.

PRESIDENTIAL ADDRESS IN SECTION C.

(*Geology and Palæontology*).

OSCILLATIONS OF THE EARTH'S SURFACE.

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That the surface of the earth has moved is, at the present day, a part of common knowledge. Every one knows that high mountains are built up of rocks which were once beneath the sea, and that coal-beds, now so deeply buried, were formed on the surface of the land. It is nearly, perhaps not quite, as well known that these movements are still going on, some parts of the world undergoing slow upheaval, others slow depression. It has, however, only lately been discovered that, in addition to these slow movements, comparatively rapid wave-like pulsations of the land take place in Europe, in Japan, and probably in other places.

It appears probable that the earth's crust is in a constant state of movement, some parts sinking, others rising. There may be portions which are in equilibrium and stationary, but probably these areas are small in comparison with those undergoing movement. Oscillation is the normal condition of the surface, immobility is the exception. Oscillations like these have doubtless been going on through all geological time, although with varying intensity; and the movements have sometimes continued so long in one direction that we find places which have been elevated five or six miles above the sea level, and we can also prove that in places depression went on to the extent of six—perhaps even eight or ten—miles below the sea.

Professor G. H. Darwin has calculated that, if the earth be as elastic as steel, a rise of one inch in the barometer over the whole of Australia would indicate an increase of pressure sufficient to depress the surface two or three inches, while the tides of the Atlantic might cause a rise and fall in the neighbouring land of five inches. To these changes may be due some of the quicker pulsations; others are annual, and appear to be due to changes in temperature, while others are independent of all meteorological causes.

The origin of these latter pulsations, as also of the slower oscillations in level, has not yet been satisfactorily explained, and as the object of this address is to place before you the present state of our knowledge on this fundamental problem of geology, it will be as well for me to commence by describing shortly the principal facts connected with the movements—that is, the principal phenomena which have to be explained.

Phenomena Connected with the Movements.

When we examine those portions of land which have been most elevated, we easily recognise two types of structure. One is the Plateau type, in which the sedimentary rocks are nearly horizontal, and the only igneous rocks are overflows of basalt. The other is the Mountain Range or Alpine type, in which we find a granitic or gneissic core, surrounded by sedimentary rocks which have been plicated, and sometimes pushed horizontally over one another; and here basalts are not commonly found in the mountains, but often occur at a little distance from them. The first of these types is evidently due to vertical uplift alone, the second to vertical uplift accompanied by lateral pressure. But the two types are connected by the Uinta and Park Ranges, the former being only a flattened dome, the second a dome into which granite and gneiss have been pushed, and the surrounding sedimentary rocks plicated or placed nearly vertical. The Andes forms another type of mountains, differing from the ordinary Alpine type by the addition of volcanoes along the centre of the range. The Caucasus is intermediate between the Alpine and Andean types, the central peaks of Elburz and Kazbec being extinct Andesitic volcanoes, surrounded by mountains of granite. What is known as the Jura type appears to be found only in mountains forming the outworks of a range on the Alpine type, and is not an independent structure. The Park Range also shows folds like the Jura.

Depression of rock masses has occurred on an enormous scale, but we cannot examine the structure of the depressed rocks until they have been re-elevated. They all appear, however, to belong to one type, which corresponds to that of the plateau or regional uplift. I am not aware of any reason for supposing that folding of rocks ever took place with depression, or that any subsidences were accompanied by lateral pressure. There are, however, many reasons for thinking that neither elevation nor depression are continuous movements, but that both are irregular, sometimes being even reversed for short intervals, and thus giving rise to oscillations.

Plications are always connected with great thickness of the plicated beds—that is, they never take place except after heavy sedimentation: a fact first pointed out by Professor James Hall of New York, and since confirmed in many parts of the world. For example, the older Palæozoic rocks are very thick in Britain, and thin out easterly through southern Scandinavia, the Gulf of

Finland, and northern Russia. Before the Devonian period they were much folded in Britain, but in Russia they remain horizontal to the present day. In the Ural Mountains, however, they were covered by heavy carboniferous deposits, and here they were disturbed immediately after the Carboniferous period. In the peninsula of India the Bijáwan series is horizontal where thin, and much folded where thick. The Star formation in Queensland is only some 1200 feet thick in the Star gold-field, and is here but little disturbed; while in the Hodgkinson and Palmer gold-fields, where it is more than 21,000 feet thick, it is highly inclined. In North America, the Palæozoic sediments of Virginia and Pennsylvania in the east, and of Nevada in the west, are each about 40,000 feet thick and much disturbed; but between them, in Colorado and the Mississippi valley, they get thin, and here they are horizontal. So with the Mesozoic rocks in the same region; they also are only folded where they are thick. All the contorted beds of mountain ranges are parts of thick deposits. The elevation of the north-west Himalaya was preceded by the deposition of 30,000 feet of strata, that of the Swiss Alps by more than 30,000 feet, that of the Australian Alps by more than 35,000 feet, and that of the Appalachians by 40,000 feet.

These examples are sufficient to show that only thick deposits are folded, but it does not appear that the plications are proportional to the thickness of the deposits. The folded Cretaceous rocks on the east base of the Rocky Mountains are not more than 12,000 feet thick, while the folded marine tertiaries of California are said to be only 4000 to 5000 feet thick. On the other hand the carbonaceous formations of New South Wales are more than 11,000 feet thick and not folded. The Gondwana system in the Raniganj coal-fields of India is 11,200 feet, and in the Satpura basin it is even 22,500 feet thick and yet not folded. So also in North America, the tertiary beds of the Wahsatch and Uinta districts are 12,400 feet, and the conformable strata of the Colorado plateau are 10,000 to 15,000 feet and yet not plicated. Evidently plication does not necessarily follow heavy sedimentation.

Another important point is that plication is not universal. Some large regions of the earth's surface have never been plicated since Archæan times. I have already mentioned the Gulf of Finland. In Canada, Cambrian rocks, 2000 feet thick, lie horizontally on contorted Archæans. The Arvali Range in Rajputana is formed of plicated Archæan schists which have not since been disturbed, for the Vindhyan system, which is of lower Palæozoic age, is found in the neighbourhood in a nearly horizontal position; indeed the Vindhyan system is horizontal over the greater part of the peninsula of India.

The action which has caused plication has constantly shifted its position. As pointed out by J. D. Dana in 1846, a continent shows a series of successive plicated bands with more or less parallel trends. In eastern North America the Pre-Ordovician folding of the Adironacks in New York was followed at the close of the Ordovician by that of the Green Mountains in Vermont; and the Blue Mountains are older than the Alleghanies. In western North America the Wahsatch Mountains, which are contemporaneous with the Alleghanies, preceded the Sierra Nevada, and these preceded the Californian coast ranges and the Rocky Mountains. In Asia the Kuenlun Range, on the northern side of the Thibetan plateau, preceded the Himalaya, and these the sub-Himalaya. In South America, the mountains of Brazil and Bolivia preceded the Andes. Even in Europe, complicated though its structure be, the folded bands get younger towards the south. Thus the region from central Britain in a south-easterly direction to central Germany was folded between the Silurian and Devonian; that from south Britain east through northern France and Westphalia to south Russia, between the Carboniferous and the Trias; central France and central Germany between the Triassic and the Jurassic; south Germany between Jurassic and Cretaceous; and Switzerland in the Tertiary.

Since the commencement of the Palæozoic era few regions are known to have been plicated more than once; but central Germany has been folded at least twice, although along different lines; and according to Professor Green, there were in South Africa two periods of plication between the Devonian and Trias, and each took the line of the Zwartebergen; but since the Trias this region has been undisturbed. Even in those regions, like the Alps and Himalaya, which were plicated in the Tertiary era, there appears to have been no previous plication of the district. This opinion is opposed to statements usually found in text-books; but the difference is due to distinguishing simple regional uplifts from those which were accompanied by plication. Regional uplifts and subsequent depression have often preceded the formation of a mountain range; but the true mountain uplift, which is accompanied by the irruption of granite and the contortion of the rocks, is seldom, if ever, repeated. The mountain uplift, however, may not be simple; it may consist of two or more periods of folding following closely after one another. A few examples showing the differences as well as the resemblances between these kinds of uplifts are necessary to establish my position.

In the *Pyrenean Region* disturbances, of which I cannot find a sufficiently full account, took place between the Devonian and Carboniferous periods, and were followed by subsidence and sedimentation up to the middle of the Cretaceous, when a gentle uplift took place without contortion. This was followed by a second subsidence and sedimentation to the close of the Eocene.

Then came the main uplift, with folding of the rocks, and the Pyrenees were formed. Slight depression occurred in the Miocene, with upheaval at its close, the miocene beds being contorted in the Lower Pyrenean Range at Corbières, but not elsewhere. These are overlain uncomformably by horizontal pliocene beds.

Our first knowledge of *Switzerland* is that during Permian and early Triassic times volcanic outbursts took place, followed by subsidence and deposition during the whole of the Mesozoic and early Eocene periods. This subsidence was not continuous, for, during the Mesozoic era, there were several oscillations in level, but without contortion. The deposits have a thickness of more than 30,000 feet, and include several masses of limestone over a thousand feet thick, which are thought to be old coral reefs. Upheaval, with plication, commenced towards the close of the Eocene. In the Miocene a great mountain range existed, with shallow seas both north and south of it. Subsidence again took place, and deposits of sandstone and conglomerate accumulated on the north side to a thickness of about 9000 feet. Then came a second elevation of more than 5000 feet, with folding during the Pliocene period, and sub-alpine Switzerland was formed. This latter folding was not equal all round, but greatest in the northern and central parts, the southern side being but little affected. At the same time the Jura mountains were raised. The rocks here are not contorted, but thrown into great folds, steep on the Swiss side and decreasing towards the French side, indicating that the thrust came from Switzerland. For the most part the synclinal folds form valleys and the anticlinals form hills which must have risen up as surface swellings from the ground ; and these swellings are supposed to have risen so rapidly that they diverted the course of the Rhine and turned it northward. Volcanic action, both north and south of Switzerland, commenced in the Miocene and declined in the Pliocene, but there are no volcanoes in the mountain range itself.

The structure of the *Himalaya Mountains* is not so well known as that of the Alps, but they contain a conformable series from the Palæozoic to the Cretaceous inclusive, indicating slow subsidence and sedimentation. At the close of the Cretaceous period elevation without contortion took place, accompanied by denudation so extensive as to lay bare in places the palæozoic rocks. At the same time the Deccan was flooded by enormous outflows of basalt, which cover more than 200,000 square miles, and reach occasionally a thickness of 6000 feet. Subsidence of the Himalayan region again took place, with the deposition of eocene beds 3000 to 5000 feet thick. Elevation with contortion followed, and the central range of the Himalaya was formed. The rise, however, was sufficiently slow to allow the Indus to retain its old channel and cut a path through the new mountains. Extensive denudation then occurred ; valleys were carved out, and the pliocene Siwalik beds deposited to a thickness of from 5000 to 10,000 feet. Then, in the Pleistocene, came another upheaval, contorting the pliocene beds and forming the sub-Himalaya; a range which runs along the south-west flank of the central Himalaya from the Punjab to Assam, the crests of the two ranges being about 125 miles apart. But these plications were local, for the pliocene beds on the north-east side, in Thibet, are not folded, but have been gently elevated. It is not supposed that the thickness of the Siwaliks shows the true vertical measure at any one time, for deposition, disturbance, and erosion went on together, so that in no place did they reach anything like 10,000 feet, from which it follows that rocks at the surface must have been greatly disturbed. Notwithstanding the comparative rapidity with which the sub-Himalaya were formed, the elevation was so slow that it never exceeded the rate at which the rivers flowing from the Central Himalaya cut down their beds; for they all—the Sutlej, Ganges, Ghogra and others—still run in their old valleys right across the crest of the sub-Himalaya.

In the *western United States* thick sediments were formed in Utah and Nevada from the Cambrian to the Carboniferous inclusive, reaching 30,000 feet in the Wahsatch district. At the close of the Carboniferous, or during the Permian period, these sediments were greatly plicated and elevated in the Basin Region, the Wahsatch and Humboldt Ranges being formed. The Colorado district to the east, in which not more than a thousand feet of strata had been deposited, still continued to subside. During the Triassic and Jurassic periods general depression took place, with especially heavy sedimentation in Nevada, west of the Humboldt Range. At the end of the Jurassic these beds were contorted and elevated, the Sierra Nevada being formed. At the same time the Basin Region was elevated without folding, while Colorado and Utah, east of the Wahsatch, where the sediments were still less than 3000 feet, although they had been accumulating from the Carboniferous period, still continued to sink. In the Cretaceous a general subsidence of the whole western continent took place, but the Basin Region was not depressed beneath the sea. At the close of the Cretaceous, general elevation began. In western Colorado and eastern Utah, where subsidence had been continuous since the Carboniferous, but only about 4000 feet of strata on an average had been deposited, the surface was elevated without plication, except locally on the east flanks of the Wahsatch, where the Cretaceous alone was 11,000 to 13,000 feet thick. The Uinta Mountains also rose some 4000 feet above the rest of the plateau, but their rise was so slow that the Green River, which crossed a portion of the uplifted area, kept its old channel, and cut down a gorge as quickly as the land rose. In central Colorado, where the deposits were between 8000 and 9000 feet thick, the Rocky Mountains were formed; extrusions of granite and gneiss took place, the sedimentary rocks on the eastern side were placed vertically or thrust into folds on the Jura type, while on the western side the disturbance was small. In California, to the west of the Sierra Nevada, where the sediments had been heavier, numerous foldings took place, and the coast range was formed. The plateau region of Colorado between the Wahsatch and Rocky Mountains, became a vast fresh-water lake, the bottom of which appears to have subsided while 5000 feet of fresh-water sediments were placed upon it; then the lake shrank and disappeared at the close of the Eocene. General elevation re-commenced in the Miocene, the floor of the old lake was thrown into long swellings, and volcanic eruptions of a basic character took place on the margins of the plateau, and on a still larger scale in California. This upward movement ceased in the middle of the Pliocene, but commenced again in the Pleistocene, and appears to be still going on. The total elevation of the plateau region from the close of the Eocene was no less than 20,000 feet, most of which occurred in the Miocene. It was accompanied by a number of north and south monoclinal folds and faults, which continued into the Pleistocene. The erosion that accompanied this elevation is as much as 10,000 feet in places, and averages 5500 to 6000 feet. In the Uinta Mountains, which were raised 4000 feet above the rest of the plateau at the close of the Cretaceous, the erosion has been in places over 18,000 feet.

The geological history of the western United States shows clearly that the forces which contorted the Sierra Nevada and coast ranges were not distinct from those which produced the regional uplift, and it is in this very region that we find in the Uinta and Rocky Mountains those intermediate types which I have already mentioned. Fifty years ago C. Darwin came to a similar conclusion from a study of the geology of South America, and stated his belief that mountain chains were only subsidiary and attendant operations on continental elevation; a view which has since been lost sight of, but is now re-established by the labours of American geologists.

The conclusions which can, I think, be fairly drawn from the facts I have just narrated are:—

1. The plicated bands of the earth's crust have been formed along areas of previous heavy sedimentation, that is in geosynclinals.

2. The formation of a geosynclinal is a very slow process, extending through at least two geological periods.

3. The subsidence that accompanies the sedimentation is not continuous, but is often broken by periods of elevation without contortion, followed by depression.

4. The subsequent elevation with plication, and the formation of what Dana calls a synclinorium, is comparatively rapid, com-

prising less than a geological period; nevertheless, the elevation is often less rapid than the rate of river erosion.

5. Folding does not go on *pari passu* with sedimentation, but the rocks in the geosynclinal remain uncontorted until the formation of the synclinorium has commenced.

6. The formation of the synclinorium is usually followed by subsidence of short duration, which is again followed by a regional uplift with local plications of the newly deposited beds, generally along one side only of the synclinorium.

7. Superficial rocks have been folded as well as deep-seated ones, while flexures like those of the Jura and Uinta Mountains are also local uprisings of the surface. Consequently, mountain ranges of the Alpine type are not the cores of broad plateaux exposed by denudation, as taught by Montlosier, but are uprisings from the surface, as taught by Von Buch, and may or may not be accompanied by regional uplifts.

8. Folding only takes place where the sediments are thick; nevertheless, very thick deposits are not in every case folded, showing that great sedimentation does not cause plication directly.

9. The forces which produce mountain ranges are only a modification of those which produce regional uplifts.

State of the Interior of the Earth.

It now becomes necessary to ascertain what is known about the condition of the interior of the earth, on the surface of which these movements take place; for it is evident that, before we can approach with confidence the question of causes, we must know not only the facts connected with the oscillations of the surface, but also what assumptions are allowable about the state of the interior. Fortunately, this problem has been much simplified by the mathematical investigations of Sir W. Thomson, Professor G. H. Darwin, and the Rev. O. Fisher, so that a short history of opinion on the subject will place any one in a position to judge for himself.

Leibnitz, in 1683, started the theory of an incandescent globe, the interior of which was fluid, and re-acted on the cooled surface; and he was followed by Descartes, Buffon, Hutton, and Dolomieu. But, in 1681, Bishop Burnet had maintained the opposite opinion, viz., that the earth is a solid, cold, inert mass, the surface of which was at first dissolved in a watery menstruum, and had gradually dried, the surplus water having been drawn off into caverns in the interior,—a doctrine which was supported by Woodward, Werner, De Luc, Pallas, De Saussure, and others. The discussion was long and even personal, but the bishop's side so completely gained the day that, in 1811, Pinkerton said that "the doctrine of a central heat seems to be universally abandoned." The theory was, however, revived by Laplace and by Cordier, who, in his "Essay on the Temperature of the Interior of the Earth," 1827, brought forward numerous reasons for thinking that sufficient heat to melt rock must exist at no great depth from the surface, and, consequently, that the earth consisted of a solid crust surrounding a still melted interior. The reasoning was supported by Fourier, and, although opposed by Poisson, was rapidly accepted by geologists as the only explanation of volcanoes, lateral movements of the crust, and subsidence of the surface, all of which seemed to necessitate a yielding interior.

But this theory received a severe blow in 1839, when Mr. W. Hopkins published the first of his "Researches in Physical Geology," in which he maintained that the amount of precession and nutation of the earth's axis proved the earth to be either solid or to have a solid crust not less than 800 miles thick. He was supported in this by Archdeacon Pratt, and afterwards by Sir W. Thomson; but their conclusions were opposed by Professor Hennessy in 1851, by M. Delaunay in 1868, and subsequently by General Barnard and Professor Newcomb. In 1876 Sir W. Thomson abandoned this argument altogether, and stated his opinion that a perfectly fluid spheroid would have a precession practically the same as that of a perfectly rigid one, and Professor Darwin has shown that this is so.

A far more important objection to the theory that the interior is fluid is the supposed absence of bodily tides. This subject was discussed in the days of Laplace and Cordier, was again taken up by Sir W. Thomson in 1863, and has since been supported by Professor G. H. Darwin. Sir W. Thomson said that, if the interior were fluid, the sun and moon would produce bodily tides, which would raise and lower the solid crust, and thus reduce the amount of the ocean tides. He calculated that if the earth was as rigid as steel, it would yield about two-fifths, and if as rigid as glass, more than three-fourths as much to the tide-producing influences as if it was fluid; and as the latter amount could, he thought, be easily observed if it occurred, he arrived at the conclusion that the earth must be more rigid than glass. Professor Hennessy objected to this conclusion, and pointed out that the conditions on which Sir W. Thomson's calculations were based are very different from the real ones. He said that if the fluid interior passes gradually into the solid crust, as it probably does, deformation of the shell may be very small, for the tidal energies would be expended in pushing aside the half-liquid matter. He also pointed out that, as the observed amount of precession is about six seconds less than that calculated for a rigid globe, some slight tidal deformation actually takes place. The Rev. O. Fisher, also, in the second edition of his "Physics of the Earth's Crust," 1889, has suggested that if the liquid interior contains gas in solution, the elasticity of the gas might compensate for varying pressure caused by tidal action, and the resulting surface movements might be small, or even nothing: there would be a density tide only, which might be unable to move the superjacent crust.

Sir W. Thomson had assumed in his investigations that the interior of the earth is perfectly elastic, which is no doubt incorrect. Professor Darwin undertook the calculations on the supposition that it is viscous or elastico-viscous, and found that in these cases the semi-diurnal bodily tides would lag so much behind the ocean tides that the two could not be compared, especially as the ocean tides are much affected by the distribution of the land-masses, which would not be the case with bodily tides. If an earth tide followed an ocean tide at a distance of less than half an oscillation, the time of apparent high ocean tide would be accelerated; and if an earth tide followed at a greater distance than half an oscillation, the time of apparent high water would be retarded. But owing to the friction on the sea bottom and the varying depth of the sea, neither the height nor the time of actual high water at any place can be calculated from theory; and observations give only the time and height of apparent high water, consequently, acceleration or retardation cannot be proved.

Sir W. Thomson always recognised the difficulties connected with the semi-diurnal tides, but thought that the longer period lunar fortnightly tide might be used for the purposes of observation, as with it the irregularities must be much less. He calculated that at Iceland and at Teneriffe the fortnightly ocean tides ought to be five inches if the earth be perfectly rigid, three inches if as rigid as steel, and one inch if the rigidity be that of glass. Subsequently, Professor Darwin found that the observed fortnightly and monthly tides at various Indian and European ports are about two-thirds of the calculated height, and, consequently, he thought that this proves the effective rigidity of the earth to be as great as that of steel. These results were obtained by employing the Newtonian or equilibrium or tidal theory, which supposes that each particle of the earth takes up the position of equilibrium. But owing to their inertia they never have time to do this completely, for the directions of the external attractions are always changing, and Professor Darwin has lately found that even the fortnightly oceanic tide could not be more than one half the equilibrium height, so that the observed tides seem to be actually greater than theory will account for. But, according to Mr. Love, "the Tidal Committee of the British Association appears to be still doubtful whether there really is an appreciable fortnightly (oceanic) tide,"* and both Professor Darwin and Sir W. Thomson have come to the conclusion that the equilibrium theory cannot be used for the purposes of calculation.

* Quoted by the Rev. O. Fisher.

Still later, Professor Darwin says that the lunar 19-yearly tide is the only one by which we can hope to test the rigidity of the earth. He calculates that this tide would give an oscillation of $1\frac{3}{5}$ inches at the poles, and about half that amount at the equator. He endeavoured to ascertain whether this tide could be detected in the observations made at Kurachi, but found that, if it existed at all, it was completely masked by tides due to meteorological causes. He concludes that "we must regard it as extremely improbable that the 19-yearly tide will ever be detected," and, consequently, that "the evaluation of the earth's rigidity appears, with present data, to be unattainable."

In the second of Mr. Hopkins' papers, already mentioned, he arrived at the conclusion that the earth must at one time have consisted of a solid crust, resting on an imperfectly fluid and highly incandescent interior; but, in 1876, Sir W. Thomson denied this, and said that if the interior were fluid the solid crust must break up by its own weight and sink into it. This opinion was based on the supposition that solid rock is more dense than when melted; but experiments have since shown that this is not always the case; and, in 1878, Sir W. Thomson, with remarkable candour, abandoned this argument also. Professor Hennessy has also pointed out that if the interior increases in density downwards an outer crust could not sink into a lower stratum, especially as in all probability it would be more or less vesicular.

That the crust of the earth floats on a liquid substratum, and is therefore in a state of hydrostatic equilibrium, was the opinion of Cordier in 1827, and of Professor G. Belli, of Pavia, in 1850, as it was also of both Sir J. Herschel and Sir G. Airy. The latter, in 1855, showed that a continental plateau one hundred miles broad and two miles high could not be supported by a solid globe of the materials we know at the surface, and that, consequently, it must float by what he called a root. The equilibrium need not be exact, although it must be within the limits of breakage of the rocks forming the plateau. Again, in 1878, he said that the form of the earth was not such as would be taken by a solid structure, but such as would be taken by a fluid mass with solids floating on it. There is, however, an objection to the idea that continents and mountains float by solid roots, which is that, if the interior gets hotter the further we leave the surface these solid roots would be pushed downward into hotter layers and would melt. It may be that in mountain ranges this melting below would be compensated by erosion above; but this would not apply to ancient plateaux like Canada and Scandinavia.

The question was again investigated by Professor Darwin in 1879. He says that if the earth had a figure of equilibrium appropriate to rotation there would be no dry land, for the surface of the solid would correspond with that of the ocean.

As there is dry land on the surface, the interior must be in a state of stress, and the materials composing it must be strong enough to bear this stress. If in any particular place there is a stress-difference, and no movement takes place, the materials must be at least as strong as matter which would break with that stress-difference, and he takes resistance to crushing as indicating the strength of the material. The results of his calculations show that if the earth is solid it must be at least as strong as strong granite ; if there is a crust a thousand miles thick, with a gaseous inside, the crust must be stronger than granite ; while, if the crust is only two or three hundred miles thick, then it must be *much* stronger than granite. In these calculations the earth is supposed to be a homogeneous incompressible elastic sphere. If the elastic sphere be very compressible, the stress-differences would not be so great. From this Professor Darwin infers that the interior of the earth is composed of solid substances stronger than granite, for he will not allow the only alternative, viz., that it is fluid.

It seems, therefore, that the only valid argument for a solid earth is that derived from the tides. But the forces concerned with the production of the oceanic semi-diurnal fortnightly and monthly tides are so complicated that the time of high water at any place cannot be calculated with precision, and it is not certain that any fortnightly and monthly tides exist. Neither can the time of high earth-tide be predicted, and consequently these tides cannot be used for estimating the rigidity of the earth. With the semi-annual tides, and with those of still longer period, it is thought that both oceanic and bodily tides can be calculated ; but, unfortunately, these tides are so small that they cannot be observed, so that here also the means of ascertaining whether bodily tides exist are absent. It is however thought, rather vaguely, that if the interior were not very rigid, the oceanic semi-diurnal tides would be much less than they are. But this has not been demonstrated, and as the land and the ocean would perform independent oscillations, it seems probable that, even if the interior be fluid, the movements of the land might be altogether hidden among the great irregularities of the ocean tides. On the other hand, it is difficult to believe that the highly-heated interior is more rigid than the cooled crust, and if it is not more rigid than the crust it must be fluid, for in no other way can the continents be sustained. It is also impossible to believe that oscillations of several miles in amplitude can take place on the surface of a rigid sphere; and we shall see presently that these movements of the surface are not caused by superficial stress-differences, but by plutonic action going on in the interior, which seems to be quite incompatible with a solid globe.

Another vague idea entertained by some geologists is that, if the earth consisted of an immense mass of incandescent liquid, covered by a shell only a few miles thick, this shell would have no stability, and catastrophes of some sort would be common. We are told that if there were a surging mass of molten lava everywhere, not far beneath our feet, earthquakes and volcanic eruptions would be far more frequent than they are. But why should molten lava surge beneath a crust of rock twenty or thirty miles thick? The difficulty is rather to discover causes sufficiently powerful to explain the observed movements; for the largest bodily tide would be under two feet, and could not influence much the position even of molten lava in a volcano like Stromboli, for the friction on the sides of the pipe would reduce the movement almost to nothing. So far as I can judge from published opinion, the tendency of geological thought during the last twelve years has been in the direction of the idea that the interior of the earth is fluid. Deductive reasonings against that idea have fallen one by one, while extended observation has more and more confirmed the geological argument in favour of a motile interior.

It must be remembered that the one argument for solidity—that of the tides—is an exceedingly complicated one, while the arguments for fluidity are simple. If it should ultimately turn out that the bodily tides are quite insignificant, or even absent, it would not necessarily follow that the earth is solid. It would be far more likely that the whole of the conditions of the tidal problem had not been taken into consideration, than that depressions of five or six miles in depth could take place on the surface of a rigid solid body. It seems to be certain that the present inequalities of the surface are far greater than can be accounted for by the contraction through cooling of a solid globe; and if the interior was not solid when the first crust was formed, it cannot be solid now.

Notwithstanding the opinions held by astronomers like Laplace, Sir J. Herschel, Sir G. Airy, M. Delaunay, and Professor Newcomb, some geologists have been so much impressed with the arguments advanced in favour of a solid earth that they have thought it necessary to frame some hypothesis which would reconcile physical arguments with geological facts. Mr. Hopkins' hypothesis of the existence of subterranean lakes of molten rock is one of these, which was at one time held to be probable by many geologists, but is now universally abandoned. Another is Sir W. Thomson's suggestion that the earth may be a cold sphere, around which a stratum of meteoric matter has accumulated, heated to the temperature of fusion by collision with the earth. Another hypothesis of the same character is the existence of a thin fluid substratum between a solid nucleus and a solid crust. This idea was originated by Mr. Poulett Scrope, and has been advocated by Professor Shaler, Professor Le Conte, M. Roche, and the Rev. O. Fisher. There are no special physical or geological reasons for thinking that a *thin* fluid substratum exists, although, if pressure be a very important agent in solidification, the earth may have solidified both from the centre and from the surface. Still, as we have to descend into the earth for nearly half its radius before we arrive at the density which iron has at the surface, we can with difficulty believe that the outer half is solid, unless it be formed of materials less dense than iron, which is very improbable. The hypothesis was originated to meet the argument founded on the amount of the precession of the equinoxes, and, as this objection to a fluid interior has been withdrawn, the hypothesis of a *thin* fluid substratum will probably be abandoned, for it affords but little help towards explaining the supposed absence of bodily tides.

Causes of the Oscillations.

We are now prepared to examine the principal theories that have been proposed to explain the movements of the surface. It would not be necessary, even if it were possible, for me to discuss them all. So long ago as 1834 Mr. Grenough, in his presidential address to the Geological Society of London, said, "the assigned causes of elevation are exceedingly various. One author raises the bottom of the sea by earthquakes; another by subterraneous fire; another by aqueous vapour; another by the contact of water with the metallic bases of the earths and alkalis. Heim ascribes it to gas, Playfair to expansive forces acting from beneath, Necker de Saussure connects it with magnetism, Wrede with a slow continuous change in the position of the earth's axis. Leslie figured to himself a stratum of concentrated atmospheric air under the ocean, to be applied, I suppose, to the same purpose"; and since then others have been added to the list, such as extravasation of water-substance and changes in the velocity of the earth's rotation.

Contraction Theory.—The theory that has gained the greatest celebrity is the one which attributes the movements of the surface to the tangential pressures set up by a cooling and contracting globe: a theory which, originating with Descartes and Sir I. Newton, was revived in 1816 and 1827 by Cordier, followed up by Elie de Beaumont and Constant Prevost in 1829, and has since been advocated by Sedgwick, De la Beche, and numerous other distinguished geologists. It supposes that the earth consists of a shrinking nucleus surrounded by a solid crust which, no longer contracting, is gradually left unsupported, and periodically adjusts itself to the shrinking nucleus by folding along bands which form mountain ranges.

This theory, so simple and so dramatic, was widely adopted both in Europe and in America, but several objections were brought forward in 1874 by Captain Dutton in the *American*

Journal of Science, and, independently, by myself in the *Geological Magazine*. It was pointed out that horizontal thrusts through more than a hundred miles of rock were impossible; that the theory gave no explanation of tension in rocks, everything being done by compression, while normal faults proved that rocks nearly everywhere had undergone tension; that long mountain chains with parallel foldings, such as actually exist, could not be the result of a collapsing spherical shell, for that would give rise to a network of small hills. It was also pointed out that the theory failed altogether to explain continental elevations, as well as the numerous oscillations in level that had occurred in many parts of the world; and, finally, that as the cooling could not have penetrated more than two or three hundred miles below the surface, the main body of the earth was as hot as ever, so that there was no shrinking nucleus for the crust to adjust itself to. Then, in 1881, the Rev. O. Fisher calculated that, supposing the earth's crust to have solidified at a temperature of 7000° F., the elevations caused by subsequent contraction would average eight or nine hundred feet; while if the temperature of solidification was 4000° F., then the average height of the elevations would be less than two hundred feet. But the average height of the actual inequalities of the earth is certainly not less than 9500 feet, so that they cannot be explained as the result of contraction. Prevost, however, recognised that the oceanic depressions could not be due to tangential thrust, although he gave no clear explanation of them. Professor J. D. Dana, in 1847, first put forward the idea that they were due to unequal radial contraction during cooling, and in this he was supported by Archdeacon Pratt and Mr. Robert Mallet. There are, no doubt, geological reasons for thinking that the land area has been increasing, and that the ocean bed has been getting deeper since Palæozoic times; but in 1881 Mr. Fisher calculated that the mean radial contraction could not have been more than two miles, so that a differential contraction of three miles, which is the average depth of the ocean, was not probable.

It was, however, reserved for Mr. Mellard Reade to give the contraction theory its death blow. In his "*Origin of Mountain Ranges*," published in 1886, he pointed out that only a very small depth of the crust was subject to compression, and that in this thin layer the compression must be greatest at the surface and diminish downwards until a level of no strain was reached, below which the crust must be in a state of tension.

The reason for this is easy to see. If we suppose the earth to commence cooling by radiation from a melted condition, it is evident that the cooling will be most rapid at the surface, for the greatest differences in temperature are there. This will continue until the surface approaches the temperature due to the radiation of heat from the sun, when the shell of greatest cooling will sink slowly down below the surface. The shell of greatest cooling will be the shell of greatest circumferential contraction, and the amount of circumferential contraction will diminish inwards and vanish at the level where no cooling is taking place. The circumferential contraction will also diminish outwards towards the surface, where also there will be no circumferential contraction, owing to the mean surface temperature being kept constant by radiation from the sun. But radial contraction would also be going on, and this would vary along any one radius, being nothing at the level of no cooling and greatest at the surface, where it is the sum of the whole radial contraction. Now, as the radius is less than the circumference, the mean rate of radial contraction is less than the mean rate of circumferential contraction ; consequently, the shell of greatest cooling, where circumferential contraction is at its maximum, must be in a state of tension, while the surface, where radial contraction is at its maximum, must be in a state of compression. The crust will be formed by an outer shell of compression resting on an inner shell of tension, the one passing gradually into the other. The level where the one passes into the other will be that level where the radial and circumferential contractions are equal. This is the level of no strain, outside of which the compression gradually increases until it reaches its maximum at the surface.

The subject has been taken up by Mr. C. Davison, Professor G. Darwin, and the Rev. O. Fisher. On the supposition that the rate of cooling varies as the square root of the time that has elapsed since the consolidation of the globe, Mr. Davison calculates that if the crust solidified at a temperature of about 7000° F., about 174,240 millions of years ago, the cooling would have penetrated 400 miles into the interior, the level of greatest cooling would be 72 miles, and the level of no strain five miles below the surface. The supposed data are, however, far too great, and Professor Darwin, taking the more reasonable assumption that solidification took place 100 millions of years ago, calculates the level of no strain at two miles deep. He also finds that, in ten millions of years, $28\frac{1}{2}$ miles of rock on a great circle would be crushed up—that is, rather more than one mile in a thousand. Also, that 228,000 square miles would be piled up on the top of the subjacent rocks—that is, a cone with a base of 228,000 square miles and a height of two or, possibly, three miles would be crushed. This would make, in ten millions of years, a mountain chain about a half or a third the size of the Himalaya. Evidently the results are much too small to account for mountain building during the Cainozoic era.

Mr. Fisher, on the supposition that the present internal temperature gradient is 1° F. in 51 feet, finds that, if the temperature of solidification was 7000° F., the level of no strain would be two miles, and the level of greatest cooling 54 miles below the surface. The radial contraction would have been six miles, and the mean height of the surface elevations formed by compression would be $6\frac{1}{3}$ feet. But if the temperature of consolidation was 4000° F., the level of no strain would be three-quarters of a mile, and the level of greatest cooling 31 miles below the surface. The radial contraction would have been two miles, and the mean height of the surface elevations only eight inches.

These calculations assume that the surface maintains a constant temperature; but as this temperature depends upon the sun, and as astronomers assure us that the sun is cooling, the surface of the earth must be cooling also; so that the level of no strain must be less than the calculated distance—that is less than two miles, probably less than one mile below the surface.

Four other objections can now be brought against the contraction theory. (1) It cannot explain the fact that rocks have been depressed far below the level of no strain, and brought up again. (2) It cannot explain the contortion of a series of beds far thicker than the whole shell of compression. (3) The contortions do not resemble those produced by a lateral thrust, which is greatest on the surface and diminishes downwards. (4) The granitic and gneissic cores of mountain ranges could not have been forced up by so superficial a cause. Professor Claypole notices these objections, and, curiously enough, supposes that the depth of the level of no strain has been miscalculated. But this is not possible. Two distinct lines of reasoning lead to the same result; and, indeed, the contraction theory had been virtually slain by Captain Dutton and Mr. Fisher before the existence of the level of no strain was discovered. Professor Claypole argues that as the centra of earthquakes are sometimes twelve miles or more deep, therefore the level of no strain must be more than twelve miles deep. This would be true, provided these earthquakes were necessarily due to compression caused by contraction. But tensile strains, which are relieved suddenly, are much more likely to produce earthquakes than compressive strains, and consequently the level of no strain lies probably above the earthquake region.

Mr. Davison has suggested a test by which the contraction theory may be tried, although it is one difficult to apply. He says that the depth of the level of no strain varies as the square root of the time since consolidation, while compression varies nearly inversely as the square root of the time, so that folding by compression ought to have been much more rapid during the early stages of the earth's history than during the latter, and the amount of rock folded in any given time ought to decrease nearly in proportion as the square root of the time increases. Satisfactory evidence to test this deduction is not, perhaps, available at present, but the fact that there are extensive regions of the earth's surface which have never been folded since the commencement of the Palæozoic era seems hardly consistent with it, and I think that most geologists would allow that since the close of the Jurassic period rock-folding has been quite as active as during any former period of equal length. But however this may be, the contraction theory is evidently inadequate to explain the formation of geosynclinals and synclinoria, and it cannot therefore be the true explanation of mountain ranges, while it has always been thought incapable of explaining continental elevations. Indeed, its effects must be so insignificant that they may be dismissed from our consideration; for, except in the deep ocean beds, they must be quite obliterated by denudation and deposition.

Gradation Theory.—Another way in which the equilibrium of the earth's crust is disturbed is the removal of rock by wind or running water, and its deposition in another place. The theory which finds in this the explanation of surface movements may be called, if we adopt Mr. W. M'Gee's terminology, the Gradation Theory. The transference of matter acts in two ways; first, by altering the load on two portions of the earth's crust, and secondly, by changing the positions of the isogeothermal surfaces in the earth, or, in other words, by altering the temperature of portions of the interior. Although the Gradation Theory includes the combined effects of both these reactions, it will be better to consider each separately, and I will take first the alteration in load.

This idea was first broached by Sir J. Herschel in a letter to Sir C. Lyell, written in 1836, but he did not support it by any geological evidence. He says, supposing the earth's crust to float on a sea of lava the effect of transference of pressure brought about in this way would be an extremely minute flexure of the strata; but, supposing the layer next below the crust to be partly solid and partly fluid, composed of a mixture of solid rock, liquid lava, and other masses in various degrees of viscidity and mobility, great inequalities might subsist in the distribution of pressure, and the consequence might be local disruptions of the crust where weakest, and escape to the surface of lava. At a later date, in his Physical Geography (1861), he speaks more strongly in favour of the theory, and says that any amount of pressure and relief which the geologist can possibly require to work out his problems are available. The theory was supported by Professor James Hall in 1859, and has been widely accepted in America, as well as by several French geologists. In England it was advocated by Dr. C. Ricketts in 1871, and lately the Rev. O. Fisher and several others have written in its favour. In 1845 Sir C. Lyell added the idea that the depression of a convex surface, like that of the earth, would produce foldings and crumblings.

The principal evidence in favour of subsidence being caused by deposition is the fact that, at the mouths of large rivers, the fluviatile deposits extend far below the sea level. Undoubtedly, depression and sedimentation go on together here. The depression, however, is not always uniform, for, according to Sir C. Lyell, there are unceasing fluctuations in the levels of those areas into which running water is transporting sediment. It is also an undoubted fact that many series of rocks, sometimes 10,000 or even 26,000 feet thick, are made up entirely of shallow water deposits; but here also subsidence has not been continuous.

Captain Dutton says of the Colorado plateau, "the surface of the plateau during Mesozoic times coincided very nearly with the sea level, but was constantly oscillating from a little above to a little below that level, and *vice versa*. On the whole, the region appears to have subsided about as fast as the sediment accumulated—thus preserving the surface nearly at a constant level." The same writer says that the tertiary fresh-water deposits round the Uinta Mountains are 10,000 feet thick, and "that these beds subsided by their gross weight as rapidly as they grew admits of no shadow of doubt." It is also very remarkable that depression often takes place along the base of mountain chains just where sedimentation has been most rapid.

On the other hand, the common occurrence of what is known as the normal series of deposits shows that subsidence is often more rapid than sedimentation, and is not, therefore, caused by it. Also extensive subsidence has often occurred without any great sedimentation. The mammalian fauna of Madagascar proves that that island has been united to Africa since the Cretaceous period, but the Mozambique Channel is now more than 6000 feet deep. The isolation of many other continental islands has, no doubt, been caused by subsidence without sedimentation, and Mr. Mellard Reade points to the Mediterranean and to the Gulf of Mexico as other examples.

Subsidence and sedimentation, no doubt, often proceed *pari passu;* but, as subsidence can take place without sedimentation, it seems probable that in some cases the sinking areas may have determined the position of sedimentation; and if the rate of sedimentation exceeded that of subsidence shallow water would be constantly maintained. Also, depression has not always followed loading. For example, the 4000 to 5000 feet of lava in the Deccan did not depress the land below the sea. It may be said that this outpouring of lava without subsidence was due to the sinking of some neighbouring area in consequence of a loading of still greater weight; but there is no evidence to favour this idea, and it cannot apply to the Sandwich Islands, which are more than a thousand miles from any area of sedimentation. Neither can it explain the rising of the bed of the Arctic Ocean, notwithstanding the detritus brought into it by the great rivers of Siberia.

In 1865 Mr. T. F. Jamieson proposed to explain the connection between glaciation and subsidence by the weight of the ice having caused depression, and its removal the subsequent elevation of the land, and in this he was followed by Professor Shaler, in 1874. M. Adhemar and Dr. Croll had previously supposed that the mass of ice had attracted the water by gravitation, but it has been clearly shown that the phenomena are far too complicated to be explained by so simple a supposition, and, indeed, do not accord with it. But neither is Mr. Jamieson's explanation in accord with the phenomena, for the subsidence did not begin until the maximum development of the ice had passed away, and the subsequent elevation was continued in spite of the second phase of the glaciation, so that the supposed effect followed long behind the supposed cause. In 1872 I suggested that these movements might have been due to the slow sinking and subsequent rise of the isogeotherms, caused by the formation and removal of the ice. Perhaps all three causes may have acted together, but certainly the weight of the ice was not the sole cause of submersion.

There is not much evidence in favour of elevation by unloading. Captain Dutton says that those regions which have suffered the greatest amount of denudation have been elevated most; but this might equally well be put the opposite way, viz., that those regions which have been elevated the most have suffered the greatest amount of denudation. Certainly, we cannot suppose that mountains ever attained the height which they would now have if the denuded portions were restored, so that no doubt elevation has gone on with denudation; but the elevation must have been more rapid than the denudation, or else there would be no mountains at all; and elevation must have commenced before any denudation took place; consequently, denudation cannot be the only cause of elevation. The best case yet made out for elevation by unloading is Mr. Gilbert's account of Lake Bonneville. This old Pleistocene lake was 200 by 150 miles in extent, but has since dried up to the comparatively small dimensions of the Salt Lake of Utah. The old lake margins are not level now, but arch up over the middle of the old lake, the crown of the dome being some 200 feet higher than the base. Mr. Gilbert says that the uprising of the old lake bottom was probably caused by the drying up of the lake, and the unloading of a thousand feet of water. If this is not the cause, the dome must be part of other undulations which have not yet been noticed, although looked for.

On the other hand, elevation without unloading has taken place during the Cainozoic era in many parts of the Atlantic and Pacific Oceans, as well as along the northern coast of Siberia. Indeed, if elevation was caused only by unloading no land would be elevated more than a few feet above the sea—probably there would never have been land at all. Depression also often accompanies denudation. If it were not so, no land could sink under the sea, and yet, undoubtedly, this has occurred many times.

If depression by loading be true, it is evident that the crust must rest on a fluid which moves laterally, so that depression in one place is compensated by elevation in another; and this was clearly recognised by Sir J. Herschel, the originator of the theory. That areas of elevation and of depression lie alongside of each other was the opinion of C. Darwin, although he did not suppose that the depression was caused by loading. Messrs. Medlicott and Blandford have also pointed out that the great plain or depression of the Indus, Ganges, and Brahmaputra is probably contemporaneous with the elevation of the sub-Himalaya, but they also state that it is not nearly sufficient to cause that elevation.

If the crust of the earth be floating in hydrostatic equilibrium on a fluid interior, as seems probable, then alterations in vertical pressure, if sufficient, must produce movements; and we should remember that as these alterations act continuously in one direction for long periods of time, on plastic materials, smaller changes than we imagine may possibly bring about movements. At the same time, it is certain that there are other and more powerful hypogene agents at work causing oscillations of the surface, and perhaps the formation of geosynclinals is the only important movement that can be attributed to denudation and deposition.

We have next to consider the effect produced by changes in temperature. Mr. Poulett Scrope has claimed to be the first to originate, in 1825, the idea that sedimentation would give rise to local increase in temperature; but a perusal of his book, called "Considerations on Volcanoes," shows this to be a mistake. He says that, as sedimentary rocks are worse conductors than crystalline rocks, the heat of the interior would accumulate in "a subterranean mass of lava more rapidly than it can pass off to the outside of the globe through the solid crust of over-lying rocks, in consequence of their inferior density and conducting powers. It is obvious," he says, "that the caloric will be concentrated in the lava and continually augment its temperature, particularly that of the lower strata, which are the nearest to the source of caloric." He further thought that this increase of heat might melt a portion of the crust, and in the later editions of his work he says that the expansion of the surrounding unmelted rocks would force up an axial wedge of molten granite, which, in its turn, would give rise to horizontal compression and crushing. But his concentration of caloric is by no means obvious, and he does not make it clear how rocks, which are strongly compressed, can add to their own compression by pushing up matter from below. Indeed, the whole hypothesis appears to be impossible.

The second part of Mr. Babbage's often-quoted letter to Dr. Fitton, in 1834, explains his views on the elevation of continents and mountain ranges by the expansion of rocks when heated.

He says, "surfaces of equal temperature within the crust must be continually changing their form and exposing thick beds near the exterior to alternations of temperature. The expansion and contraction of these strata will probably form rents, raise mountain chains, and elevate even continents." The letter is very vague, but he evidently saw the impossibility of land being elevated above the sea by this cause, unless the rise of the isogeotherms was less rapid than sedimentation; for he says, "The whole expansion, however, may not take place until *long* after the filling up of the sea," but he gives no reasons for this opinion.

Sir J. Herschel, who thought of this theory independently of Babbage, and enunciated it at the same time as his theory of alteration in pressure, applies it to the elevation of continents and to the formation of volcanoes, but says nothing about mountain ranges. However, he states the theory very clearly. He says: "With equilibrium of temperature and pressure within the earth, the interior isothermal strata will be spherical, but as they approach the surface they will conform themselves to the configuration of the solid portion. But when the concave bottom of an ocean is filled by deposition it may become horizontal, or even convex, and the isotherms will rise upwards. But if the deeper strata be already at the melting point, its level will be raised, and the new strata, *water included*, will be melted." Lyell misinterpreted Babbage's meaning, which is not very clear, and took the expansion to be upwards only, in which case it appears to be miserably inadequate to perform the work assigned to it; but in the anniversary address to the Geological Society of London, in 1859, Professor Phillips, speaking about the theory, said: "If we suppose a change of temperature of 100° F. to cause expansion in a solid mass 500 miles across, this would occasion a change of linear dimensions of above a quarter of a mile in limestone and sandstone. If the pressure occasioned by this were relieved by one vertical fault it must be 16 miles in height, if by one general curve upwards it would have an elevation in the middle of about 8 miles. Though, in fact, neither of these assumptions as to the form of the surface of relief can be adopted, they show how great is the *power* of changing form and relative height generated by changing temperature in rock masses." In the same year Professor James Hall pointed out that, as a matter of fact, mountains had been formed only in areas of great sedimentation, but although this evidence added immensely to the probability of the theory, it nearly died out, until it was independently supported in 1886 by M. Faye and Mr. Mellard Reade.

I will ask you to allow me to explain a little more precisely what is supposed to take place in these thick sediments. If we suppose the bottom of the sea to be at a temperature of zero, and to be gradually covered up by deposits which attain a thickness of 50,000 feet, then the base of the new deposits will be gradually warmed, by conduction of heat from below, to about 1000° F. The temperature of the deposits would gradually diminish upwards until it was zero at the new surface. Below the new deposits the increase of temperature of the old surface would also be 1000° F., and the increase for each layer downwards would gradually diminish to nothing. Consequently, the level of fusion would rise in the old crust nearly 50,000 feet, and the solid crust would maintain, approximately, its old thickness. The expansion caused by the heat, and, consequently, the internal stresses, would be greatest in the old crust, while in the new deposits it would diminish upwards to nothing. It is usually supposed that the heat would expand all rocks except clay, which at first contracts as part of the water is driven off; but it does not seem certain that such would actually be the case with deeply buried rocks. It seems quite possible that the expansion, which is not much more than one inch in two and a half chains for every 100° F., may be well within the limits of elasticity of the rocks, in which case extension need not necessarily occur. If, however, the heat be sufficiently great to produce crystallisation, then the previously non-crystalline rocks would probably become denser and contract, and thus cause the surface to sink. This is the opinion of Dr. Sterry Hunt, Professor Le Conte, Professor Lloyd Morgan, and others; consequently, it is far from certain that the rise of the isogeotherms would produce elevation at all. Professor Le Conte has suggested that the increasing heat in the newly laid down rocks may give rise to chemical action, which would still more increase the temperature; but Dr. Sterry Hunt thinks that any chemical processes which might be set up in the buried sediments would absorb rather than generate heat.

Mr. Mellard Reade, who is the ablest exponent of this theory, claims that an expansion would certainly take place quite sufficient to account for mountain ranges. In his "Origin of Mountain Ranges," 1886, he says that if an area of 500 miles long by 500 broad has its temperature raised by a mean of 1000° F., the result would be an expansion of 52,135 cubic miles. Now, this heating implies the deposition of more than 50,000 feet of sediment over the whole area, and does not take into consideration any thinning out of the deposits towards the margin. Either we must double the area of deposition or halve the effects of expansion. Taking the latter as the more probable, we find that the expansion would be sufficient to form a mountain range 500 miles long, 15,000 feet high, and about 28 miles broad at the base, which is not a high nor a broad range for such exceptionally heavy sedimentation; and even this allows nothing for condensation produced by a temperature certainly sufficient to induce crystallisation, nor for condensation produced by pressure, nor for denudation during elevation, which would reduce the height by a third at least. Evidently expansion, in the form supposed by Mr. Reade, is not capable of producing a large mountain range. Indeed it is only by supposing the beds to arch up in a dome, as suggested by Professor Phillips, and independently by myself in 1872, that sufficient elevation can be attained. But this implies that mountain ranges are the remnants of plateaux, which I thought to be correct in 1872, but which has been amply disproved.

There are also many other phenomena connected with the formation of mountain ranges which this theory fails to explain. In the first place, we have seen that no folding took place in the Alps and in the Himalaya, until the final upheaval began, which shows, either that the heat does not expand the rocks in the way supposed, or that the temperature does not rise until just before the final uplift takes place. To me the former seems to be by far the more probable, but Mr. Mellard Reade takes the latter view. He says: "It is extremely probable that while the area is subsiding, the isogeotherms are sinking also, and that the after raising of temperature, or rising of the isogeotherms is an extremely slow process." In a later paper, "On Slickensides and Normal Faults," published in the *Pro. Liverpool Geol. Soc., 1888-9*, which he kindly sent to me, Mr. Reade says: "So slowly does internal heat escape by conduction through the present crust of the globe, that the blanketing of sediments, such as we assume, will not affect the temperature of the lower layers of the under crust till long after the compression induced by expansion in the upper layers of rock and in the sediments themselves, has commenced the work of mountain upheaval." I must confess that I do not understand either of these remarks, and both seem to me to be opposed to the laws of thermotics. Certainly they demand an explanation before they can be received as probable; for, as we now know, geosynclinals take two or more geological periods to form, and it seems certain that the isogeotherms would rise nearly as rapidly as the sediments.

The objection here noticed was urged by Mr. Hopkins in a Report to the British Association in 1847, and, in my opinion, it has never been fully met. He there says that Babbage's theory is inadmissible, because, if it were correct, elevation and not depression ought to go with sedimentation; and that deposition is so slow that whenever it ceases, the isogeotherms would very nearly have their proper position, so that expansion and deposition would cease together. In 1873, I attempted to show that sedimentation was, on the average, three times as rapid as the rise of the isogeotherms; but, although this might occasionally be the case, I now think that it has been very unusual, and cannot have occurred in large geosynclinals, especially during the earlier geological periods.

Another difficulty is, that gentle oscillations, without folding, have sometimes preceded the final uplift. If these elevations are due to the expansion of heated rock, it is difficult to see how, by the theory, they could have subsided again, for this subsidence could only take place by a retreat of the isogeotherms, for which no cause is assigned.

Another and last objection is that the existence in the Satpura Basin in India, of sediments 22,500 feet thick, which have never been plicated, proves that a rise in the isogeotherms is not the direct cause of contortion, for if it were so, there would be some proportion between thickness and amount of contortion. This objection is, I think, fatal to the theory.

Eighteen years ago, having convinced myself that the contraction theory was quite incapable of performing the duties ascribed to it, I advocated the gradation (or as I named it, the Herschel-Babbage) theory, which I thought would afford a complete explanation of the phenomena. But since then the survey of North America has opened out to us a new geology quite unlike that of Europe, and the surveys of Australasia and India have supplied us with many important facts. Moreover, during the last fifteen years the various theories have been discussed in all their bearings by many able geologists, and I now see that I was wrong in thinking that the gradation theory offered a sufficient explanation. It is evident to me now that this theory, although containing some truth, explains minor details only, and does not touch the fundamental causes. As has been so well stated by Mr. W. J. McGee, in the *Geological Magazine* for November, 1888, it accounts for many of the consequent processes, but not for any of the antecedent processes. It accounts neither for regional elevation nor for subsidence; it gives no sufficient explanation of contortions, over-thrusts, and granitic cores; and it supplies no adequate machinery for causing alternating oscillations of the surface.

Internal Changes in Temperature.—The contraction and gradation theories, either separately or together, are evidently incapable of explaining the facts. As Professor J. D. Dana has lately shown, the deep sea troughs are not the result of superficial causes, but of work going on in the interior of the globe, and we are driven to look to changes in volume in masses of the earth's interior to explain the movements of the surface. Now, changes in volume must be due either to changes in density caused by changes in temperature, or to changes in the quantity of matter at any particular place, caused by internal movements, or, possibly, to a combination of both.

Hydrothermal metamorphism is sometimes cited as a cause of increase of volume as well as of decrease of density in rocks; but there seems to be a fallacy here. A combination of water with the minerals forming a rock will no doubt decrease the density of that rock, but there will be no great increase of volume. The metamorphosed rock will not occupy more space than the unmetamorphosed rock and the water did before. If the water can penetrate to the minerals there is room for the minerals to expand, and there will be no important increase in bulk of the rock. Hydrothermal metamorphism has often occurred in large masses of rock which show no signs of having been under great stress, and, consequently, could not have exerted great pressure on the surrounding rocks during the process. Changes in density giving rise to changes in total bulk must be due to changes in temperature, which may be brought about either by mechanical or by chemical means.

The hypothesis of the mechanical origin of the heat has been advocated by G. L. Vose, Professor Wurtz, and R. Mallet. The idea is founded on the supposition that the contraction of the earth by radiation furnishes the necessary energy, and it falls with the contraction theory. No other mechanical theory attempts to explain the origin of the movements, and there is only one chemical theory, viz., the oxidation of a metallic nucleus by the infiltration downwards of surface water.

This theory was originated by Sir Humphrey Davy in 1808, to account for volcanoes, and, although he abandoned it in 1828, it was ably supported by Dr. C. Daubeny. Sir H. De la Beche, in 1834, was also inclined to think that it might account for oscillations of the surface, the subsequent radiation of the heat causing depression. "For while," he says, "intense heat was developed by the combination of the oxygen of one charge of water with the metallic base, no more water could approach the lower body from above until the heat was sufficiently radiated or conducted away, and therefore there would be no gradual and continued expansion unchecked by contraction." At the present day this theory is almost universally abandoned, although it still seems to be looked upon with a favourable eye by Professor Judd. But we have no reason to suppose that unoxidised sodium or potassium ever formed a portion of the earth since it had a solid crust, and iron, which probably exists in the interior, would not furnish the necessary heat by the decomposition of water. Also, the whole of the present ocean would not oxidise a layer more than two miles deep; so that if oxidation has been the cause of the movements, an enormous amount of water must have been decomposed. But, as dry land was probably in existence in the Archæan era, and has certainly existed continuously since the Silurian period, we cannot admit the disappearance of such a large body of water.

Mr. Mellard Reade says: "It is not improbable that large masses of the heated globe, far below our thirty-mile zone, undergo slow changes which produce fluctuations of temperature even in this super-heated zone." Also, that "Chemical re-action can hardly yet have ceased, considering the multifarious materials of which the globe is composed, and chemical reaction may mean increase or diminution of bulk." But, if these things are probable, it must be possible to frame a hypothesis explaining what the changes are and how they are brought about, which is not done.

When we remember that as the earth cooled slowly from a gaseous state, the materials composing it must have arranged themselves according to their density, it would seem that, after a liquid condition had been attained, convection currents would not be possible except on the surface from the poles to the equator, and even these would cease as soon as a solid crust was formed. Under these circumstances, the deeper parts of the earth must be in a state of profound repose with all chemical affinities, satisfied for the temperature and pressure, and disturbed only by the attraction of the other heavenly bodies. It is then difficult to believe that any chemical reactions on a large scale are taking place in the interior masses of the earth, and much more difficult is it to suppose that such changes are alternating so as sometimes to raise, sometimes to lower, the temperature in the same place. At any rate, no one as yet has suggested any reasonable explanation of such re-actions, and Dr. Sterry Hunt, perhaps our highest authority on this point, says: "The notion of a subterranean combustion or fermentation as a source of heat is to be rejected as irrational."

Internal Movements.—We have still to consider the hypothesis that oscillations of the surface are due to changes in the quantity of matter at any particular place brought about by movements of a fluid interior. Mr. C. Darwin, in 1838, said that the irruption of melted rock into the mountains, which he thought to be a part of continental elevation, was caused by some slow but great change in the interior of the earth, which, however, he made no attempt to explain. Humboldt thought that alterations in the molten interior might cause displacements of mass which would modify the shape of the earth. Professor J. Phillips, in 1855, also thought that the interior of the earth was arranged in concentric layers of different densities, and that intestine movements might cause displacements, the less dense portions accumulating on some radii, the more dense on others. Those radii with a surplus of less dense material would elongate, while those with a surplus of more dense would shrink. Very small internal changes, he remarks, would alter the length of a terrestrial radius by 2000 or 3000 feet. In this way he explained the formation of continental and oceanic areas. He thought that an acidic magma, being the first to solidify, would segregate under what are the continental areas, leaving the more basic lava in still liquid lakes, the solid parts having a tendency to rise, the liquid to sink. Professor Prestwich said, in 1888, that great continental elevations and depressions are "due, possibly, to the slow transference from one area to another of a partially resisting plastic medium within confined limits." And Mr. Fisher, who has quite lately supported this theory, thinks that a thin liquid substratum exists, which is hotter and therefore less dense under the oceanic areas than under the continents, and as the substratum cannot be in equilibrium when it is not of equal density at equal depths, convection currents take place, the more heated material under the oceans flowing towards the continental areas and descending there, while new upward currents are started under the oceans. The surface currents, he also thinks, tend to carry the crust with them and thus compress it. The immediate cause of these movements, he says, is the heat of the interior, but he makes no attempt to explain why the liquid substratum under the oceans should be constantly more highly heated than that under the continents, and the hypothesis requires an unequal distribution of temperature in the interior which does not appear to be possible.

There is some independent evidence, although it is slight, to show that internal movements do actually take place in the earth. Professor Newcomb, from some observed irregularities in the moon's motion, infers that the rotational velocity of the earth is not constant, but irregular, and he suggests as an explanation the flow of a large mass of internal fluid from equatorial to polar regions, and *vice versa*. Also, Captain F. G. Evans, in 1878, stated his opinion that certain changes known to have taken place in terrestrial magnetism are caused, not by any external agency, but by movements going on in the interior. Mr. Fisher finds another reason in the thinness of the earth's crust, which, he says, probably does not much exceed 25 miles. He calculates that if the fluid interior was quiescent the crust would have attained a thickness of 25 miles in eleven millions of years, and as a much longer time than that, he thinks, has elapsed since solidification of the exterior took place, there must be some agent at work preventing the crust from thickening. This agent he holds to be convection currents, which, coming up from below, melt off the inner layers.

But assuming that internal currents take place, we have at present no adequate explanation of the cause. Professor Phillips' hypothesis gives no explanation of alternating movements, and therefore does not recommend itself as a sufficient cause of oscillations. The only possible efficient motor seems to me to be bodily tides. Humboldt, in his "Cosmos," quotes Ampère as being of opinion that bodily tides must exercise considerable force, and that it was difficult to conceive how the crust resisted them. He also says that Poisson allowed the existence of bodily tides, but regarded them as inconsiderable, "as in the open sea the effect hardly amounts to fifteen inches." That some tidal deformation must exist is also allowed by Professor Darwin, and this tidal deformation will be greatest in the outer layers and diminish towards the centre, where it will vanish. It is hardly possible that the crust is sufficiently strong or sufficiently elastic to resist all outward movement; far more likely it yields to the pressure, and in that case it seems probable that, owing to unequal yielding of the crust, slow currents might be set up in the fluid layers immediately underlying it. The daily oscillations of the pendulum observed by Professor Milne in Japan, and by M. Plantamour on Lake Geneva, may, in fact, be due to tidal pulsations.*

The short period semi-diurnal tides must cause confused movements, if any, but the longer period lunar fortnightly and 19-yearly tides, as well as the solar semi-annual and annual tides, would tend to produce steadier currents. However, the effects of these bodily tides must be very small.

If internal currents really exist it seems probable that elevation and subsidence of the surface would follow on the principle stated by Professor Phillips. If movements take place in an internal fluid which increases in density downwards, the mean density along any one radius would be variable, and, as the mass along each radius would remain nearly constant, the length of the radii would vary or would try to vary. Now, as the temperature of fusion, as well as the conductivity, is different in different rocks the solid crust cannot have a uniform thickness; and as the strength or coherence of a rock is independent of both those properties, the surface of the fluid interior must be opposed by unequal resistances. This being so, suppose a slow current of less dense and more superficial material to set from A to B, and a deeper return current of denser matter, but of smaller volume, to set from B to A, then there will be a tendency to elevate the crust in the neighbourhood of B and to depress it in the neighbourhood of A. If we further suppose that at some place in the neighbourhood of B the crust was weaker than elsewhere, then that part would be more elevated, and the current of superficial molten matter would set to it. The position of this weak place might have been determined by previous sedimentation having raised the melting point in the old crust, while the newer sediments were not so consolidated as the old ones, as suggested by Dr. Sterry Hunt and Professor Dana. Or, as suggested by Mr. Fisher, contraction of the lower sedimentary rocks by metamorphism might have formed fissures into which the subjacent molten rock could force its way. If the crust was sufficiently strong to bear the strain, regional elevation would take place, or a mountain range of the Uinta type might be formed. But if the crust gave way the molten matter would be forced into the fracture, would crush and contort the rocks on each side, and a mountain range on the alpine type would be

* Since this address was delivered I have learnt that Mr. H. C. Russell has observed earth pulsations in Sydney. *(Vide Roy. Soc. N.S.W., vol. XIX., 1885, p. 51).*

formed. Or, if the flow of material still continued towards the same place, a mountain range on the Andean type would be the result. It is possible that with an elastico-viscous crust capable of taking a permanent set and a viscid interior, bodily tides might produce forced oscillations of the surface very different in character to the tides of a fluid body, and that slow movements might continue long after the exciting cause had ceased. In this way the irregularities in earth pulsations may possibly be accounted for.

This is to some extent a return to the views of Dr. James Hutton, but he and his followers conceived the breaking of the crust to be followed by an impetuous rush of molten granite, carrying everything before it, and forming a mountain chain at a single stroke. But, in 1838, C. Darwin taught that mountain chains were formed, not by one enormous overflow, but by a long succession of small movements, each being due to the injection of molten rock, which became solid during the intervals; and this view of the injection of granite harmonises well with the hypothesis that the injection is due, indirectly perhaps, to bodily tides a few inches in height.

Mountain ranges are said to be of all ages, and this is true in a sense, but not in the same sense that sediments are said to be of all ages. Sedimentation is always going on in some part of the globe: it is a continuous phenomenon, as also is oscillation of the surface. But mountain building shows a kind of periodicity. Mountains are produced at certain periods which alternate with longer intervals of comparative repose, these intervals being of unequal length. This has always been recognised by geologists, and in the early days gave rise to the hypothesis of catastrophes. When advancing knowledge showed the incorrectness of general catastrophes, the uniformitarian doctrine came to be believed, and the periodic movements of the crust were put down to the shrinking of a cooling nucleus; they were no longer catastrophes, but paroxysms. This explanation disappears with the contraction theory, but the fact of periodicity in certain earth movements still remains, although the paroxysms are now regarded as relative and not absolute or sudden. These periods of relative paroxysmic movement by the theory now under discussion are due chiefly to periodic weakenings of the crust in different places caused by the accumulation of sediments, which thus allow the outflow of currents of a fluid interior.

Sir H. De la Beche, in 1834, pointed out how the association of granite with contorted rocks is so common that there must be something connected with the former which has had an influence on the latter. The injection of a large mass of molten matter would, he said, produce a state of things favourable to contortion, but if the intruding mass was more solid the conditions would be still more favourable, and, he continued, we can readily conceive that the sedimentary rocks of the Alps have been squeezed laterally by the pressure on them of the gneiss and other rocks of the central chain. The addition of C. Darwin's hypothesis of a series of small injections each, as a rule, hardening before the next took place, makes this explanation still more probable, and it also agrees with the fact that the thrust has always come from the central and most disturbed districts, and not from the flanks. Also, as we now know that granite is transformed into gneiss by pressure, the occurrence of a gneissic zone surrounding the granite and unconformable to the overlying sedimentary rocks is accounted for without supposing the presence of Archæan rocks wherever mountain uplifts have taken place.

Again, the common occurrence of granite in the central axis of a mountain chain, and of basic volcanic rocks on one or both flanks, cannot be accidental, and is partly explained by this hypothesis, which supposes the withdrawal of the upper acidic magma to the axis of the mountains, leaving the crust on the flanks to rest upon more basic material. In the same way it explains why the rocks brought up by oceanic volcanoes are almost exclusively basic.

If the hypothesis be correct, it would follow that mountain ranges need not have solid roots to support them, as supposed by Sir G. Airy and Mr. Fisher. These roots may be liquid, and held in their position by the curvature of the crust, although constantly changing a little in volume and producing oscillations of the surface. Fluid roots would account for all the phenomena of the plumb-line and of the pendulum equally as well as solid roots, but Mr. Fisher objects that if the molten magma rose up into the base of the range the increase of underground temperature would be greater in mountainous regions instead of being, as it is, less. But the form and position of the isogeotherms near the surface is a very complicated matter, and certainly does not rest upon this one point alone. Probably the less rapid increase of underground temperature in mountains than in plains is due to the far greater facilities for the downward percolation of surface water in the former than in the latter regions; and this seems to accord better with the fact that hot springs are commonly found in mountains.

Conclusion.—Professor J. D. Dana has lately shown that there is a system in the feature-lines of the earth's surface which is world-wide in its scope; and, since these feature-lines have been developed with the progress of geological history, the system must have had its foundation at the earth's genesis, and has been developed to full completion with its growth. Consequently, this system cannot be due to superficial causes, but must come primarily from systematic work within. Professor G. H. Darwin has attributed this systematic work to the moon, which, as the crust of the earth solidified, raised wrinkles on its surface; and it seems almost certain that it must in some way be due to the attractions of the sun and moon, for no other reasonable hypothesis can be suggested. No doubt the theory that oscillations of the surface are due to internal movements set up by bodily tides rests at present on no observational basis. But there are reasons for thinking that such internal movements are possible, or even probable ; and, if such movements do actually take place, the theory gives a simple and fairly complete explanation of the surface movements.

In both regional and mountain upheaval we find a very slow subsidence followed by a comparatively rapid elevation, the principal difference between them being that in a mountain range granite has broken through the crust and the sedimentary rocks have been metamorphosed and plicated, while in regional upheaval there is no visible granite and the sedimentary rocks have been stretched. These two types, it must be remembered, are not isolated but connected by others, which thus afford additional evidence of the unity of the elevatory force. If the lateral pressure, the effects of which are plainly visible in mountain ranges, is caused by expansion of the sedimentary rocks, as the gradation theory supposes, then it must be quite a different thing from the vertical pressure which causes regional uplifts, and there is no reason why the two should so often occur together. But if the lateral pressure be due to the irruption of granite, then the force which causes uplifts causes lateral pressure as well. In other words, the only difference between the two kinds of uplift is that in one the molten interior has broken through the crust and contorted it, while in the other case it has not done so.

The cause of the difference between the two kinds of uplift seems to be the amount of previous sedimentation on the area. If sedimentation has been very heavy the crust is, in some way, so weakened that the granite breaks through. But if previous sedimentation is not heavy the crust remains sufficiently strong to resist breakage, and a series of oscillations may follow, until at last the sediments attain the necessary thickness, the crust is broken through and permanent elevation takes place. This explains why regional uplifts followed by subsidence have often preceded the mountain uplift which terminates for a time the series of oscillations. If it should be proved that areas of elevation and depression always lie alongside one another, and if this holds for ocean beds as well as for continents, it will go far to prove the theory, for there is no other explanation but that of internal movement.

I have thus tried to give you as complete an account as I can of the present position of theory on this fundamental problem of dynamical geology. You will notice that during the last fifty years investigation has been more destructive than constructive, but progress has been made. Formidable obstacles have been removed, and much new information has been gained. No doubt the outlook is still foggy, but the horizon is clearing, and we may hope that when we have fuller knowledge of the movements of the crust we shall find a clear explanation of their cause. And now, as I bring my address to a close, the thought will come that you may say all this is mere speculation which can never be verified, and not true science. I readily acknowledge the truth of the criticism, but in my defence I will quote a passage from Dr. Whewell's "Philosophy of the Inductive Sciences." He says, "Who can attend to the appearances which come under the notice of the geologist,—strata regularly bedded, full of the remains of animals such as now live in the depth of the ocean, raised to the tops of mountains, broken, contorted, mixed with rocks such as now flow from the mouths of volcanos,—who can see phenomena like these and imagine that he best promotes the progress of our knowledge of our earth's history by noting down the facts and abstaining from all inquiry whether these are really proofs of past states of the earth and of subterraneous forces, or merely an accidental imitation of the effects of such causes? In this and similar cases, to proscribe the inquiry into causes would be to annihilate the science."

PRESIDENTIAL ADDRESS IN SECTION D.

BIOLOGY.

By PROFESSOR A. P. W. THOMAS, M.A., F.L.S., F.G.S.

In the choice of the subject for a presidential address, much latitude is allowed by precedent, and the arrangement is, no doubt, an advantageous one from the point of view of the person called upon to occupy a position which has its responsibilities as well as its honours. An address from the president of one of our sections may, it appears to me, take one of three directions: it may deal with general topics, or review recent advances in that science to which the section is devoted, or it may give a general account of work to which the speaker has given special attention.

The growth of the biological sciences has been so great that even the barest review is impracticable in the compass of an hour's address, whilst the increase of specialisation is so great that it can seldom happen that a worker's own particular line of study can be of much interest to all his hearers, whose labours probably lie in very different directions. I have refrained, therefore, from choosing a subject suggested by my own research and propose to speak to you on more general topics, and more particularly on that part of the work of this Association which falls to the share of those who attend in the section of Biology.

In the main object of the Association—the advancement of science—all sections are interested alike, and in one of the chief advantages of our meeting all share alike. Every scientific worker needs to meet his fellows; he is strengthened and stimulated by talking to sympathetic minds on those subjects which engross so large a portion of his intellectual life. If this need is felt in England, how much more must it be felt in this new Southern world, where the population is scattered, and where a man may find himself many days' travel from the possibility of intercourse with those who follow the same branch of study. I need not insist on this, for who has not felt the mental stimulus of conversation, and been surprised at times with the clearness and vigour with which ideas present themselves to the mind whilst speaking to one who can give both sympathy and just criticism?

Further, there is presented in the meetings of this Association an opportunity for workers in every department of knowledge to discuss and arrive at conclusions on the important topics of the day—conclusions which, as the united opinion of the Association, may have their full weight in questions of public moment. As Emerson has well said, it is agreed that in the sections of the British Association more information is mutually and effectually communicated in a few hours than in many months of ordinary correspondence and the printing and transmission of ponderous reports.

The general aim of our Association is declared to be the advancement of science. For this advancement many workers are needed, and for this, as well as for other reasons, it will be the duty of the Association to consider the place taken by science in colonial education. Royal Commissions and leading men in every department of human thought have recognised the necessity of the introduction of a liberal measure of scientific knowledge and training into our systems of education. Nevertheless, the day when science will take its proper position as a means of education appears to be far off. It is still a common thing for a boy or girl to pass through their schooldays without any scientific training; it is still the usual thing for university degrees to be granted to students who have no knowledge of the scientific methods which have revolutionised modern thought and action.

Many causes combine to produce this state of matters—not only vested interests and stubborn traditions, but also a lack of teachers competent to give instruction in science, and some uncertainty as to what subjects are to be taught, and how they are to be taught.

It is alleged, further, that no time can be found in the school curriculum for science. I remember only too well that in my schooldays I spent some six months in tinkering at Latin verses —a cruel and barbarous waste of time. Fortunately, in many schools this particular abuse has been removed, but subjects are still retained whose only claims to their prominence are those of fashion and tradition.

It is not my intention to enter into the question of the relative merits of different branches of study, and still less to depreciate the value of any subject in particular, but it is necessary to point out constantly that in matters of education the choice must be given to that which is most valuable: hence prominence must be given to those studies which teach us how to conform our actions to the laws of the world of nature in which we are placed. The study of natural law is science, and it appears a remarkable circumstance that the learning of these laws should occupy so insignificant a portion of education.

It is clear that, if science-teaching is to be extended, the study of science must form an integral part of the training of the teacher. Let me give you an instance of this, which has come under my own observation. The mainstay of New Zealand, as well as of the other Australian colonies, is unquestionably agriculture. Being desirous of helping in the introduction of more scientific and, therefore, of truer and more economical methods of cultivation than the primitive ones still so largely employed in the colonies, it appeared to me that one measure which would harmonise with the local conditions would be to offer prizes for agricultural science, to be competed for in the public schools. I found, however, that such a course would be useless. It was true that teachers were allowed to take the subject as one of the class subjects for the standard examinations, but the regulation was a dead letter. I was informed that the subject could not possibly be taught, because teachers could not be found who had any acquaintance with it. The cause of this neglect of so important a subject—one, too, which the Education Department had some desire to encourage—was easily discovered. The regulation for teacher's certificates in New Zealand recognised a great variety of subjects, many of them of a highly ornamental character, including Greek and Italian, but nowhere was the subject of agriculture, or science applied to agriculture, recognised. And yet the subject is one of fundamental importance, for a larger proportion of the population has need of a knowledge of the principles of agricultural science than of any other subject bearing upon human industries.

So long as science is practically excluded from the examinations for teachers' certificates and degrees, so long will it be impossible to introduce any real teaching of science into the schools. And I would remark here that it is necessary that the habits of observation and inference from observation should be acquired whilst the mind is young and still in a plastic condition. It is said that one who desires to attain a complete mastery of the violin must begin to practise whilst still little more than an infant, or otherwise the joints and tendons of the hand stiffen so as to impede the necessary freedom of action. So it is with the sciences which deal with the observation of natural objects: the cultivation of the power of observation must commence before the mind stiffens into indifference from lack of use. The training of the future workers of this Association should then begin whilst they are at school.

But the question is very far from being merely that of the acquisition of workers by this Association. The advancement of science is synonymous with human progress, and if the development of scientific training will add a few recruits to those who endeavour, by patient and laborious research, to penetrate further into the secrets of nature, it will add far more to the army of industrial workers who apply the knowledge already gained by scientific workers to the advancement of the social and material welfare of man.

There is one impediment to the progress of scientific education in its early stages which this Association may do something to overcome. If any time is given to science in schools, the subject chosen is usually chemistry, and it is taught as if each boy were to be trained as an analytical chemist, whilst little attempt is made to render the subject a real instrument of mental training. It has always appeared to me that the science-teaching in schools should be far less specialised, that it should cover a much wider field, that it should, for instance, invariably include some knowledge of the physical properties of matter, and both of plant-life and animal life. But I attach far more importance to the training to be derived from these subjects than to the actual knowledge of facts which may be gained. The British Association has a committee appointed to consider the improvement of science-teaching, and certain recommendations have recently been published through the columns of *Nature* which, to a large extent, follow the lines I have indicated, and these I would earnestly recommend to your attention.

There is another educational subject about which I wish to say a few words, namely, the development of Natural History museums as educational institutions. It is a subject on which I have had occasion to think and write for some years, and it is one with which biologists are especially concerned, for a very large proportion of the natural objects which are accumulated in such museums are either plants or animals. It has always appeared to me that a museum can be, and should be, made a most powerful means of popular education; but in going through museums in many parts of the world, the feeling has again and again been forced upon me that in this respect they are failures. Walking around the well-stored courts and galleries which teem with treasures from all quarters of the world, I have observed the visitors. Perhaps they are standing before a case of tropical birds, and you may think that to their imagination is presented the tangled luxuriance of a tropical forest, the warm air filled with the cries of the birds as they flit from tree to tree, or climb along the branches in search of insects or fruit; whilst in the sunshine, amongst the flowers, the humming birds dart with flash of crimson, sapphire and gold, now poised for a moment in front of a flower, with the long bill inserted into its calyx in search of honey, now with a gleam of brilliant colour away to seek food elsewhere. The naturalist may see all this and much more, but the ordinary visitor only sees rows of dead stuffed birds of various colours and sizes, which appeal to his mind no more than the stuffed birds you may see in a milliner's shop. He does not even know the names of the birds, for although there are labels with the Latin names set out at full length, the Latin repels the unaccustomed eye, and is therefore disregarded. It may be said, perhaps, that museums are not for such people. My sympathies, however, are altogether with these visitors. I believe that our museums ought to provide for them in the first place, that they ought to attract and instruct them.

There are two reasons why museums achieve so little of the good which may reasonably be expected from them. The first reason is that it is assumed that the visitors have a considerable knowledge of the objects exhibited. No mistake could be more fatal. It is true that most visitors are acquainted with sundry facts in natural history, but this knowledge goes a very little way in collections arranged for the benefit of the specialist. The ordinary visitor is not a trained zoologist, he is not familiar with the objects exhibited, his powers of observation have probably never been cultivated, and he is ignorant of the way in which every point of structure in an animal corresponds with the use of the part. Thus, he does not observe the differences between the stout legs of the ostrich, used for running, the comparatively slender legs of the stork, used for wading, and the short legs with webbed toes of the swimming birds, for he does not know that from the structure of an animal its habits of life may be inferred. The birds stand in the museum on pieces of wood in solemn rows, away from their natural surroundings, and there is no descriptive label to give any indication; all that the visitor can learn is that the ostrich is called *Struthio*, and the stork *Ciconia*. How much profit has he derived from his visit to the museum?

The second reason why museums fail to effect their purpose is that they do not present a true picture of nature or of the working of natural laws. It has been abundantly shown by modern research that there is the closest connection between any organic being and its surroundings. The animal is a living being, influenced at every moment by other living beings around it; by its food supply; by climatic and all other external conditions. So the stuffed animal of the museum, removed from its natural environment, does not truly represent the animal in life. What is the real interest attached to an animal? Is it so many square inches of brown fur? Is it not rather its life? And what instruction is to be gathered from it? Is it not instructive as an exemplification of the laws to which organic beings are subject?

It is over 30 years since Darwin pointed out how important and intimate were the relations of living beings to their environment. His teaching infused new life into the study of Biology but the enthusiasm does not seem to have extended to museums. One would think that the "Origin of Species" had never entered the doors of a museum. Most museums seem to be arranged chiefly, though most inadequately, with regard to the wants of the specialist, and the general public are scarcely thought of. But they fail in providing for both classes, for a specialist's museum is about as much use to the general public as a Greek author is to one who does not know the Greek alphabet. The specialist, too, is badly provided for. He cannot study the objects as they stand in the museum, locked up in glass cases, imperfectly visible and inaccessible.

I believe, therefore, that museums, open to the general public, should be arranged solely with reference to their wants. Such museums will, however, be available to all, for the specialist will be at home in the museum, however it be arranged. Two rules, at least, it seems to me, should guide us in preparing the part of the museum intended for the general public. (1) It must not be assumed that the visitor possesses any knowledge of the objects exhibited. The information should be conveyed by the arrangement or grouping of the objects, and, where this is not possible, by an ample system of descriptions written in plain English. (2) We must represent an animal as a living being, and in such a way as to illustrate the working of the laws of nature. To do this we must endeavour to place it in surroundings resembling those in which it naturally lives.

This subject of museum reform is no new-fangled one. Nearly twenty-six years ago Gray drew the attention of the British Association to the need of improvement in museums, and expressed views which do not greatly differ from those expressed by Professor Flower, as the president of the British Association, at the meeting held last September at Newcastle. There is one point in Professor Flower's address which is especially noteworthy. He says that "what a museum depends upon most for its success and usefulness is not its buildings, not its cases, not even its specimens, but its curator. He and his staff are the life and soul of the institution, upon whom its whole value depends; and yet in many—I may say in most—of our institutions they are the last to be thought of."

If the public museum is to be a means of popular education, it follows that its curators must be teachers of the people—that they must possess the gift of popular exposition. The functions of the curator of a museum are held by some to be those of a caretaker, just sufficiently skilled to name and catalogue the objects under his charge. But in the larger museums it is expected that the curator will use the materials accumulated there for the purpose of advancing knowledge. Now, it is generally believed by those who have had opportunities for observation that the combination of teaching with research in the professorial chairs has led to the most successful results in European universities; and I venture to think that the endeavour to set forth and illustrate the fundamental laws of nature by the arrangement and description of a popular museum would be an actual assistance to the curators in their work of research. Some progress is being made in a few English museums, as at South Kensington, towards improving their condition, but though the principle on which the much-needed reform is to be carried out may be clear enough, there is much to be done in working out the details of the scheme. Though this work naturally falls to the curators, it is yet a work of such magnitude, and one so obviously calculated to advance biological science, that I have not hesitated to bring the subject forward for the consideration of this section.

Amongst the work in which this section is especially interested, the study of the remarkable fauna and flora of Australasia must take a prominent place. With the view of facilitating this work, a committee has already been appointed to prepare a catalogue of all scientific papers dealing with Australasian biology. A necessary part of the work will consist in the collection and examination of all the living forms found within the Australasian area. This task of cataloguing an enormous series of plants and animals is, in many respects, an ungrateful one; it is one which is little appreciated by the public, and at which even scientific workers are sometimes inclined to scoff. Nevertheless, it is absolutely necessary that it should be done, for we know not how soon the knowledge of even the obscurest form may attain importance for scientific or economic reasons. We owe, then, our truest thanks to all those indefatigable workers who are content to devote their lives or leisure to some special group of living beings, be they beetles or diatoms.

Having thus acknowledged our indebtedness, we may, perhaps, be allowed to point out some of the failings of specialisation. It may be freely granted that the vast acquisitions of modern science render the evil of specialisation unavoidable—all who desire to extend knowledge must take up this cross. In biology, the rule, "Know a little of everything and all of something," is as safe a guide as in other pursuits; but the specialist is apt, in his enthusiasm, to lose touch with the workers in other fields, and to disregard the advances made in his subject as a whole. It is well to remind ourselves that the end of biological study is not merely to name and describe new species. In the light of modern science the species is but the expression of a passing stage of development of a long line of descent—the real objects of interest are the individuals; and the worker who takes the trouble to join together species by the demonstration of the intermediate links is more entitled to the gratitude of the world than the one who founds a fresh species for every local variety. We have, unfortunately, seen too much of the foundation of new species on imperfect data, or even on single mutilated specimens. The description of those superficial characters of the dead organism by which it may be identified is but the beginning of the biologist's work, and one who rests content with this is like the traveller who, setting forth on a long journey, stays at the first inn on his road. The way may be long and difficult, but the end of the journey is not here—the journey lies not *to* this but *through* this, to the promised land of a more complete knowledge of the laws of life.

To reach our end we require to study the organism as a living entity, to study it in relation to its surroundings, to follow the long history of its race. The study of the life-history of the organism is, therefore, one of great importance; and though it is not work which can be hurried, but demands long and patient observation, it is a task which is a satisfaction in itself, and is fruitful in valuable results.

In addition to our special work, dealing with the extensive fauna and flora of Australasia, we have the same fundamental problems before us as our fellow-workers in the Northern Hemisphere. We have introduced many of the familiar plants and animals of Europe—too many, indeed, as witness the rabbits. We have introduced, too, into our midst a large proportion of the parasitic diseases of Europe. Is not Victoria known to scientific students all over the world as the spot scourged beyond all other spots in the world, save one, by the insidious *Echinococcus*, productive of hydatid disease? So, too, with reference to stock. I once had occasion, in New Zealand, to examine the internal parasitic diseases of sheep and in a single sheep found no fewer than ten different kinds of parasites, all of them forms which must have been introduced from Europe, for there are no indigenous parasites to attack sheep.

Again, we have allowed many of the worst microbic diseases of the old world to acclimatise themselves with us. We have typhoid, scarlatina, diphtheria, consumption, and many another disease. Of the ravages of the typhoid parasite I need hardly speak, for will not this fell disease to-day claim and be allowed to take its score of victims from this colony alone?

There is still much work to be done with reference to these injurious forms of life, but when we attain a fuller knowledge of them we may hope at least to control their ravages, if not actually to exterminate them.

During the last few years there has been a marked tendency for the most able workers in biology to concentrate their attention upon questions of a fundamental character. The question of the nature of life and the elementary properties of living bodies have attracted the greatest interest, and though we are still far from being able to answer the question, What is life? important advances have been made, sufficient to hold out ample encouragement to renewed efforts. When the microscope was applied to the study of animal and plant structure, it was found that all, except the simplest elementary organisms, were composed of vast numbers of units of structure to which the name of cells was given. It was recognised that the essential part of the cell was of a viscid material, neither solid nor fluid, colourless, and having the general appearance of a dusty jelly, though far from having the composition and properties of mere jelly. To this living matter the term protoplasm was applied, and for a long series of years it was deemed sufficient to refer all the characters of living bodies to the properties of the protoplasm.

Such reference to protoplasm was, however, no explanation, though it was the first step towards an understanding of the problems of living matter. For many years Max Schultze's definition of protoplasm was generally accepted. He regarded the protoplasm, or cell-substance, as a homogeneous, glassy, and transparent substance, viscid, or of firmer consistence. The cell-substance contained a nearly homogeneous nucleus of rounded form, which, in turn, contained the nucleoli. The cell-substance was regarded as separable only into the homogeneous groundmass or protoplasm and the numerous imbedded granules.

Further research, however, aided partly by later improvements in the microscope, has shown that the protoplasm is far from being homogeneous; that it usually, if not always, possesses a definite and complicated structure, being composed of two different substances, not granules and a homogeneous groundmass, but threads or a network of fibres and intermediate substance. The extraordinary changes which the network in the nucleus of the cell undergoes during the process of multiplication have formed the subject of a vast number of papers during the last decade. It seems improbable that with this microscopic analysis we have arrived at all the intricacies of the structure of living matter. The advance of physiological study has shown the intimate correspondence of structure with function, it has shown that with every variation in the structure of an organ there is associated a variation in the function or duty of that organ. Physiological analysis has indeed gone further, and in many cases has demonstrated a complexity of function which is greater than that of visible structure. This structure of living matter is of no ordinary interest to the biologist. We have in the microscopic speck of protoplasm all the fundamental properties of the living organism presented to us. Such a speck of protoplasm may contain within itself all the potentialities of development of the highest or lowest organism. It may develop in one direction into a man, or in another into a worm, and we must assume that the potentialities of development in the different cases are represented materially by the structure and chemical composition of the network and intermediate substance.

It is obvious enough that we are still but at the beginning of our knowledge of life. There is a boundless field for generations of workers, and we may look forward with confidence to many a discovery to delight the human mind and to add to human health and happiness, as well as to more material welfare. It is not possible for all to be workers in the domain of the biological sciences, but all alike will, as living beings, share in the benefits of discoveries in the laws governing the world of life. It is on these grounds that we can, as students of biology, most surely claim the sympathy of the general public, and will it not be well for us to value and foster all friendliness towards our pursuits which we receive from their hands?

And here, in concluding, I may be allowed to urge the importance of a wider diffusion of the knowledge of biological laws. It is not enough that the laws of life and therefore of health and harmony with nature should be known to a few biologists. The whole population should live in conformity with those laws. A wider diffusion of the knowledge resulting from biological enquiries will be required to form the basis of an intelligent public opinion. I do not refer here simply to questions of sanitation, but to that wider range of problems taking cognisance of all the relations of man as a living being to his environment and including the rearing of a vigorous race, a system of mental training which shall regard the physiological requirements of mind, and the social relations of communities of men.

PRESIDENTIAL ADDRESS IN SECTION E.

GEOGRAPHY.

By W. H. MISKIN, F.E.S.

It was not without a certain degree of reluctance that I accepted the honor and responsibility of the post of presiding over the deliberations of Section E of this, the second Congress of the Australasian Association for the Advancement of Science; but the desire to promote the views, as I understand them, of the authorities to whom has been entrusted the direction of these proceedings, *i.e.*, to secure the representation of each of the various colonies in the presidential chairs of the several sections, tempted me to overcome the scruple that otherwise prompted me, from the consciousness of my own unfitness, to presume to take the lead in the presence of so many gentlemen of far greater experience and capacity. Having, however, committed myself to the task, it behoves me to proceed to fulfil to the best of my power the duties that devolve upon me as your President upon this auspicious occasion, the first of which—a most pleasurable one—I take to be the offer of a hearty welcome to the numerous assemblage here present, and my congratulations upon the happy meeting of so many colleagues gathered together from all parts of our great southern land—a felicitous augury, I venture to express the hope, of future federation upon other and more extended subjects—to deal with the particular branch of science that has been deputed as our share of the proceedings of the present Association meeting.

The pleasure which, however, we may derive from these considerations is shadowed by the reflection of the cause that has led to the occupancy of the chair by the present holder. You will, of course, anticipate that I refer to the loss to the science of Geography and to our deliberations to-day—the lamented decease of one who has done so much in Australasia in the furtherance of the cause we have at heart, and who would have so much more worthily and efficiently under happier circumstances have addressed you upon this occasion—the late Sir Edward Strickland. *Requiescat in pace.* It is also my mournful duty to refer to another heavy loss to the, alas, but too meagre ranks in this part of the world of men who are able and willing to devote their energies and talents to the pursuit of science—the late Rev. J. E. Tenison-Woods, a fellow of the R. G. Society, and an hon.

member of more than one of the branches of the Royal Geographical Society of Australasia, whose valuable life is a sacrifice to disease contracted in the ardour of exploratory investigation in the Malayan Peninsula and Northern Australia, too soon following the fate of his friend and coadjutor in the same expedition, the Rev. B. Scortechini, F.L.S., an ardent and accomplished student in the field of botany, swelling the roll of immortal names, martyrs to the cause of science and exploratory research, typified by memories of such names as Leichardt, Burke, Wills, and many others—names to be handed down to the future posterity of our country as household words, luminous as examples of self-sacrifice in the cause of duty for future generations to revere and emulate.

As the text of my inaugural address I have adopted, and I think I could not have followed a more profitable course, the form of a review of the progress of geographical research and literature during the period that has elapsed since the last assemblage of this Association, having regard primarily to our own part of the world, and then more generally to that of the world at large, viewing first the purely exploratory aspect as to what has been accomplished, what is presently in progress, and what may be anticipated in the future; glancing cursorily at the results that may reasonably be expected to follow scientifically, educationally and commercially, and including the doings of other kindred associations.

And here I may pause to remark that in dealing with the matter that I address myself to, it is difficult, nay, almost impossible, to dilate at length upon such a subject without to some extent traversing ground already exhaustively discussed in the numerous addresses recently delivered to various cognate assemblies upon similar occasions to the present, and indeed, I fear, without leaving some opening for a charge of plagiarism. It would be superfluous on my part to attempt to enter into an exposition of the meaning or object of the science of geography or of its necessity or advantages. The first has been too frequently expounded by abler hands, and the latter is surely obvious to the meanest understanding. To repeat would be wearisome and profitless.

Exploratory.

The greatest achievement in the way of exploration and discovery in our part of the world is unquestionably the triumphant success of Sir Wm. McGregor's expedition for the ascent of the highest peak of the Owen Stanley range of mountains in S.E. New Guinea, named by him Mount Victoria—a point hitherto considered almost inaccessible—and the identifying and naming other mountains in the immediate neighbourhood, with their correct positions and the altitudes of their various peaks, and the precise mapping of the country explored and observed by him. An excellent paper descriptive of this expedition, compiled from Sir Wm. McGregor's own notes and remarks, is communicated to the Queensland Branch of the Royal Geographical Society of Australasia by the indefatigable hon. secretary of that branch, Mr. J. P. Thomson, and appears in its transactions, accompanied by a well-executed map prepared in the Survey Department of that colony from Sir William's drawings.

The altitude of Mount Victoria is determined by Sir Wm. McGregor to be 13,122 feet, and discloses at its summit an almost Alpine character in its flora, representative specimens of which, of great interest to science, have been submitted to the investigation of the learned Baron von Mueller, whose observations thereon have been made public. Further discoveries of great interest and importance in this almost unknown region may be looked for in the future, through the indomitable energy and courage of his Honour the Administrator of the Government of this the latest acquisition to the empire.

Our German cousins, with their usual indefatigable zeal and perseverance, have also not been idle in their part of this great island, but have pushed exploration in all directions, advancing toward a thorough knowledge of the physical character and capabilities of their possession; not, I regret to say, without the consequent sacrifice of valuable health and life that exploration in such latitudes demands of the pioneers of civilisation.

From South Australia exploration, assisted, I believe, financially by Victorian contributions, has been pushed towards the centre of the continent under the leadership of Mr. W. Tietkins, from whose report, when available, much interesting and valuable information may be expected. From New South Wales also an expedition, under Mr. Arthur Vogan, has been sent westward, no results of which, however, are yet to hand.

In Queensland a small party, led by Mr. A. Meston, subsidised by the Government of that colony, gained the summit of Mount Bellenden Kerr, alleged to have been hitherto untrodden by the foot of the white man; but beyond some zoological and botanical discoveries, no great scientific interest attaches to this expedition, if it can be so called.

The South Pacific Archipelago we must look to, surely in the not very distant future, as a field for closer exploration, particularly from Australian sources; for is it not obvious that the whole of these fertile islands, great with the possibilities of commerce, and even possibly of settlement, known at present only by the most superficial intercourse with their barbarous and savage inhabitants through the merest trade skirmishing, if I may use the term, and ephemeral missionary settlement, must come within the jurisdiction and influence of the future great

Australasian federation? Geographically, I say they naturally connect with our continent, and I predict they must fall under the sway of the power that is best able, by every natural and material advantage, to bring them within the pale of and make them amenable to the march of civilisation. Before turning from our own immediate region, there is another, not very remote, in which we are deeply concerned, and which must not be overlooked. I refer to the Antarctic, a subject upon which a great deal has been heard of lately, unfortunately with no practical results at present, beyond the formulation of a scheme for exploration and investigation—one in which our Victorian friends have evinced especial interest. Apart from the utilitarian aspect of Antarctic research, as applying to commercial geography, questions will arise as to whether or not our climate is influenced by the ice-bound regions of the south. It would be illogical, while admitting the modifying influences of the warm currents of the Gulf Stream upon the climate of Southern Europe and other parts, to at the same time regard with indifference the possible influence of the cold Antarctic polar drift currents upon the climate of New Zealand, Tasmania, and the southern parts of the Australian continent.

It is not a difficult matter, in terrestrial physics, to give an estimate of the results brought about by the contact, or what may be termed overlapping, of hot and cold currents; and that the necessary conditions of condensation are thus brought about by the contact of cold Antarctic currents with the super-heated equatorial currents of our continent, there can, I submit, be no doubt. It therefore behoves us, as Australasians, apart from the commercial considerations of the subject, which must, however, be considerable, to investigate these agencies, bearing as they do so materially upon our climate, the conditions of which so seriously influence our existence, and thus enable us to apply the knowledge so gained to an endeavour, if possible, to ameliorate to some extent the effects of recurring droughts which operate so disastrously upon the welfare of our country.

Turning to the other regions of the globe, we find the greatest energy and enterprise everywhere actively displayed, evidencing the extent to which the value and importance of the closest and most detailed investigation of the unknown or unsettled portions are feverishly regarded, whether as presenting fields for scientific discovery and possible colonisation for the ever-increasing surplus population of the densely-peopled countries of Europe, or for the expansion of commerce, daily increasing in keenness of competition.

Upon the great continent of Africa, for so long the chief field, as, alas! also the grave of so many illustrious heroes, of exploration, the tide of exploratory investigation has, as usual, set strongly. Foremost here are the wonderful exploits of that most intrepid explorer, Stanley, in the heart of Equatorial Africa, especially in his recent expedition for the relief of Emin Pasha, a history of which has to a certain point been already communicated to the world; and now that we have happily the knowledge of his safe arrival within the bounds of civilisation, after surmounting the difficulties, hardships, and perils of his adventurous and protracted travel, we may, our minds being eased of the anxiety and suspense of his long watched for appearance, patiently await the further history of thrilling episodes and marvellous discoveries that undoubtedly the great traveller will have to disclose, varied and extensive enough, probably, to satisfy the curiosity of the lovers of the new and wonderful as the cravings of the seekers after scientific facts and data, equally with the would-be pioneers of commercial enterprise.

Other recent expeditions, north and south of the equator, have been successfully pursued respectively by Teleki and Arnot, and very considerable and important additional knowledge of the geography of those regions made known. Central South Africa has been the scene of the exertions of Mr. F. C. Selous, while in the north Mr. De Foucauld in the Atlas Mountains and Messrs. Thorn and Harris in Morocco publish the result of their respective labours in the countries named.

In Upper Burmah considerable advance has been made in topographical and cartographical investigation of the country, principally in conjunction with military expeditions, all conducing to a more thorough knowledge of this, one of the latest additions to British dominions.

In Central Asia we find the Russians ever pushing their advance towards the walls of China and the gates of India, first by explorations, followed by military occupation, with the unwearying, restless, but ever-progressing steps characteristic of that mighty empire, a menace alike to our commercial prestige in those regions as to the very bulwarks of defence of our Indian possessions. An admirable essay, illustrating this subject, was delivered at the recent meeting of the British Association of Science on "Our Trade in Central Asia," by the Hon. G. Curzon, M.P. Proceeding north, we see the same Power exploring and extending their knowledge of the unknown parts of Siberia, their efforts in this direction considerably assisted by the enterprise of a British subject, Captain Wiggins, who has successfully demonstrated the feasibility of opening a trade-route into the heart of that hitherto supposed inhospitable region, by the navigation of the Obi and Yenisei rivers, disemboguing into the Arctic Ocean, by availing of the proper but brief season during which those generally frozen seas are temporarily open to the passage of vessels, thus presenting a new field for commercial enterprise, of vast importance to the maritime countries of Western Europe. A very interesting *resumé* of nautical exploratory research in this particular direction, and general summary of results, is contained in a communication by Prince Krapotkin to the *Manchester Guardian*, appearing in the *Home News* of the 22nd November last.

Dr. Nansen's adventurous journey upon snow-shoes across the ice-bound peninsula of Greenland is possibly familiar to most of us, a truly perilous and heroic exploit, not, perhaps, affording any great results beyond proving that this part of Greenland is an immense barren waste of snow and ice, although many scientific facts and observations affecting glacial phenomena are communicated by that gentleman from his experiences upon the occasion. But as demonstrating what is capable of being accomplished by a band of hardy and courageous men in conquering the obstacles of nature presented in its most grim and forbidding aspect, this certainly ranks as one of the first achievements of the age.

I have thus briefly referred to a few of what appear to me the most important recent events in the way of exploratory geography. To attempt to give anything like a complete history of every investigation of interest would occupy more time than I dare try your patience with. Enough has, I think, been mentioned to show how our fellow-workers in all parts of the world appreciate the importance of the subject, and to stimulate us in this southern world of ours to increased effort, and to prove ourselves worthy of the race from which we have sprung—one that has always been in the van of exploration and discovery—and worthy inheritors of a land where so much still remains to be accomplished in this direction.

Commercial.

Whether regarded as the resulting effect of exploration and discovery, or as the means of further and closer investigation, to be followed by settlement and commerce, we cannot overlook the close relationship that railways bear to the subject of geography, at least to the interiors of countries, and the effect they must necessarily have in the entire change of the aspect of the countries they traverse. In these days of gigantic engineering undertakings we are accustomed to be surprised at nothing. Such reflections come to our minds when we contemplate the projected scheme for the construction of a line of railway in the Congo Free State in Central Africa by a company already incorporated, with a registered capital of £1,000,000 sterling, from a point on the Congo River to Stanley Falls, a distance of 250 miles, beginning, passing through, and ending in a region revelling in the very wildest state of nature, peopled by a race of the most barbarous and untutored savages, and at present lacking the merest approach to a step in civilisation—a wonderful enterprise truly. What extraordinary developments will be the result of this astounding temerity remains to be seen.

Another proposed undertaking of magnitude is the projected line of railway across the continent of Asia by the Russians, to bring them into direct connection with their possessions upon the Pacific coast—also a mighty enterprise, but differing essentially from that previously considered in having at least an objective base and terminus. This is however, I think, but in its inceptive stage, not having proceeded beyond the initiation of preliminary survey. The effects of the construction by the Russian Government of the Trans-Caspian line into the heart of Central Asia has already produced most astounding results in the knowledge of and development of those regions.

Amongst the South American States we find the extension of railway construction being pressed with unprecedented activity, there being estimated to be now no less than 17,000 miles in existence, with a corresponding opening up and settlement of the interior of the continent. While upon the subject of what comes fittingly under the head of the commercial feature of my subject, I may mention a very practical paper upon the immediate relation of commerce with geography, entitled "The Physical Basis of Commercial Geography," contributed by Dr. Hugh Robert Mill to the late British Association meeting.

Educational.

The importance of the study of geography in educational establishments has been gradually, but surely, forcing its way upon our countrymen, who have been hitherto behind other nations in recognising its utility, nay, necessity. Lectureships in the Universities of Oxford and Cambridge have been for some little time now established, and very satisfactory and encouraging results have followed. The Royal Geographical Society, to further encourage the prosecution of this important branch of learning, offer their medals, scholarships, and prizes to the universities and various training colleges, and these have been, during the past year, extensively and keenly competed for.

For a thoroughly exhaustive treatment of this subject we have but to refer to the able lecture upon "The Method Applied to the Teaching of Geography in the School," by Professor Laurie, contained in the *Scottish Geographical Magazine*, 1886; and more recently a valuable paper under a somewhat similar title appeared in the Proceedings of the Queensland Branch of the Royal Geographical Society of Australasia, 1888, by Mr. J. P. Thomson, hon. secretary of that branch. I may appropriately here, perhaps, with reference to an earlier remark as to the advance made by other nations over our own in the matter of educational geography, show how far we are in the rear generally in the study of Geography as a science. I cannot illustrate better than by quoting some statistics I have come across. They are extracted from Professor Wagner's *Geographisches Jahrbuch* as follows:—

	Societies.	Members.	Revenue.	Serials.
France and her colonies ...	29	19,800	£12,200	45
Germany	22	9,200	£4,600	41
Great Britain and Possessions	9	5,650	£12,000	10

Nomenclature.

A matter of considerable importance to geographical science has been referred to in several quarters recently. It is with respect to the application of names to newly-discovered natural features and localities, and it is satisfactory to observe that a unanimous consensus of opinion seems to prevail in all authoritative sources that in every case the native name should, if possible of being ascertained, be retained in preference to the much-to-be deprecated practice, unfortunately but too common, of servilely attaching complimentary and but too frequently utterly meaningless ones, to the exclusion of already well-established and generally appropriate native designations. As we are well aware, there are few landmarks or waterways in our colonies but have an appellation in the euphonious and poetic language of the unfortunate race that are so speedily becoming extinct. Let us hope that the strongly-expressed opinion upon this point will be regarded by explorers in the future, and that, in this part of the globe at any rate, the history of a human race, who must in the course of a very short period be but a memory of the past, may be perpetuated in a small degree by the scant justice of at least paying respect to their right of nomenclature to possessions of which they were forcibly deprived.

The past year has been, as before observed, exceptionally remarkable for the universal interest shown in the wide field of geographical observation, and the unanimous and spontaneous desire to promulgate the higher and broader order of knowledge occupied by the more liberally interpreted problems of scientific geography. This common centre of organised effort, constituting the event of the year, has been, of course, the great meeting in Paris. Here, in the centre of activity of geographical science, the ancient Geographical Society of Paris befittingly concentrated all its co-workers from every part of the world, representing nearly every kindred institution in existence, for the discussion of the various important questions having relation to the science of geography. This, the fourth International Congress of Goegraphical Sciences, was opened by the veteran president,

M. Ferdinand de Lesseps, who, in the course of a brilliant address, referring to the various questions for discussion, aptly remarked: "Geography, as we understand it in the present age, is not only the abstract knowledge of our globe; it comprehends also the complete relations of the earth and man, relations which we endeavour to ameliorate. This is the scope of geography, and we say with pride there is none grander."

The deliberations of this Congress were occupied with numerous scientific problems, and prominent amongst the divisions was the subject of geography grouped in seven sections, embracing amongst them the following subjects:—Geodesy, Hydrography, Topography, Cartography, Meteorology and Climatology, Geology, Medical Geography, Commercial and Statistical Geography, History of Geography and Cartography, Teaching and Diffusion of Geography, Voyages and Exploration, Ethnography, and Anthropology. Special attention was also given to geographical education, and details were formulated as to materials necessary in teaching geography, such as the choice of books, cartographic exercises, atlases, wall-maps, panoramas and reliefs; while in group 6 (Voyages and Explorations) the rules for adoption by explorers in naming their discoveries were fully discussed, and resulted in the unanimous adoption of a resolution that "the right of the explorer only begins when the country he is exploring has no native inhabitants."

The results of this Congress, which cannot fail to be of great value in opening fresh channels to "scientific discussion which may inspire but not divide," and in throwing renewed light upon obscure problems in which we are involved, will be looked forward to with great interest by our organisations in Australasia.

In September last, the annual British Association of Science meeting was held at Newcastle-upon-Tyne, at which no less than 2437 persons attended. The Geographical Section was strongly represented, and numerous able and interesting papers were contributed.

Finally, we may, I think, be pardoned for referring with a sense of self-congratulation to the records of our own Society, which has some time since, as an evidence of the interest in and importance in which such organisations are held, been distinguished by the gracious permission of the Sovereign to add the term "Royal" as a prefix to its title of the "Geographical Society of Australasia," the vocation of which is being steadily, and I think I may add creditably, fulfilled through the efforts of the several branches, all of which have successfully produced volumes of proceedings that will, I think, bear favourable comparison with those of the older societies, in whose steps they seek to worthily follow, displaying an amount of vitality under many difficulties, having regard to the limited extent of the leisured class of people in these busy working communities, that is highly encouraging.

And now, in bringing my, I fear, rather rambling discourse to a conclusion, I would desire, while reiterating the importance of the study generally of geography as a science, bearing in mind that science as a brotherhood and as a subject for study recognises no distinction of race or country, and no restriction of regions, to impress upon you the plain duty that is incumbent upon all of us who are possessed of the means and opportunity, as Australasians, to do what is in the power of each of us, be it ever so small, to contribute our mite to the record of geographical knowledge of this our adopted land, either of facts observed, or the result of reasoning on already ascertained data, remembering that geography is a science happily defined as the "Science of Distributions," and as has been already before remarked, sufficiently comprehensive to embrace the study of geology, zoology, botany, climatic and meteorological conditions and phenomena, the commercial and industrial possibilities of a country, and in fact everything affecting the physical condition of the surface of our globe, and thus assist in building up the destiny of what must in the future assume the position of a mighty power, that will prove to be not only a subject of pride to the grand old country from which it has sprung, but which, retaining its veneration and affection for the dear land in whose glorious history and traditions we still claim a birthright, will have the privilege of being to it a source of strength and possible support.

PRESIDENTIAL ADDRESS IN SECTION F.

(Economic and Social Science and Statistics.)

OBSERVATIONS ON CURRENT SOCIAL AND ECONOMIC PROBLEMS.

By ROBERT M. JOHNSTON, F.L.S.

Causes of Existing Poverty and Misery.

It cannot be denied, in spite of the great accumulation of wealth and the increased command over the forces of nature during the present century, that there is still to be found much poverty and distress, especially in large centres of population, and that much of it is due to the unequal distribution of wealth; and whether we may or may not be able to point out a remedy, it is utterly repugnant to the best feelings of human nature to sink into the despair or apathy of many who say, "Let alone; whatever is is best or worst, and cannot be helped." Whatever errors the Socialists and Communists are chargeable with, they must be credited with warm aspirations for the amelioration and improvement of suffering humanity, and are free from the charge of indifference. The latter, however, are too emotional to perceive the great difficulties of the problems which have always engaged the deepest attention of earnest Social Economists, and are too ready to advocate the introduction of their own pet schemes, without having taken sufficient trouble either to test their adequacy, or to fathom the true nature of fundamental difficulties, which would in most cases be made vastly more formidable by the various plans propounded by them for their removal. Thus some, having been misled by the assumption that all our evils are due to individual property right and unequal distribution of wealth, employ all their ingenuity to show that all existing evils are attributable to these, and to these alone.

Yet there are many other influences far more potent for evil, which no scheme yet propounded by Political Economists, Socialists, or Communists may wisely undervalue or ignore. Of such are the following:—

(1.) The superabundant proportions of human beings in existence who, free from restraint, are naturally disposed to be idle, sensuous, and wicked; or who are ignorant, foolish, and improvident.

(2.) The difficulties of supplying other motives more adequate than self-interest in effecting conformity to the necessary social laws and virtues, and as a spur to industry and useful application of powers.

(3.) The inequalities of different habitable portions of the earth as regards productiveness, climate, disease, density of population, and the difference of civilisation and racial characteristics.

(4.) The periodic failure of food supply (famine), whether due to seasonal influence, exhaustion of soil, violence, wilful waste, or improvidence.

(5.) Effectual means for elimination from society of the more pronounced forms of hereditary vice and madness, which, if allowed to persist, would endanger society.

(6.) Absence of facilities for relieving the pressure of population in over-peopled lands by migration.

(7.) Difficulties connected with free exchange of products between different nations whose artisans and labourers are living under different material and social conditions, *e.g.*, slave labour and free labour.

(8.) Difficulties in effecting adequate exchange of products with other nations where, as in England, local foods, products, and the raw materials for manufacture are locally far below the level of requirement of an ever-increasing population.

(9.) The want and misery brought upon the handicapped and practically immobile breadwinner, whose special skill, acquired by slow training during many years, is no longer in demand, either from the sudden or gradual transfer of an industry to a foreign centre, or from the sudden or gradual adoption of a new mode of production rendering his special skill obsolete.

(10.) Misery and want caused to particular divisions of labour by the arbitrary disturbance of the proper relative proportions of the community necessary to fulfil with satisfaction the mutual exchange of service and the necessary supply of the whole round of wants.

(11.) Difficulties and dangers arising from local increase of population, especially when foreign, thinly-populated lands are forcibly closed to emigrants, as in the experience of the Chinese.

(12.) The misery caused by war, strife, murder, accident, painful disease, and preventible forms of death.

(13.) The terrible root difficulty connected with either (1) decrease, (2) stationariness, or (3) rapid increase of population.

(14.) The absolute limits of space requisite for the reception and sustenance of man.

The last two form *the population difficulty ;* in itself the chief cause of human trouble.

Is the Poverty of the Masses a Necessary Concomitant of Increased Accumulation of Wealth in the Aggregate?

All observers are nearly agreed that the accumulation of wealth and wealth-producing power have prodigiously increased within the present century. Of this there can be little doubt. Modern discoveries—as regards the properties of matter, the discovery and development of new lands, the uses of steam, electricity, and labour-saving inventions in every department of social and industrial life—have enormously increased man's power over the forces of nature. With this immense gain of power, vast continents of virgin forest and barren swamp have become gardens of plenty. Rivers, mountains, and other formidable obstacles to communication or distribution of products have been bridged or pierced by railways, roads, and other superior means of distribution; and the wide ocean, connecting far distant lands, now forms the easy and open highway of magnificent steamers, which vie in regularity and speed with the railway train in bringing to local markets daily supplies of the fresh meat, fish, fruit, and cereals of lands many thousand miles away. As a natural consequence, famines such as are known to have been so common and so terrible in England in the immediately preceding centuries are rendered an impossibility.

How is it, then, that we are again brought face to face with the old terrible problems: "The Misery of the Masses," "The Labourer's Struggle for Existence," "The Growth of Poverty," "The Increase of Pauperism and Crime?" If we can judge by the popular literature of the day, the state of the masses in Europe seems to be verging into as hopeless a condition as that which existed prior to the introduction of our vaunted discoveries.

Indeed, one writer, who recently has been heard above all other claimants for reform, confidently affirms that "it is true wealth has been greatly increased, and that the average of comfort, leisure, and refinement has been raised—but these gains are not general. *In them the lowest class do not share.*" He broadly insists that increase in poverty is the constant concomitant of increase in aggregate wealth, and that this constant "association of poverty with progress is the great enigma of our times." Is it true, as this writer confidently affirms, that with all the advantages which man has gained in his increased and increasing command over the forces of nature, our present civilisation has by its customs and provisions barred the effectual distribution of accumulated wealth, and the only effect produced is that of making the rich richer and the poor poorer?

This cannot be answered effectively without some enquiry into that form of wealth which constitutes man's chief satisfactions.

Are these sufficient in the aggregate to suffice for all, if proper means for effecting distribution were employed, supposing such means were possible? Or is the aggregate supply of primary wants insufficient to provide for all needs, even were the most thorough means devised for its distribution?

Wants of Man.

The satisfaction of the wants of man is the mainspring of all his activities. Wants are interminable. Some affect his very existence, while others only concern his greater degree of comfort or happiness. In all enquiries into matters deeply concerning the existence and welfare of man it is well, therefore, to keep these fundamental distinctions clearly in view; for not a few of our misconceptions arise from a failure on the part of social and political economists to establish a satisfactory classification of wants according to their varying importance.

Broadly speaking, these may be divided into three great groups:—

(1.) Wants Essential to Life Itself.
(2.) Wants Essential to Comfort.
(3.) Luxurious Wants.

Whatever eccentricities may be exhibited by isolated individuals at times, it is unmistakable that the intensity of the struggle for wants among communities is determined by the *nature* of the wants; and, invariably, so long as the reason of man is preserved, the greater intensity of the struggle—beginning with the most important—is in the order before given, viz.:—

Wants essential to—

(1.) Life.
(2.) Comfort.
(3.) Luxury.

Man can, and, unfortunately, the masses of men are often obliged to, exist without the enjoyment of luxurious wants. He may even be deprived of all wants beyond the *first* group, and still maintain a more or less extended life-struggle with misery of some kind; but if the wants of the *first group* be ever so little curtailed below a certain minimum, he will speedily perish miserably.

Preserve to man his life, and, if needs be, he will eagerly exchange for its preservation all his comforts and luxuries. Deny him life, and all other forms of the Economist's *wealth of exchange* becomes to him as dross—absolutely valueless. It is for many reasons necessary at this stage to confine attention to those primary wants essential to life itself; and for greater clearness these may be restricted to that minimum of each great want necessary to maintain the life of each person. The exact minimum of these, whatever their form may be, depends upon the energy destroyed by work, and upon the physical condition of the labourer's environment, and may be stated thus:—

The minimum to maintain existence of—

Food.
Shelter.
Rest.

Without a certain minimum of these, man, like all living organisms, must perish inevitably.

Division of Labour—Advantages and Defects.

Division of labour necessary to produce necessary satisfactions, and to distribute them in large civilised communities, undoubtedly ensures greater skill, and prevents unnecessary waste of the aggregate time and energy of the individuals. Were it not for this provision, no country could sustain the life of large numbers. This division of labour, however, rests upon the tacit understanding that energies in other directions than that of actually producing food may constantly be exchanged for food and other primary satisfactions. Individual societies, communities, and nations are alike in this respect; for no matter the skill, time, and labour proffered or applied for or in the production of other than primary satisfactions, it is necessary that they be constantly exchangeable in sufficient amount to obtain at least that minimum of primary needs from other persons or communities, who, under this system, are supposed to produce a sufficient surplus for the satisfaction of all other members of society not immediately engaged in the production of primary wants. Were it not for this understood assurance, the present civilisation—with special centres of manufactures for the world at large, its defined local division of labour and individual rights in large areas of land—would be altogether impossible.

Among the conflicting opinions of Political Economists, Socialists, and Communists, there is at any rate this one fundamental point of agreement, viz., that by a proper division of labour or services the sum total of human satisfactions are greatly superior, and are enjoyed by vastly greater numbers than would be possible to men were each to work in a state of isolation, and each one obliged to attempt to create the whole round of his own requirements. Let us take it for granted, then, that division of services is a necessity; but while so doing, let us bear in mind that the greater satisfaction of wants in the aggregate may be attained, and yet, owing to an imperfect scheme of distribution, a sufficiency, nay, even the minimum of primary satisfaction necessary to maintain life, may fail to reach many; and hence it may appear that much of the idleness, pauperism, crime, misery, and death experienced in crowded centres is due to the defects of distribution.

Let us therefore examine this root difficulty, free from the clouds of irrelevant or less urgent considerations. Division of labour without facilities for exchange may render a unit more helpless in such a scheme than he would be in a savage state. Much ingenuity and ability has been exercised by many writers in showing to us, as Bastiat does, the glorious provisions of one of the so-called social harmonies *(Liberty alias Competition)* in preventing monopoly, and in effecting the distribution of wealth. And it may be at once conceded that human society does reap all the advantages claimed on behalf of competition.

The question, however, is not—Does competition effect much good? That may be readily conceded. But confining attention to the minimum of primary wants alone—Do the combined effects of division of services, competition, and modes of exchange now existing provide for the *preservation of due proportions between the different classes of services*, so as to ensure the production of primary needs in sufficiency for the wants of all; and are the means of exchange sufficiently perfect to secure with more or less certainty a due modicum of primary needs to all. In a word, is the "all for each" as effectively complete as the "each for all?"

If this latter provision be defective—and this unfortunately seems too true—can the defects be removed? And if this be impossible, can the evils be minimised to any extent? All possessors of services must be enabled to secure primary wants, or they perish. References to the wide distribution of wealth in exchange or commercial *value*, or to standard prices or wages—low or high—are utterly misleading. Without the power to acquire, or the actual possession of a due provision of that portion of exchange wealth—not necessarily possessing a high exchange value—the whole aggregate of the remaining part of the world's *wealth in exchange* would be worthless; for it would fail to preserve the life of the man destitute of primary satisfactions. This is the root difficulty; and it is forcibly exemplified in the first notable exchange recorded in sacred history between the typical representative of the hunter of wild animals and the more skilled and peaceful agriculturists:—

> . . . And Esau was a cunning hunter, a man of the field; and Jacob was a plain man dwelling in tents. . . . And Jacob sold pottage: and Esau came from the field and he was faint: And Esau said to Jacob, Feed me, I pray thee, with that same red pottage, for I am faint. . . . And Jacob said, Sell me this day thy birthright. And Esau said, Behold I am at the point to die, and what profit shall this birthright do to me? And Jacob said, Swear to me this day; and he sware unto him: and he sold his birthright unto Jacob. Then Jacob gave Esau bread and pottage of lentiles; and he did eat and drink, and rose up and went his way; thus Esau despised his birthright.—(*Genesis xxv. 27-34.*)

It is fortunate for Esau that he had the power of effecting an exchange, and that, notwithstanding the exorbitancy of the seller's terms, he had no hesitancy in exchanging (or despising, as it is stated) the less needful satisfactions for the more pressing or primary; for in the trial of Job's integrity and fortitude it is affirmed, with truth, that skin for skin, all that a man hath will he give for his life.

Unfortunately for the working-class breadwinner, his only birthright is physical power and manual skill, and although these are all he can offer for his life needs, he cannot always as a competitor effect the necessary exchange; and too often he, and those depending upon him, travel the swift road to beggary and death.

Thus there are still defects, whether remediable or otherwise, in the present civilisation, so long as these fundamental necessities of a power to exchange with primary satisfactions are imperfect, *e.g.*, certain divisions of human kind are not directly engaged in producing primary needs *for themselves.* They are mostly engaged merely in rendering more or less skilled services, in return for tokens (money or other medium) understood to have at least the power of effecting corresponding *definite supplies* of primary wants. But this division has another difficulty.

The actual owner of the power (rich capitalist) to effect the production of things which may be exchanged for a corresponding quantity of primary needs, may in all likelihood be able to effect such exchanges; but the poor capitalist, the possessor of the power of mere services, such as the navvy, the house servant, the blacksmith, may often be unable to exchange his services towards the production of these very things; and under such conditions, as the needful exchange cannot be effected, the unemployed wage-earner in the division of human labour must be supported by drawing upon a more or less limited surplus previously earned; failing that, he must either borrow, take the risk of violent means to secure primary wants, be fed by private or public charity, or die of starvation.

This, then, is the problem of problems of the present day. References to current high rates of wages, the low prices of provisions, or the increasing aggregate value of wealth in exchange, do not always disclose this skeleton in the social cupboard. When the ship of society is barred into many more or less water-tight compartments, the ship itself may not founder, although one or two minor chambers be damaged and waterlogged, and their contents destroyed. If the larger and more important chambers, however, be destroyed, the whole ship may founder, and those who may effect escape may be small indeed. This allegorical picture must not be pressed too hard. It may be sufficient, however, to draw attention to a dangerous side of the division of labour composition of modern society.

But, says the the theorist: True, his services were shut out by over-competition in that particular place or in that particular occupation; but if he only knew at that moment that by transferring his services to other employments, or to the same occupation in another place, the balance of service for service would be adjusted, and the life of himself and his dependants would be saved. Ah, if he only knew! But the possession of knowledge is in itself practically a form of wealth, and that he did not possess any more than he did the necessary capital to acquire the necessary skill in the new occupation calling for services, or in the necessary capital to transfer himself and his household to a great distance where his own special skill was then in demand. We may therefore summarise the difficulties lying at the root of all social problems as follows:—

(1.) All breadwinners and their families, to maintain existence, must possess primary satisfactions, whether they can effect exchange of services or not.

(2.) Many breadwinners, whether due to lack of knowledge or inability to change their occupations or locality, cannot obtain employment, and therefore cannot effect exchange.

(3) Such of the latter as by former misfortunes have been deprived of every form of wealth in exchange, must beg or steal from public or private resources, or die of starvation.

Thus it is shown that one of the great economic harmonies in *competition*, while it effects much good in distributing wealth and breaking down monopolies and privileges, and in enlarging the domain of community in the enjoyment of the gratuitous products of nature and invention, also, as one of the mills of God, directs its force terribly on the mere monopolists of bone and muscle; competition grinding them smaller and smaller as its force is augmented by increasing numbers.

Further Difficulties Connected With the Division of Labour—Allocation.

One of the most formidable difficulties connected with the division of labour is *allocation;* for it is evident that if, in the technical training of the young, due regard be not paid to the chances of finding employment in the service to which the future breadwinner aspires, disaster or a disappointed life may be the result. This, being a relative matter, applies to a small community as well as to a large one. Few take into consideration that there is a natural law in operation which as surely determines the numbers required for each great class of employment as do the natural laws which locally determine the times and relative heights of the tide. No social advancement by means of the higher education of the people can ever alter the relative numbers of the various branches of human service; and should it be thought possible that the education of the masses exerts any influence in the nature of its training in disturbing the necessary proportions of each great group of services upon which our lives and our civilisation depends, it would certainly prove that the general spread of higher education was a curse and not a blessing.

Services would never become a marketable commodity of value in exchange if it were not for wants. Kinds of services, therefore, must be exactly proportionate to kinds of wants. The wants which demand the expenditure of the greater amount of labour must necessarily absorb the greater amount of persons requiring employment, without regard to their capacities, attainments, or personal desires; and, so far as the mass of human beings are concerned, there is no choice.

The great wants—food, clothing, and shelter—are by far the greatest factors in the determination of the aggregate numbers that must be employed if the wants are to be satisfied. The same three great wants also determine the necessary amount and proportions of capital, machinery, and land to be employed, together with the necessary proportion of labourers for each kind of occupation which, directly or indirectly, is somehow utilised in the production of the said three great wants.

It is true the strict average proportions of the various classes of labour machinery may not be found to be quite the same in each country; but this does not affect the aggregate of all countries. It is not absolutely necessary that the manufactures and agricultural industries of any one country should preserve the world's strict average proportions to each other, so far as that one country is concerned, so long as it is free to make necessary exchanges with other countries for disposing or making good their respective local surpluses and deficiencies. Nevertheless, countries confined to the production of satisfactions for their own wants, or, what is the same, the world as a whole, must preserve the strict average proportion and quantity of labour and machinery in the production of satisfactions for those three great wants which are the mainsprings of all human activities and efforts. It is necessary, therefore, to make a very wide net to obtain approximate information with respect to the amount and due proportions of all kinds of services employed in the production of the whole round of wants of each country. It is unfortunate that figures relating to the occupations of all countries are not accessible; but reference to the ascertained occupations of Australasia, United States of America, British India, and seven principal States of Europe, embracing 433 millions of people, and representing all climes and all forms of industry, afford a basis wide enough to secure fairly accurate information.

The figures contained in the following table of classified occupation of these countries afford valuable information with regard to the definite proportions of the division of labour engaged in the production of supply of human wants :—

PROPORTIONAL CLASSIFICATION OF THE OCCUPATIONS OF ALL PERSONS ENGAGED IN THE SUPPLY OF HUMAN WANTS :—

COUNTRY.	Population last Census (1=1000)	Breadwinners (Percentage).									Dependants (Percentage).			All.	Persons supported by each Breadwinner.
		1	2	3	4	5	1-5	6	7	6-7	8	9	8-9	1-9	
		Professional.	Domestic.	Commercial.	Industrial.	Agricultural.	Total of Group.	Property, Rank.	Others.	Total of Group.	Wives, Children, Scholars.	Paupers, Criminals.	Total.	All.	No.
England, Wales ...	26,094	2·4	6·9	3·7	24·5	5·3	42·8	...	...	...	...	...	...	100	2·29
Scotland	3,735	2·6	4·7	3·5	24·4	7·0	42·2	...	...	...	...	...	...	100	2·33
Ireland	5,174	3·8	8·2	1·4	13·3	19·0	45·7	...	...	...	...	...	...	100	2·15
United Kingdom ...	35,003	2·7	7·0	3·3	23·0	7·5	43·5	...	...	...	...	...	...	100	2·25
Six Colonies of Australasia :—															
Victoria	862	1·6	4·5	4·1	18·8	14·5	43·5	0·2	0·6	0·8	54·5	1·2	55·7	100	2·24
Queensland ...	213	1·4	5·0	5·1	18·3	15·7	45·5	0·1	0·6	0·7	52·8	1·0	53·8	100	2·16
South Australia ...	280	1·4	4·1	4·8	16·5	12·6	39·4	0·3	0·7	1·0	58·9	0·7	59·6	100	2·47
Western Australia	30	1·6	3·9	5·1	12·6	16·1	39·3	0·3	1·6	1·9	56·2	2·6	58·8	100	2·43
Tasmania	116	1·5	4·6	3·4	16·5	16·9	42·9	0·5	0·6	1·1	55·5	0·5	56·0	100	2·27
New Zealand ...	490	1·5	4·1	4·3	16·8	11·2	37·9	0·1	0·6	0·7	60·7	0·7	61·4	100	2·56
Total of six Colonies of Australasia.	1,991	1·5	4·4	4·4	17·7	13·7	41·7	0·2	0·6	0·8	56·6	0·9	57·5	100	2·35
United States ...	50,155	1·8	6·3	3·6	7·6	15·3	34·6	...	...	...	...	...	...	...	2·83
Prussia	27,279	2·1	3·2	3·3	13·0	17·0	38·6	...	...	...	...	...	...	...	2·54
France	37,321	1·8	6·3	4·2	12·0	18·0	42·3	...	...	...	...	...	...	...	2·32
Austria	22,144	1·9	4·0	2·0	10·0	28·0	45·9	...	...	...	...	...	...	...	2·14
Belgium	5,520	3·0	9·0	4·4	17·2	14·6	48 2	...	...	...	...	...	...	...	2·04
India	253,891	1·3	1·1	1·4	14·6	28·0	46·2	...	...	...	...	...	...	...	2·13
TOTALS ...	433,304	1·6	3·0	2·3	13·3	23·2	43·4	...	...	...	...	...	...	...	2·26

From this table we learn that all people are divided into two important groups, viz., breadwinners, representing about 44·2 per cent. of all persons, and non-breadwinners or dependants, composed mainly of wives and children, representing 55·8 per cent. of the total populations. Thus it appears that the wants of all must be provided by the service of less than half the total number of those who consume wants. The proportions of the breadwinners necessary to effect this service are as follows. That is to say, for every 100 persons engaged in services of exchange value there must be on the aggregate the following proportions nearly :—

PERCENTAGE PROPORTION.

Agricultural and Pastoral services	52·5
Industrial services	30·1
Domestic services...	6·8
Commercial services	5·2
Professional and other undefined services	5·4
Total	100·0

It will be seen that the simple services of the agriculturist and herdsman are by far the most important (52·5 per cent.), and that the next in importance are the industrial services, embracing all artisans and labourers, representing 30·1 per cent. The higher skilled workmen of this group only represent about 11 per cent. of all services. As the balance of services—commercial and professional—only amount to 10·6 per cent., it follows that of all services required only 21·6 *per cent. demand skill of a higher order ;* and that 78·4 per cent. represent agricultural and other labourers and domestic servants, in respect of which skill of a high order is not absolutely requisite.

It is largely due to the flooding of particular kinds of employment beyond the strict proportions which local wants demand that inconvenience or distress is felt in young as well as old countries. The numbers which can find entry into the higher industrial, the commercial, and professional divisions cannot, without unhealthy competition, be increased beyond the relative proportions which these divisions must bear to the producing industries of the particular country ; and these dominating industries in Australasia are agricultural, pastoral, and mining. Employment in other divisions can only follow substantial increases in the three industries named ; for manufacturing industries cannot alter their present proportions independently, as in England, until such time as they are able to manufacture for the markets of other countries than the local one. This applies much more strongly to the smaller division represented by unskilled labour (not agricultural), and by the commercial and professional classes. These certainly may only increase according to their rigid proportion ; and this must be determined by a previous increase in the fundamental producing industries of the particular place.

The principal producing industries of the place may increase irrespective of other local divisions (*i.e.*, agricultural, pastoral, and mining), as their products may find the necessary consumer in foreign markets. Whatever influence, therefore, may bar the progress of the dominating producing industries of the place *must also bar occupations in all other divisions of services.*

It is clear from what has been stated that applicants for a given kind of employment may often fail, not because there is no room for more labour, but because the *direction* in which the applicants have been trained, or in which they desire to be employed, is out of harmony with the natural or local proportions of that particular service necessary in the production of general satisfactions.

From this cause arises much difficulty and distress. It largely adds to the proportion of *dependants*, and consequently the direct or indirect strain (*i.e.*, support of friends, relatives, private and public charities) upon the actual breadwinners becomes oppressive. I do not here touch upon artificial aids to local production in its effects upon the alteration or disturbance of the relative proportions of the division of services upon which such aid must have an immediate effect, further than to remark that if the aid by tariff duties or other means enables the local division at once to cover the ground formerly supplied by foreign industry, it can only do so either by increasing the machinery or the relative proportion of numbers employed locally in the division of service affected. The advantage or disadvantage of adopting such a policy is hereafter discussed. It is sufficient for the present purpose to show the possible effect it may exert upon local *employment* alone.

Satisfaction of Wants and Theory of Obstacles Considered.

Human satisfactions are enjoyed to the fullest extent with the smallest expenditure of time and human energy in regions where the natural sources of human satisfactions are vast and rich, and under conditions where the fewest obstacles intervene between actual producers and actual consumers. Extra time and labour, often necessarily spent in *mere distribution*, are in themselves *obstacles*, and directly tend to lessen the quota of satisfactions which might be enjoyed by each individual. All conditions, therefore, which necessitate the larger expenditure of time and labour (such as extreme distance between the several kinds of producers and manufacturers), as well as conditions which necessitate extra provision against loss or waste of satisfactions produced or being produced (such as dangers from loss by storms, inundations, fire, waste by war, civil strife, robbery, depredations by wild animals, idle and useless dependants, plagues of parasites, disease, etc.), curtail of necessity the amount of necessary satisfaction which otherwise might be enjoyed by each useful human unit. Obstacles, therefore, greatly reduce the amount of human satisfactions so far as each individual is concerned, although in the aggregate this is not so easily comprehended. Lowness of nominal prices is not a correct index of conditions most favourable for the attainment of the greatest amount of satisfactions with the smallest expenditure of time and human energy: for it often happens that low prices may be caused by *excessive expenditure* of human energy forced upon a struggling producer, or by poverty due to forced idleness on the part of a large body of consumers. While it may often happen—as in young colonies—that a high price is no index of a lower supply of satisfactions, but rather of the smaller amount of obstacles intervening between consumer and producer, and gratuitous sources of nature, the smaller amount of enforced idleness on the part of consumer giving him a greater purchasing power; and the greater advantage of the producer, due to similar causes, enabling him to obtain all the most necessary round of satisfactions with a smaller expenditure of time and labour. Mere cheapness of satisfactions, therefore, is not a reliable index of individual welfare. Purchasing power, as indicated by expenditure of time and labour, is the only true index as between countries differently circumstanced, and this purchasing power of the consumer—unlike the unreliable *nominal cost or wage*—is always in harmony with the amount of obstacles intervening between the actual producers of satisfactions and the actual consumers.

This method of determining the condition of different communities will be better understood if we carefully investigate the effect of obstacles more closely. As the factors are variable and numerous, the only way to arrive at true conclusions is to approach the question by the mathematical method: thus:—

Let N = Natural agents and products; or the gratuitous forces of nature.

P = Productive power of human agencies, including skill and energy, and skilled appliances.

O = Obstacles intervening between NP, or producer and consumers.

C = Producers, dependants, distributors, etc., representing the living population; or consumers.

Then $\frac{NP - O}{C}$ = Represents the amount of the average satisfactions provided for each individual.

And $\frac{NP+O}{C}$ = Represents the nominal cost of satisfactions for each individual on the average—or it may fairly represent the amount of exertion or energy expended by human energy.

Having stated the general effect of obstacles between direct producer and consumer as minimising the actual supply of necessary satisfactions to each consumer where the values of N and P and C are constant, it follows inevitably that the amount of satisfactions to each individual is in direct correspondence to the amount of O; increasing with its decrease, and decreasing with its increase.

The effect upon *price*, however, is exactly the reverse of this, as a *definite amount of satisfactions increase* in price in correspondence with the increase in obstacles (O), and decrease correspondingly with its decrease.

This law is not invalidated because in particular cases (1) price is comparatively low when O is absolutely great, and conversely (2), price is comparatively low when O is absolutely small; for in every such case there must be corresponding dissimilarity in the other elements to explain this effect, *i.e.* :—

The effect (1) could only happen in cases where either N or P is abnormally or relatively great, or C is comparatively small; and similarly the effect (2) could only happen in cases where either N or P is abnormally or relatively small or C is comparatively great.

The failure to grasp these fundamental considerations is the chief cause of the blunders in all reasonings connected with questions related to the policy of different nations in respect of artificial restrictions, hindrances, or facilities in the interchange of foreign products.

To make this matter more clear, it may be advantageous in demonstration to set forth a number of examples for the sake of illustrating the important truths involved in the effects produced where one or all the factors are different in value :—

(1.) Where soil, climate, or natural utilities are particularly advantageous, the value of N is at its best or maximum $= N^m$

(2.) Where skill and energy exist, and are employed to the best advantage, the largest results are attained for $P = P^m$

(3.) Where the smallest number of obstacles occur between NP and C, the largest amount of satisfactions fall to the share of $C = C^m$

(4.) The most perfect conditions favourable for effecting the highest amount of satisfactions to each individual consumer coincide with $\frac{N^m\ P^m\ - O^n}{C}$

Or,

If we separate P^m into labourers (L) and instruments (1), the fruit of former efforts, saved from previous consumption, and devoted by inventive skill and energy to more or less permanent aids to L, we have a more perfect statement of (4) thus :—

$$\text{(A)} \quad S^m = \frac{N^m (L^n I^m) - O^n}{C^n}$$ = The ideally best conditions for the attainment of the highest satisfactions of human wants with the least expenditure of human energy.

Or greatest quota of satisfactions

Understanding by *m* and *n* the indices of the *maximum* and *minimum* of the various conditions, then it would logically follow that the converse or worst possible conditions for attaining the necessary satisfactions of human wants, involving also the greatest expenditure of human energy, would be when the equation becomes

$$\text{(B)} \qquad \frac{N^n (L^m I^n) - O^m}{C^m} = S$$

This being so, it also follows that this stage will be coincident with conditions which favour the maximum of cost for each satisfaction, thus :—

$$\frac{N^n (L^m I^n) + O^m}{C^m} = P$$

Similarly, the conditions favourable to the attainment of minimum of lowest cost or price (P^n) would coincide with stage A, thus :—

$$\frac{N^m (L^n I^m) + O^n}{C^n} = P^n$$

Reasoning from these premises, it is clear that the results S and P, or their values, can never be satisfactorily known, unless we can gauge the values of their respective co-efficients. That is, we must know not merely what is the tendency of any one factor, but we must also know the tendency of all factors affecting the problem. Nay, more, if Political Economy is ever to be dignified by the name of "The *Science* of Political Economy," it must not merely take cognisance of the tendency of every one of these factors, but, like the skilled physicist, its disciples must not talk of the "teachings" "or conclusions" drawn from them until they are prepared to place approximate values against the tendency of each factor, and then to strike a balance showing the ultimate effects of the ever-varying combinations in ever-varying localities.

The difficulty of the problem is no excuse for ignoring the necessity for the adoption of this course. Hitherto, to a great extent, the subject has been governed by the more or less plausible generalisations of mere literary men; and their deserved fame and undoubted ability and skill as such have given them a prestige in political matters to which they are not entitled from a practical or scientific point of view. That they have done good service in arousing and sustaining attention on such important matters is readily admitted; but further progress is impossible so long as the inexact methods of the mere literary athlete are employed. In future the progress of Political Economy as a science depends upon demonstrations based upon quantitative analysis, and not as heretofore upon authoritative dogmas based upon the qualitative analysis of any *one* factor of the problem arbitrarily chosen from a compound or complex equation.

It is obvious that we may concur with most of the writers on Political Economy as to the general tendency of any one influence; but while this is so, it may not be a safe proceeding to trust the effect of this one tendency—even admitting its importance—as determining the ultimate conclusion; for other tendencies, minus or plus, must be reckoned with before any reliable conclusion can be arrived at. Pathos and literary merit are powerful adjuncts, no doubt, but in the solution of political problems they are worse than useless where complete and exact methods are eschewed.

The Best Mode for Effecting the Highest Quota of Satisfactions with a Minimum of Trouble Depends upon the Local Value and Extent of Natural Sources of Supply.

The principal material satisfactions essential to the happiness and cultured content of human life primarily depend upon natural sources of supply, and that country whose natural sources afford the greatest potential of elements which may be made to contribute to the material satisfactions of cultured men, is also the country wherein the greatest number of people may best fulfil all those mutual services to each other which cover the whole round of wants of an ideally happy community. The essential natural conditions for the sustenance of a highly-cultured community, and permitting a natural, healthy expansion, are:—

(1.) Large area covering all zones of climate favourable for the production of all reasonable wants, and possessing richly all the elements essential to production, such as water, fertile soil, the varied mineral and vegetable products, and such flocks and herds as most contribute to the welfare of man.

(2.) Division of labour—each division carefully apportioned in relation to the probable amount of different satisfactions required; and each labourer in every division carefully trained in that branch of work to which he has been apportioned.

(3. The creation and maintenance of instruments which best supplement man's efforts in modifying and distributing the products derived from natural sources, and so enabling each unit to enjoy the maximum of desirable satisfaction with that minimum of exertion which is most conducive to the health and happiness of the individual.

Now, if it were possible to find such a combination of favourable conditions, wherein all the wants of man could be completely met, it follows that interchange with other countries, so far as material needs are concerned, would not only be unnecessary but *disadvantageous.*

It is true, on moral grounds, a nation enjoying the maximum of satisfactions with a minimum of exertion or maximum of ease might either reduce the amount of satisfactions or increase its exertions for purposes of benevolence as directed towards a country less favourably situated; but there would be no such necessity on commercial grounds as laid down by the earlier economists, except upon the plea that we should buy in the cheapest market. But this last plea, the favourite maxim of Free Trade theorists, ignores many consequences of the most vital importance.

First, the ideal state contemplated had already discovered and achieved that final state of content or *end* to which a people can aspire to—that is, a maximum of desirable satisfactions combined with a minimum of reasonable exertion. This being so, why should they attempt to procure this end by another *method* untried by them, seeing that they could not improve their condition in this way, but might make it worse. But as this plea must be discussed, let us see under such circumstances what it might lead to.

Buy in the Cheapest Market.

In our ideally perfect state, let us for convenient reference call it "Euphrasia," one of the fundamental conditions regulating its well-being is, that all for each is considered of as great if not greater importance as each for all.

The favourable natural conditions were experienced to be such that the round of wants of all might be satisfactorily supplied without demanding from any one group of its divisions of labour more than forty-four hours of public labour per week. But it was also carefully determined that although a certain aggregate of labour when properly directed would affect this desirable end, a corresponding or even a much greater amount of labour could not produce the same result if the previously carefully arranged and periodical regulation of the apportionment of labourers were subsequently disturbed in an arbitrary way. Every arbitrary disturbance of the proportion of labourers trained and originally apportioned to a special work or function has the effect of lowering the purchasing power of the section which was arbitrarily increased, because it introduced either curtailment of employment, wrongful competition, over-production, or diminished purchasing power within that particular section of the division of labour; and in the section from which they were arbitrarily withdrawn, it either lessened the amount of aggregate satisfactions required for all, or, if it have not that effect, it increases the hours of labour of those within the division beyond the maximum standard, without additional recompense for increased exertion. If, however, the additional hours are rewarded by extra satisfactions, it must be at the expense of the general consumers, thus lessening their average of aggregate satisfactions.

The wrongful over-production is a direct loss to the whole community so healthfully regulated by community of interests.

Oh, but your ideal Euphrasian forgets, says the Economist, that the surplus of A division might by interchange with another nation be made to restore the balance thus arbitrarily destroyed by A recompensing through products needed in division B where a deficiency was caused. This is true, but at best this course only helps to restore the loss occasioned by the arbitrary disturbance of the apportionment of the local Euphrasian division of services. Nay, more, the loss occasioned could not be fully restored by *an equal exchange of labour and skill*, for the exchange with the distant foreign country involved a fresh expenditure of labour in transfer and agencies of exchange—thus increasing the value of O or obstacles—between producer and consumer, and so inevitably lessening the quota of the essential material satisfactions to be divided among consumers. It must be borne in mind that Euphrasia is assumed to possess the maximum of favourable natural resources—plus best art appliances—and, consequently, the restoration of the destroyed equilibrium in Euphrasia could only be effected by a skilled people, who of necessity were forced to adapt themselves to circumstances by either being satisfied with a lower requirement of wants than that enjoyed by the Euphrasians, or by a similar standard of material satisfactions gained at a much greater expenditure of labour.

For the sake of illustration, let us further examine this theory of obstacles. It will readily be granted that where two producing centres are situated at vastly different distances from consuming centres, that supply from the nearer producing centre can be effected by a much smaller expenditure of labour than by the more distant centre of production.

Thus, if A be 8000 miles distant, and B 40 miles, it follows that the extra labour and time consumed in carrying the extra 7960 miles is a serious disadvantage. Men do not consume distance. In itself it does not add a jot to the ultimate material wants of man otherwise produced. Distribution is certainly a necessity, but the smaller the need for distribution the larger the produce to be divided, for it is obvious that the more machines and human beings that are abstracted from direct production of essential satisfactions, the smaller is the quantity falling to the share of each consumer of wants. Thus, if 100 producers and 50 distributors provide the ideal quota of wants of an Euphrasian at the maximum of eight hours per day—say 10 wants per day—then the 100 producers must each have produced 15 wants, for consumers include producers and non-producers, or producers and distributors, and these number 150, and

$$\frac{100 \times 15}{150} = 10$$

for each consumer, or, on the basis of exertion which lies at the root of price or cost, we might put it that for the aggregate hours of labour in producing and distributing each consumer was put in the possession of 10 wants. Now, if we increase obstacles, we cannot supply the same number of wants without individually increasing the hours of labour. Thus, if the additional distance involves the labour of 50 additional distributors, and if producer and consumer alike share the additional labour thrown upon them, we have

$$\frac{200 \times 8}{150} = 10{\cdot}66$$

Thus, to maintain the same share of wants as formerly, the necessary increase of 50 non-producers or distributors involved fully an extra two hours labour per day, or 25 per cent. extra exertion on the part of all breadwinners. In like manner it may be shown, if the amount of exertions per individual remain undisturbed, then the amount of wants formerly supplied to each consumer must be lessened, thus:—

$$\frac{150 \times 10}{200} = 7{\cdot}5 \text{ wants per consumer}$$

Thus we have with the increased obstacles a diminution in the satisfaction of wants equivalent to a reduction of 25 per cent.

In these simple illustrations the direct effects of increased obstacles between producer and consumer are set forth in plain terms, so far as interchange with a distant country affects the conditions of a country circumstanced like our ideal Euphrasia. To apply the argument involving obstacles to other countries not so favourably conditioned as Euphrasia might favour the adoption of interchange between two or more distant countries, as effecting improvement in the condition of consumers in each country; but this improvement could only reach the highest possible quota for such a place where the exchanges are confined to the necessary products, which are either naturally easily produced beyond local needs, or in respect of products which are naturally deficient within its own border. In such case, the exchange of the former by exports would have to be met with a similar value of imports of the latter. But even here the disadvantageous effects of obstacles are not a whit lessened. The disadvantageous effects of obstacles have to be endured so long as they do not outweigh the advantages of the desired exchanges.

Nay, there is one form of want—Food—which no obstacle can outweigh so long as the energies of the labourer in other directions remain unexhausted. The unfortunate country so circumstanced must of necessity effect exchanges with food conntries, or perish as a community. Still more terrible is it for the masses of this country if it should happen that it lacks the natural or raw products upon whose manufacture the exchanges for the food of other countries depends.

In such a case the friction of obstacles (distance) between (1) producer of raw products (2), manufacturer, and (3), consumer, attains its maximum, notwithstanding that science and skill may have done, and are still doing, wonders by steam and other contrivances on sea and land to minimise its lowering influence on the amount of satisfactions proportionate to labour exerted.

The Economist may here exclaim: How does the Euphrasian argument from obstacles reconcile itself with such a case as the United Kingdom. He will no doubt proceed to show that no nation on earth has carried the method of interchange with other countries to so high a pitch as the United Kingdom. Her vessels are found laden with the products of exchange in every important harbour of every country.

Her aggregate wealth is the envy of nations, amounting to a sum something approaching £1,300,000,000 as a yearly income. Her external interchange trade amounts to 643 millions yearly, 362 millions being imports and 281 millions being exports. Her annual value of real estate alone reaches £196,000,000. Surely, he would continue confidently, this is the most complete vindication that could be given practically that the nation which has the greatest amount of foreign interchange trade and, presumably, the greatest amount of obstacles, is also the nation which, by her great wealth, affords the greatest amount of satisfactions to divide among her consumers.

The answer to this supposed objection certainly involves many complex questions, but it may at once be affirmed that it does not in the slightest degree diminish the value of the argument from obstacles as applied to Euphrasia. In making this affirmation, it is not denied that the wealth of the United Kingdom in *the* *aggregate* is unbounded, and no one can reflect upon her grand achievements in science, wealth, and progress without admiration and pride. The skill and energy of her people are marvellous, and our admiration is not lessened, but increased, by the thought that her vast resources and enormous interchange of trade have been built up by her prodigious energy and industry in *spite of obstacles of every kind.* Her skill, daring, and enterprise have given her the command of important lands under every clime. This skill and enterprise, however, could not within her own borders increase, beyond a certain limit, the necessary supplies to meet her rapidly growing needs, as regards food and clothing for her people and raw products to supplement her needs for supplying manufactures in exchange for prime necessaries, failing which she could not support the lives of her people. It is necessity, therefore, which inevitably forced her to direct her industries in such a manner that her lack in food and other raw products at home should be purchased by a surplus creation of manufactures. Food, being one of the prime essentials to the life of each person, must be secured in sufficient quantity, or the lives of her workers cannot be sustained. A nation possessed of all other forms of the world's wealth of exchange could not preserve the lives of her people if this one form of wealth—Food—be lacking or insufficient. With such a nation—so unfavourably conditioned—her existence depends upon her power to command supplies of the food of other countries in exchange for such products as food-producing countries may think it desirable to take from her.

The food-producing countries may carry on this exchange as a matter of choice or preference; but with the food-requiring country the exchange must be effected—on the best terms possible—but if necessity presses hard, *it must be effected upon any terms forced upon her.*

Fortunately for such a country, all lands capable of producing large food supplies are not in the condition of our ideal Euphrasia, and hence there is little danger of a stoppage of food exchanges for manufactures so long as the food-producing country is tempted by cheapness to buy those of the food-lacking country in preference to making them for herself, or of buying them from a rival manufacturing country on *still* more advantageous terms.

Free Trade.

A food-lacking country must therefore favour free interchange of trade, for it is necessary to her existence. A country with ample natural sources unutilised or partly utilised would only suffer a *temporary inconvenience* by the cessation of imports of foreign manufactures, and it is possible that this inconvenience, which forced her to supply her own wants from sources and agencies within her own borders, might result in increasing the amount of satisfactions for each consumer with an expenditure of a smaller amount of exertion on the part of each producer and distributor.

Aggregate Wealth and Individual Wealth.

But let us again return to the outward indices of the prosperity of the United Kingdom. Admitting that she has great wealth in the aggregate, it does not necessarily follow that the share of satisfactions falling to the bulk of her people compares favourably with countries whose aggregate wealth is comparatively small. In point of fact, any aggregate respecting the wealth of a country is a pure abstraction. It is as such enjoyed by no one. It is the share falling on the average to each individual which is the true indication of real wealth, or of the satisfactions enjoyed by the unit.

This is significantly demonstrated by contrasting two widely differing countries in respeot of that abstract idea called national wealth :—

	Tasmania.	United Kingdom.
Area	16,778,000	... 77,800,000
Ditto per head of population ...	114·13	... 2·05
Aggregate earnings of wages class	5,519,340	... 800,084,000
Working class breadwinners, estimated	61,326	... 15,884,000
Wages ditto per head per year ...	£90	... £51
Average hours employed per week	44	... 55
Wages per head per week	34s. 6d.	... 19s. 3d.
Average wages per head per hour	9·⁴⁰d.	... 4·²⁰d.
Average cost of one quarter of wheat	32s. 6d.	... 32s. 6d.
Equivalent of ditto in true purchasing power, viz., *hours' labour*	41·⁵ hours	... 92·⁹ hours

Thus it will be seen that, notwithstanding the imposing effect of the vast aggregate wealth of labour in England, representing over eight hundred million pounds sterling, the purchase of one quarter of wheat—the staff of life—demands of her workmen the expenditure of 92·⁹ hours' time in labour, whereas in Tasmania the same amount of satisfactions can be gained by the expenditure of 41·⁵ hours of labour ; that is, the English workman would have to work, if work could be placed at his disposal (in itself a greater difficulty), 123 per cent. more hours to attain the same purchasing power possessed by the Tasmanian workman, whose *aggregate wealth* only represents 0·69 per cent. of the corresponding *aggregate* in England.

This clearly proves how misleading are the effects produced by allowing the mind to dwell upon mere abstractions based upon aggregates

The Effect of Strikes or a Rise in Wages in Food-Producing and Food-Lacking Countries.

But the difference in the purchasing power of the English breadwinner is not the only disadvantage. Her purchasing power is also not merely limited by the extent of the market for her manufactures, but upon her success in underselling foreign rivals who are also by necessity compelled to exchange manufactures for the prime necessaries of raw products of food and clothing; and hence her success depends either upon her superiority in skill and local appliances, or in cheapness or extending the hours of labour. It is a necessity that a manufacturing country must produce cheaply, and necessity will force her to attain this end by extending the hours of the labourer without extra recompense, should other means fail her as a competitor for the bread and raw products of food-producing countries. Strikes and combinations among workmen are only of value to them within very narrow limits. For let us suppose that England's supremacy as a manufacturing country depends upon her present power to undersell rival countries to the extent of 15 per cent., it would then follow that any *nominal success* attained by the combined strikes of her workmen, thereby improving their hours of labour or rates of wages to the extent of, say, 16 to 20 per cent. would be altogether disastrous, for it would destroy the competitive power of England as a manufacturer for other countries than her own. But if England was thus shut within herself there would probably be no employment whatever, and no means of subsistence for perhaps 20 millions of her present population of 38 millions. This would be a terrible result arising out of the success of combined strikes among her manufacturing workmen.

That an increase of the cost of her products to the extent of what has been indicated is not a very improbable matter springing from strikes has been foreshadowed by the recent combination among English dock labourers, who succeeded in having their rate of wages raised 2d. per hour. As the average rate of workmen in England is only $4{\cdot}^{20}$d. per hour, a general increase of 1½d. per hour would raise the cost of wages $35{\cdot}^{7}$ per cent.; and as the price of labour is the chief item of cost in all manufactures, it is not improbable that the ultimate cost of her manufactures would be raised 20 per cent., thus cutting her off from her previous advantage, which enabled her successfully to outrival all other countries in supplying the external markets of the world with manufactures.

In countries where food and raw products are or can be produced far in excess of local requirements, the effect of prohibitive tariffs in raising local prices would not have a similar effect. If the cost of living would be *nominally raised* thereby, it would be exactly or nearly counterbalanced by a *nominal increase in earnings locally.* Thus, for example, if the consumer had to pay 20 per cent. extra for all articles of consumption, it is probable that even this would not be disadvantageous; for it is almost certain that the true purchasing powers of labour—relative to staff of life—would be very little altered, as the *price of labour* would also tend to approach an increase of 20 per cent.

But there is one effect which this would have upon a food-producing country, which would show a decided contrast with a similar rise of wages in a manufacturing country such as England, viz., it would draw to the former the manufacturing labourers of manufacturing or densely-peopled centres; for instead of cutting off sources of employment, as in England, it would of necessity require her to import *labourers* to produce those wants locally, or a great portion of them, which formerly had been supplied to her by the manufactures of *external* labour. That is, broadly, its main effect would be to increase the local *labour market* or widen the field for the employment of local labour. At first this would also have the effect of diminishing the aggregate extent of *external commerce;* but it need hardly be discussed, all things being fairly equal as regards natural sources, that the supply of exchanges by home products, instead of by foreign, is all in favour of diminution of *obstacles*, and therefore, upon the whole, advantageous. . . . This problem has already been worked out in the United States of America, and whatever the ultimate effects may be when local population approaches too close to her limits of natural powers for producing *food and necessary raw materials* for her own people, it is undoubted that 60 *millions* would not be profitably employed and well supported if it were not for her policy of favouring the creation of her own wants as far as possible by the energies of *local labourers.*

It must be granted, however, that the policy which is advantageous to a rich food and raw-producing country, such as America, would be annihilation to a country such as England, where the population by far exceeds her natural sources of supply as regards food and other essential raw products.

A country so circumstanced must maintain a Free Trade policy or perish. With countries thinly populated, possessing illimitable sources of natural wealth, including soil, climate, and all conditions favourable for the production of food and raw products in excess of local wants, it must inevitably follow that the tendencies and influences arising from the desire to extend the *local field of employment* must be in the direction of *Protection*, or restrictions upon foreign trade. It is the conditions of the various countries which determine *means* to ends. In one country the *means* is Protection, in the other Free Trade; but the *end* in both cases is the same, viz., *the best available mode of supplying the greatest amount of satisfactions to each individual (including local* *employment to the rising generation) with the least expenditure of individual effort.*

If Mr. Henry M. Hoyt, who has so ably defended the American policy of Protection, had premised that he was referring solely to countries rich in all natural sources—far surpassing the demands of all possible local requirements—we might agree with his ideal as regards the policy to be pursued, viz:—"The nearer we come to organising and conducting our *competing industries*, as if we were the only nation on the planet, the more we shall make, and the more we shall divide among the makers. Let us, at least, enter upon all the industries authorised by the nature of *our* things. Thus we shall reach the greatest annual product of the industry of the society."

When, however, any country's population fails or is unable to cultivate 2·81 acres per head within her own borders, the policy suggested by Mr. Hoyt must of necessity be abandoned in favour of Free Trade. This necessity—involving the population difficulty—is, however, an evil, and not an advantage to the masses.

Natural Limits to the Numbers Engaged in various Occupations.

Most writers on social problems tacitly assume that no other considerations than those of Supply and Demand, or Competition and Remuneration, need be taken into account when questions relating to the numbers that may be employed in the various branches of human industry are concerned. Indeed, so able an exponent of the principles of Political Economy as Mr. Henry Sidgwick assumes with confidence that the adjustment of the apportionment of the employed in the various divisions of industry is sufficiently determined by "rates of remuneration." He states (p. 182, *Principles of Political Economy*)—"We assume that labour and capital are *mobile*, or capable of being attracted by a higher rate of remuneration both from district to district and from industry to industry, so that not merely are the wages paid for the same quality in any one industry approximately the same, but also, when the remuneration of labourers or capitalists in any industry is known to be higher than that of labourer or capitalist in some other industry entailing no more sacrifice or outlay and requiring no scarcer qualifications, the difference tends to be gradually reduced by the attractions which this higher remuneration exercises on actual or prospective labourers or employers."

There is not the faintest recognition here of natural limits to or absolute necessity for employment in a given direction, irrespective of the aggregate intensity of energies expended or market rates and prices. Neither does he recognise the universal truth in matters animate and inanimate that mobility or movement in a new direction requires a fresh expenditure of force commensurate with the nature of the subject, the time occupied in transition, and the friction to be overcome, due to inertia or foreign resisting media. A physicist would never dream of discussing the mobility of material substances in such a loose way. He would first consider the mass or weight of the substance, the distance and direction of movement, the rate of movement and time, and the friction due to inertia or existing diversity of movement, and from these he would compute the fresh demand upon energy or force to execute the desired movement.

Because the Political Economist does not think, or does not choose to think, that the transfer of a labourer or capitalist to a new place or to a new kind of occupation involves a process analogous to the movement of inanimate bodies, it is not the less true. Take the case of a shoemaker reduced to a state of idleness, or partial idleness, by competition among excessive numbers, or some other cause locally or generally. We will suppose that this workman has a family of five persons, including himself, to provide for, in addition to his quota of expenditure required for State purposes, such as General Government, Law, and Protection, including Gaols, Military and Naval Defences, Police, Education, Public Hospitals, Asylums, Support of Paupers, &c. It is obvious, therefore, that when fairly employed in this branch of labour—making boots and shoes—he is not merely rendering reciprocal services to his countrymen, but he helps them to provide for such expenditure as the requirements of the particular State demands. The greater the effort or energy expended by him during the year, the greater is the value of produce by him added to the commonwealth in all these respects, in addition to the important part of support of the four dependants specially related to him.

Under ordinary circumstances (excluding foreign interference, and making due allowance for special skill) all branches of services within a certain country are paid at rates of wages which are, broadly speaking, correlative to effort or time expended, and, consequently, so long as the rates of wages are locally proportionate to definite efforts and skill, it matters not whether the average rate per hour be nominally high or low, so long as expenditure is also determined locally by such correlative conditions. Thus take the following illustrations :—Suppose the price of bread is determined by a daily effort of 10 hours, and that all other services are modified and constantly exchanged in prices which, whether high or low, are also proportioned to the nominal price of, say, the *quarter of wheat*. Under these circumstances, it would not matter to the shoemaker whether the *nominal* or money cost of his wages was high or low, for it would have the same *purchasing power* over the things which he required to satisfy the wants of himself and family, besides the proportion required from him for the *service* of the State Thus if the standard—the quarter of wheat—bore always the same relation to his remuneration of 10 hours' labour, and to the various items of his expenditure, it mattered not a whit to him whether the nominal money cost of wheat was high or low. In Australia the average relation between a breadwinner's effort expended and a quarter of wheat usually represents $44\frac{1}{2}$ hours' labour, equal to $5\frac{1}{2}$ days' labour (8 hours) nearly. If, therefore, the quarter of wheat and other things (including expenditure) always bore a corresponding relation to each other, as $44\frac{1}{2}$ hours' common labour bears as the equivalent to one quarter wheat, it follows of necessity that nominal prices, whether high or low, would not increase or decrease his receipts or expenditure, nor his average gains or losses. Thus, so far, the various divisions of labour within any one State would never be affected, in reciprocal interchanges with each other, by alteration in the nominal cost of services, so long as the alteration in cost was a general one within the State, and governed by local natural conditions.

But a different result would follow, so far as the shoemaker is concerned, if manufactures of boots and shoes were largely introduced from a country where nominal money prices were generally much lower, or where the average breadwinners of the population—reduced to a perilous condition—were forced to increase their expenditure of daily effort relative to the standard of cost of one quarter of wheat to 89 hours, or $7\frac{5}{12}$ days' labour of 12 hours a day. The local shoemaker would not have the advantage of distance and cost of transit, as in the case of the local quarryman or coal-miner; for shoes and boots can be transferred long distances at a relatively small cost, and hence, if not protected in some other way, the local shoemaker would be unable to compete with the foreign low-paid worker. Not only would he have to increase his efforts to the same extent as the foreign competitor, but he would (were it not impossible) have to *exceed* his efforts before he could drive the foreign competitor from the field, and failing this, he would be reduced, perhaps, to half-time employment at the foreign rate of wages, and, probably, soon he and his family, overwhelmed with poverty, would become local victims to competition; and, instead of being a help to the State, would become dependants upon the rest of the breadwinners, thus increasing their State burdens.

It is usual with theorists to talk lightly of the *mobility* of labour under such circumstances, and to show that the local shoemaker, finding himself unable to compete in his capacity as shoemaker, would at once transfer his services to some other branch of labour, where, it is supposed by theorists, that there is always some providential provision. But all such writers do not seem to be aware that, in a country where manufacturing industries do not dominate, there is a tendency to narrow the scope of operations, and to close more and more the doors of entrance to the remaining branches of active industries in proportion to the number of local industries actually driven out of existence by the influx of foreign manufactures. This is undoubted, so far as local market is concerned. No one can affirm, with reason, that an industry driven out does not correspondingly delimit the demand upon the *local market.* Logically, therefore, the only direction in which our shoemaker could maintain his existence as a breadwinner would be—(1) to convert himself into a labourer in raw products, for which there is still a profitable demand in *foreign markets;* (2) transport himself and his family to a country where his particular services are in demand; or (3) starve or become dependant paupers, supported by the local State, already too heavily burdened by poor rates, etc.

In theoretical discussion this case would be disposed of by wordy wrangling or special pleading, indictment of the capacity or lack of reasoning power of opponents, references to alleged harmonies of competition and to dogmas and general conclusions of various political economists of accepted authority. The usual ruts of controversy may afford ample opportunities for theorists to display literary skill, aided by the usual handy assortment of stock illustrations. But, instead of a literary sham-fight, let the theorist enter into the real difficulties by discussing the matter, practically, with the distressed shoemaker. For this purpose we will take a common incident in these colonies.

A deputation from the shoemakers, driven out of employment by competition with cheap foreign manufactures.

(Shoemaker) spokesman for deputation.

(Theorist) representing the Government.

Shoemaker: On behalf of myself and my distressed fellow-workmen and their families I have been asked to represent to the Government the terrible distress into which we have fallen by the influx of manufactures of boots and shoes from Europe, at such low prices that we have not only been knocked off employment by local manufacturers, who were unable to compete with foreign houses, but we find that, as individual workmen, with such high ruling rates in rent, clothing, and other necessaries, besides a high local taxation, we are unable to earn enough to maintain ourselves and families, even if we were able to get full *employment* at the foreign selling prices.

Theorist: I sympathise deeply with your distress, but we cannot interfere with the laws of free interchange. You must, therefore, seek employment in some other way.

Shoemaker: But we cannot turn our hands to another trade, and even if we tried, we would have to spend years as apprentices. Even in our own trade we had, as young men, to spend three or four years as apprentices, partly or wholly supported the while by our parents. Now we have no such help. On the contrary we are each burdened with the support of a family. Even if we could manage for ourselves, what is to become of our families in the meantime?

Theorist: I admit this difficulty, but is there not plenty of work open to you in this country where you could turn your labour to account, where no special skill is required, or, at any rate, where bone and muscle is all that is necessary.

Shoemaker: True, in time some of us might obtain work as labourers in the fields among farmers, or on public works or mines, but the failure in our own industry in such a thinly-populated country causes a depression in nearly all local occupations; for it must be admitted a considerable portion of the products of other trades and industries have been directly affected by our distress and our lessened consumption, due to lack of purchasing power. Besides, I have been told by farmers that they have themselves long struggled with adverse circumstances in competing against more favoured agriculturists in America, who are able to sell in European markets at prices which tend to become lower year by year, and if a local market is not soon established, many of them will have to give in. If other trades are crushed by foreign competition as we have been, what hope have the farmers of holding on, let alone the outlook for their own children, where every branch of industry seems to be already overstocked, even in this rich and extensive country with a sparse population. In addition to what I have stated, I am informed by those who have given much attention to agriculture that there is only a limited amount of land where agriculture might be successfully carried on; but this form of industry will not admit of the employment of more than 35 persons to the square mile of land in cultivation, and if this be so, and if farmers cannot exchange products of the same kind with each other, how can a local market become a possibility in the absence of a local community of trades and manufacturers?

Theorist: I admit that the home trader and home workman may *temporarily suffer loss* from the competition of foreign traders and workmen in the same branch of industry, but it must be remembered that *everything* will again be adjusted, because capital is constantly exerting a tendency to *smooth down* any *temporary* inequality in the profits of different trades. Even if you suffer from foreign importations, the Government is not bound to protect you; for there can be no right which has a juster claim than that every individual of the community should be freely permitted to obtain commodities where he can buy them on the cheapest terms, and to sell them where he can realise the highest price.

Shoemaker: It is easy for theorists to write such things. I am unable to understand exactly what you mean by suffering a *temporary loss*, or what the process may be which you euphoniously term a tendency to *smooth down any temporary inequality.* I and my fellow-workmen are now unemployed; many of us, with our families, are in great distress—without *instant employment or relief from some source, many of us will die of starvation.* We have no means, and if we had we do not know where to go to better our miserable condition. Do you mean, if many of us succumb and die from want and misery, thereby thinning our own ranks as competitors for the existing small field of employment still remaining, that this is the *smoothing down process* to which we are referred for comfort? Good heavens, surely not this? Remember that we are human beings, not machines. The machine may stand idle for a time and *live.* Men cannot. Friction in inanimate machinery means dissipation of power in heat; with men friction means distress, misery and death. Men are not machines, and loose analogies based upon the laws of physical processes cannot be grimly applied to men fighting for life and exposed to suffering. You say that Government is not bound to protect its own workmen, and that there can be no right having a juster claim than that every individual should have the most absolute freedom in buying in the cheapest market and selling in the dearest, irrespective of any local claims of sympathy or rational or racial ties of common interest. Such a commercial Law, not Bond, cannot be consistent with the conditions which necessitate the maintenance, defence and independence of individual nationalities. To be logical, it would necessitate the breaking down of all individual States, all individual race conglomerations, and the fusing of all human elements into one grand State of the world. Until that time arrives there must of necessity be localised interests, governed by the same local general condition, which maintain separate nationalities. All the social organisations of the State, such as Railways, Roads, Bridges, Harbours, Post and Telegraph, Schools, Defence and Protection, Poor Laws, &c., can only be logically maintained upon the admitted necessity of some common local rational interest, having special concern for the general welfare of the particular nation; and these special local interests are so intertwined by so many bonds more precious than mere questions regarding *absolute cost of products in money,* that it seems absurd to say that the destruction or suffering of any of its members are locally only of equal concern to a corresponding evil in a foreign State similarly constituted. The necessary gravitation and concentration, interests and sympathies around home and fatherland are as natural as perspective in optics; the greatest density must be near the centre of self, home and family, becoming weaker and weaker as the related rings of friends, relations, club, townsmen, nation, race are passed through, to the thinner sympathies lying beyond, embracing humanity generally, where foreign races and states are bound, and they themselves are related obversely to us in a similarly graduated series of interests and sympathies. It is this grand gravitation of human interests and sympathies which make possible ideas and forces which make home, friend, and fatherland; and these, not nominal cost of products, are the great factors which determine the engergies and welfare of any community. Commercial laws tend to destroy the heart of all ideas which centre in home and fatherland, and if the nation is to live it must carefully guard against their decrepitating influence. Their shuttle seems just as ready to weave the shroud of a nation as to bind nations in bonds of broader sympathies.

Dominating Wants Determine Occupations and Necessarily Produce Inequalities in the Form of Services.

Hitherto, in the writings of social reformers, the greater part of the attention has been confined to the monopoly by the few of the lands, houses, railways, and other instruments connected with the production, security, and distribution of the necessary wants of human beings. It is generally assumed that there is abundance of primary wants for each one if the aggregate products annually created were more equitably distributed. But if the necessary primary satisfactions were annually produced in sufficient quantity for the wants of all, it would go to prove the curious and inexplicable circumstance that the present haphazard training, and supply and demand, allocation of those who are engaged, or who are being trained to engage, in the various divisions of labour are in perfect harmony with conditions which combine to effect that result, which might seem too formidable if undertaken by the most absolute regulations of intelligent prevision. The present supply of satisfactions is determined by the estimates or combined action of self-interested producers. It cannot be affirmed, on the basis of *producers' self-interest*, that wants are produced with the sole idea of providing the highest quota of each satisfaction to each individual. At best they favour the *minimum* supply, as self-interest is best rewarded by a *keen* demand—involving high prices—a result which would not be attained if the maximum quota of satisfactions for each individual was created. Of course, the absence of a perfect scheme of combined prevision among producing competitors, and the unforeseen variable effects springing from natural causes year by year, often produce abundance or superfluity, or over-production, as it is termed; but this is a result not premeditated, and, although favourable to consumers for the time being, it is a mere accident, causing a fall in prices, and is likely to be followed by purposeful under-production during the succeeding period, in order to produce a straitened market with a corresponding rise in prices, and results in a certain reduction of the ideal quantity of satisfactions falling to the lot of each consumer of the poorer classes. But this tendency of *self-interested* producers striving to produce *under* the necessary requirement is just the very condition for involving the poor in the continual battle with poverty and want; and all that can be said in favour of self-interest is, that hitherto there has been no better method devised which would so effectually serve the majority of human beings. Is it to be wondered, then, that the *less fit* (happily a minority) in the struggle for existence should at times cruelly feel pinching want, when upon them must fall the evil of the barely-sufficing aggregate scarcity, the ideal creation which the self-interested producers strive for. It has been shown that the supply of wants is at present alone roughly predetermined by the self-interested calculations of producers, and that their aim is to extend the field of production as far as they can in safety to themselves—and that means as near an approach to a full supply as will ensure good prices, involving a tight market, or scarcity. Consumers, who desire abundance, do not determine the forthcoming supplies. Producers' interests, therefore, are antagonistic to any social ideal which would bring the highest quota of necessary satisfactions easily within the reach of all men. Therefore, so long as producers' self-interest rules supreme in the creation of necessary products, so long must we expect the periodic suffering and pinching of the lower stratum of the working classes. Bastiat even is forced to admit that "antagonistic desires cannot at one and the same time coincide with the general good." "As a purchaser he desires abundance; as a seller he desires scarcity." "The wishes and desires of the *consumers* are those which are in harmony with the public interest." Food, clothing, houses, railways, steamboats, and the various machines of production are almost wholly regulated in the interests of producers, competition alone preventing this interest from working in too great antagonism to the interests of *consumers*. Nearly all breadwinners, therefore, in detail defeat, to some extent, their own ultimate interests as general consumers by regulating the production of supplies upon a principle which is inimical to their interests as consumers. Nor is this the only evil. All wages-breadwinners must produce, or serve to produce, before they can earn the right to share or consume the fruits of production. But the *numbers of the employed* depend almost wholly upon the *self-interest* of the *large capitalist producers*. It is not the interest of large capitalist producers to provide the full quota of wage-earning employment to *all* breadwinners. The larger the number of fully employed labourers the keener is the demand for products, and indirectly this may have some influence upon certain producers. But this indirect consideration is too feeble to interest producers in any scheme for the general good which might be directed to ensuring full employment to *all* breadwinners. It is manifest, therefore, that in the present scheme of the division of labour there are two ugly defects. *First,* there is no interest intelligently organised to train and determine according to natural proportions the occupations of the future breadwinners. *Second,* the only existing agency which determines the extent of employment is guided by a principle which has for its object neither the supply of the highest quota of satisfactions to consumers nor the more needful provision for securing employment for all breadwinners. In the latter case, competition, instead of befriending the wage-earner and dependants as consumers, operates all the more harshly upon the larger number who are handicapped in the race by aimless training, or no training, for the nature of services that might possibly be otherwise open to some of them.

Utopian Schemes of Socialists.

It is not a matter of surprise, therefore, that the mass of wage-earners should readily sympathise with every vague Utopian scheme of the Socialists, which holds out, however faultily, some promise or plan for dealing more effectually with the root difficulties which affect them most nearly, viz., security of employment, protection from over-competition, shorter hours labour with more adequate remuneration, redistribution of wealth, &c., &c. But it is needless to point out that, before the redistribution of the aggregate of all forms of existing wealth of exchange (so-called) can be dealt with, it must be clear that this wealth consists of such forms as might effectually satisfy all the primary wants and comforts of human beings. That existing *wealth in exchange,* even if equally distributed, would fulfil this most necessary provision is a pure assumption. It has already been shown that a great part of the existing nominal wealth of exchange largely owned by the rich consists of the mere *tools* and *instruments* of production, and that the real wealth appropriated as consumable wealth, or primary satisfactions, is already more widely and evenly distributed than is generally supposed. Even under the most thorough Socialistic scheme this form of wealth would be far less generally distributed than at present; for, according to such a scheme, it would be wholly reserved in the hands of the executive Government. It is utterly misleading to reckon upon the existing wealth of capitalists as a source for raising the quota of the real consumable and primary satifactions. The only distribution possible in this respect would be the empty idea of part-ownership. It is the increase to necessary current productions *designed for actual consumption* (material satisfactions) which alone can raise the average standard of primary satisfactions, and so dispose of material want, or poverty and distress. The question therefore arises—Suppose that such a scheme were practicable, would the producing energies of men be greater and more effective than under the scheme of Competition, Liberty, Right of Inheritance, Property Right, or Individualism as it is called? To be more effective in one essential, it must utterly fail in the other. The workers must be trained and allocated to specific occupations in strict conformity to the amount and nature of the labour actually required to produce the primary satisfactions and comforts desired. Training for every specific occupation requires considerable time, but for the occupation of skill a large amount of time must be consumed in acquiring the necessary training, irrespective of questions with regard to the unequal distribution of capacity.

Now, on the basis of equality, it may be easy to divide products; that according to actual needs is simple enough, involving no insuperable difficulty. But what about the allocation to different employments? How can the easy, the refined, and the skilled occupations be allocated on any scheme of equality? The majority must, as heretofore, sweat at the hard and dirty forms of labour; but what power or what plan can be devised which will enable any elective executive to doom once and for ever the majority of learners and workers to the hard and irksome occupations, and to fix the minority in the refined, the easy and skilled services? Suppose it were for a time instituted, how long would the unfortunate majority be content to submit to their lot before an irresistible cry for *redistribution of occupations* arose; and if it arose, where is the force stronger than the majority of freemen to preserve the break-down of the social organisation necessary to produce the primary supply wants according to individual needs? What compensation can be given to the masses toiling in the more wearisome occupations? Extra allowance of satisfactions cannot be thought of, for that would destroy the coveted ideal of equality in the distribution of satisfactions according to needs. Shorter hours cannot be allowed without trenching upon equality of leisure. The unequal distribution of natural capacity, and the time necessary to acquire knowledge of more than one technical branch of skilled employment make it impossible to share in turn for a time all possible forms of labour. In short, the practical difficulties standing in the way of *equality* in the *allocation of employment* appear to be insuperable, and would most certainly, if there were no other objection, destroy any social organisation on a *large scale* which had been courageous enough to attempt it. Reference to simple communities, as in America, following agriculture pursuits mainly, and not of themselves fulfilling for themselves the whole round of human wants, are utterly misleading. Such small communities are composed of a peculiar, select class, who voluntarily bind themselves to a more or less ascetic life, and all such petty attempts tend to perish from lack of internal vitality. With a large mixed body of men, embracing all occupations, and endowed with ordinary passions and desires, the results would be chaotic and disastrous in the extreme. One effect, terrible to contemplate, would seem to be inevitable, viz., that the indiscriminate distribution of products among all men would destroy the major source of savings at present so largely devoted to the creation and maintenance of the powerful and costly auxiliary aids to human labour, and the slight individual gain per head in material satisfactions would only be of a very temporary character, for it would soon be lost by the new impulse to the improvident to rapidly increase their numbers.

What would be the Probable Effect upon Social Well-being if the Major Source of Savings were Destroyed.

In another place it has been indicated that the mere "two hands," or the unaided labour of man, would not only fail to produce the average comforts and luxuries now enjoyed by nearly all classes of men, but more calamitous still, they would fail to produce the *prime necessaries* of life in sufficient quantity to maintain the lives of the existing population. Defects in the existing scheme of civilisation, some of which seem to be ineradicable, may be truly charged yearly with the destruction of thousands of valuable lives; but were the present major source of savings dissipated or destroyed by equality in share of earnings, either by lowering the powers of production or by slightly raising temporarily the average amount of satisfactions *consumed or enjoyed*, the new conditions (equality of earnings) would be a blight and a curse, for while the existing defects in distribution may be the cause of the misery and destruction of thousands of valuable lives, the *equality* scheme would certainly entail the misery and destruction of millions now living in a state of comparative comfort. Many who fail to ponder over those root difficulties may exclaim—How can you explain this paradox? Why should the fairer distribution of wealth (that according to actual individual needs, without regard to inequalities of natural powers, capacities or inheritance), raising the average comfort of the majority and lowering the superfluous and luxurious satisfactions of the minority, be productive of such disaster?

The answer is plain enough. The power to effect large savings, or to create the more costly auxiliaries of labour, depends mainly upon the existence of specially favourable conditions.

(1.) The desire to accumulate or save can only become strong enough to be effective when the stronger desires for primary satisfactions are appeased.

(2.) Savings or accumulations, therefore, can never be produced by labourers or others whose earnings do not exceed the supply necessary to satisfy the three primary wants. The majority of breadwinners are always in this "hand-to-mouth" condition, and rarely, of themselves, are able to contribute to the maintenance and increase of machines and instruments to serve as auxiliaries of production to future labour. They, however, in their social relations, more than contribute the average share of the future surplus workers, whose efforts must be proportionately supplemented by capital and power-multiplying instruments if they are to enjoy the same or a further improved condition.

Those workers whose earnings are sufficient to provide comforts beyond the limits of bare prime necessaries may, however, by self-denial in the satisfactions of *comforts*, lay by a small store of savings which, in time, may swell into such valuable auxiliaries to earnings, that the self-denial in comforts hitherto may be rewarded in the greater satisfaction in comfort in the future, and even in adding considerably to the store of wealth, which may be converted into the more permanent capitalised auxiliary instruments of power, which will benefit the generation coming after them.

Those, however, who contribute most largely to the creation of the permanent instruments which add unknown power to the efforts of hand labour, are chiefly those who either have inherited these or similar creations from their ancestors, or who, by extraordinary energy, skill, or self-denial, or all together—in the earlier part of their lives—are now enabled, after satisfying the three primary wants and comforts, to indulge the prevailing passion of comfortable people, *i.e.*, the accumulation of wealth or power over wealth. This passion in itself is, at this stage, undoubtedly a personal luxury; but, unlike the luxuries which are directed to greater *personal consumption*, it is fortunately directed to that form of immaterial enjoyment which springs from the knowledge that the owner possesses the power to direct the mode or secure the best conditions in which wealth may be further employed. Fortunately for the world at large, self-interest at this stage converts into a virtue what otherwise would be a vice; for the passion to further secure luxury of power over wealth, and to augment it, restricts personal indulgence in further consuming the *material fruits of labour and the material gratuitous stores of nature*, and runs parallel with that course which favours increased production relative to numbers, involving the improvement of the social and economic condition of all labourers; *i.e.*, the wealthy man or industrial chief does not, or cannot, increase his own personal consumption of the *material* fruits of labour, skill, enterprise, and the gratuitous gifts of nature beyond a moderate standard. The unconsumed material surplus by passion, self-interest, and even the better motives, is necessarily devoted to multiplying and sustaining the inanimate, costly, and powerful permanent aids to human productive power which alone distinguishes civilised populous communities from those of the miserable and bare-handed savage races, whose command of a continent of the richest land upon the globe is too feeble to support in comfort a few insignificant wandering tribes.

The broad conclusions to be drawn from the foregoing considerations are:—That the social condition of mankind cannot be improved, or even maintained, unless a considerable proportion of the aggregate primary satisfactions produced be specially devoted continuously to agencies set apart for the maintenance, creation, discovery and improvement of such machines, tools, instruments and skilled contrivances as promise to add most effectually to man's power in transforming the forces of nature to the service of man. That the devotion of such a large proportion of created products to such purposes, entailing such a tax upon the aggregate store of *present* satisfactions, for and upon the individual share which otherwise might fall to each consumer, can only be secured by society living under peculiarly favourable conditions, such as has already been indicated. This involves favourable natural conditions as regards extent and quality of soil and climate; maximum of skill and energy, tempered by the reasonable maximum of allowance for leisure and rest; division of labour—each division carefully disciplined, apportioned, and maintained in strict relation to the probable amount of the different satisfactions and needs required, and each member of the community in the dependant and under tutelary conditions—carefully trained in strictly corresponding proportions to that branch of work in which it has been predetermined that the individual must in the future devote his life's service; the adoption of such regulations as will restrict the number of consumers and dependants within reasonable limits—that is, within the present limits of the producing powers of the society—to provide a reasonable quota of satisfactions to each individual. The last provision involves the great population difficulty.

Population Difficulties, or the Struggle for Existence.

Darwin (page 52, "Origin of Species") has observed "that in a state of nature almost every full-grown plant annually produces seed, and amongst animals there are few which do not annually pair. Hence we may confidently assert that all plants and animals are tending to increase at a geometrical ratio—that all would rapidly stock every station in which they could anyhow exist. And this geometrical tendency to increase must be checked by destruction at some period of life," and, as an inevitable consequence, he goes on to add "that each individual lives by a struggle at some period of its life, that heavy destruction falls either on the young or old during each generation, or at recurrent intervals. Lighten any check, mitigate the destruction ever so little, and the number of the species will almost instantaneously increase to any amount."

These considerations, when fully appreciated, form the foundation of the problem of Malthus.*

Increasing Numbers.

Residents of new countries, with a scant population, and with vast natural resources in the shape of unlimited areas of unoccupied and unutilised virgin lands, longingly picture the transformation of these areas into yellow cornfields, fruitful gardens, verdant pasturage teeming with browsing cattle, busy industrial centres crowded with the homes of industrious and happy people.

Ah! little do they know of the never-failing Nemesis which, like a sleuth-hound, dogs the steps of an ever-increasing population. Happy selectors of easily-acquired choice lands may luxuriously grumble at the amount of their taxation, the *low price of mutton and corn*, their bad roads, and the impossibility of extending their operations in the production of corn and wool, so long as the wages of farm and other labour are *so high.*

The professional and merchant class may reasonably grumble at the scarcity of men and products which restricts their respective callings, and may impatiently rail against the slow progress which the country is making in *population* and *the creation of products.* The few wealthy men of leisure may hanker after the amusements and honours so common in thickly-crowded centres, where the *attractive ministry of cheap labour* is but too common.

The comparative comfortable artisan or labourer, under such favourable conditions, may *in verbal or literary debate* still wage a lively dispute whether the irksome eight hours' labour—or weekly half-holiday—may not be further improved, and the rate of wages *further raised above the rates of over-peopled old countries*, but he does not view with favour the fresh introduction of labourers in *his own craft.*

The consumers of the services of local dear labour may desire the introduction of the surplus cheaper labour of Europe, and for the sake of Protection may urge upon the Government the necessity of extending the advantages of external Free Trade. On the other hand, the protector of a local monopoly of relatively high wages, or dearer local manufactures, may more strenuously advocate the necessity of increasing the tariff on all manufactures from other countries, especially on such as may be produced locally. It will be seen, therefore, that in young countries, as well as in the old, we have the battle of interests still waged, if not so keen. The competitor or seller of services cries for Protection; and the user or consumer of services enlarges upon the harmonies and advantages of universal Free Trade.

* An Essay on the Principle of Population. Malthus. (2 vols., London, 1826.)

Few recognise the truth that individual welfare depends less upon the greatness of the aggregate wealth of a country than upon the proportion which freedom from excessive competition gives each individual over the local natural sources of utility. including primary wants; and that the country possessing the greatest aggregate of material wealth may, owing to the competition of excessive numbers, present the spectacle of a small privileged minority absorbing an unparalleled share of luxurious wealth, while the masses are struggling for the barest subsistence.

All other things being equal, it follows that in the country where Nature's gratuitous stores of wealth, as regards food and other essential products, far exceeds the power of its inhabitants to utilise, yet, notwithstanding the comparative insignificance of its accumulated wealth in exchange, its inhabitants on the average are individually happier, and enjoy a much larger share of material comforts than the inhabitants of countries, however great the aggregate wealth, but whose natural resources, as regards food products, are far below the local requirements of its teeming inhabitants.

Two nations, standing in this relation to each other, would correspond to the relation of two iudividuals, where one is the privileged capitalist or buyer, and the other the unprivileged seller of labour service. In other words, the latter would be in the position of the needy Esau in being forced to sell his whole birthright to preserve his life; the former would occupy the favourable position of Jacob, who had merely to part with a portion of his surplus of primary wants (red pottage) to secure a large augmentation to his wealth of pleonexia.

This, unfortunately, for many old centres of civilisation, is no overdrawn statement—the creation of enthusiastic declamation or sentimentality—for if we take one of the most vigorous countries of Europe (England), with its untold wealth in the aggregate, and compare it with the young colony of Victoria, we may readily demonstrate the verity of what has been alleged.

Can a Higher Culture be Maintained in any one Country Without Regulating its Intercourse with Other Races of Men in a Lower Plane of Civilisation?

There is still another difficulty to face, even if one enlightened country, by providence, had succeeded in adapting the growth of its population to the means of subsistence. And this difficulty now presses hard upon the labourers of a higher civilisation open by Free Trade to the competition of the labour market of a lower or more degraded form of civilisation. The partial exclusion of cheap Chinese labour from America and these colonies, may or may not, have been in accord with the principle of Free Trade;

but it opens up a grave subject. For if a higher culture could be enabled by provident moral or self-control to successfully grapple and overcome the present enigmas of social science, how is it possible that such a culture could be effectually preserved if it were open to be disturbed by the cheap labour or the starvation price products of other nations, who, by improvidence and lack of moral control, were still sunk in the abyss of that wretchedness which is due to over-population? In this aspect I am humbly of opinion the doctrines of Free Trade and Protection require further consideration; and it is with the hope that the reasonable discussion of such matters may shed fresh light upon this and related problems that I have had the courage to address you upon these old, well-worn, but hitherto insoluble difficulties belonging to social and economic science.

One thought impresses me not a little. It is this—All truths that are painful are blindly and passionately resisted by the majority, who also are ever prone to reward skill when it is employed in opposing or obscuring what is hateful. It cannot be hoped, therefore, that the warnings given with respect to the danger that awaits us in the near future will be much heeded at present. The world's greatest intellects and genius are, for the most part, supported in defending popular views; for it is not found to be a difficult matter for men of greatest literary talent and skill to show, where complications abound, that the true is false and the false is true. Popular favour is a terrible task-master, for she refuses bread to those who fail to work her pleasure. I do not, therefore, undervalue the temptation which ensnares the majority of able minds to continue the defence of pleasant delusions, when these alone find a ready market of *exchange value*. But the evil time draws too near for delusive teaching. It is now necessary that those who see the rocks ahead should speak out faithfully.

PRESIDENTIAL ADDRESS IN SECTION G.

ANTHROPOLOGY.

By the Hon. JOHN FORREST, C.M.G., M.L.C.

It seems to me that a few words on the condition of the Australian aboriginal race will fittingly open our proceedings on this important occasion, and if the very few words I have to say will lead to some greater interest being taken in their customs, manners and traditions, I will be greatly pleased.

The condition of the Australian aboriginal race when the civilisation of the Old World was introduced to their island continent is one of the most interesting subjects that can occupy the thoughts of those who contemplate the history of the human family scattered throughout the world.

There is no doubt but that Australia has been peopled for a considerable time, and it is also certain that its original people are much lower in the human order than any of their neigbours.

These facts being admitted, it becomes interesting to speculate as to the causes which have acted upon these people and have led them to follow the nomadic life in which they were found and in which they now exist.

To find a people without any idea of cultivating the soil, without any permanent dwellings, in many places without any clothing, without any means of cooking, other than by roasting in the ashes—and without any villages—was certainly an extraordinary discovery, and must have astonished and puzzled the early explorers of Australia. Dampier, who visited the north-west coast of Australia in 1688 expresses his surprise and disgust in these words:—"The inhabitants of this country are the miserablest people in the world—the Hottentots of the Cape of Good Hope, though a nasty people, yet for wealth are gentlemen to these, who have no houses and skin garments, sheep, poultry and fruits of the earth, ostrich eggs, &c., as the Hottentots have; and, setting aside their human shape, they differ but little from brutes—they have no houses, but lie in the open air without any covering, the earth being their bed and the heaven their canopy."

One might have reasonably expected that in an immense continent the people of the different portions might have been found to differ largely in their customs and manners, and in their state of civilization, and that an altogether different state of things would exist on the east coast from that existing on the west coast, separated by more than 2000 miles. This, I think, might have been reasonably expected ; but, strange to say, the same habits, customs, and manners were found to exist throughout this great continent. Although there were no means of inter-communication, although the languages or dialects were altogether different; although they were separated by immense distances ; although no sympathy, or even knowledge of one another existed, it is still a fact that they were found to be the same people, with the same laws, customs, and manners, and, to a very large extent, with the same ideas and traditions.

When it is considered that probably for many thousands of years this continent has been peopled ; that even supposing they originated from a few persons cast away on this island continent, is it not marvellous that they should have retained their original character, and, being subject to like conditions of soil and climate, should now be found to be the same people in all important respects?

In considering this question, one is lost in amazement. Why has no superior genius arisen through the ages of the past to instil into his people an ambition to rise from their servile and degraded condition? Why has it not occurred to some one of these people to build a permanent habitation to protect him from the rain and the sun? I have myself often noticed that, in north-west Australia, the natives have no covering by night or day, and although skins of animals are abundant, they do not trouble to make a rug, or even a cloak.

As no idea appears to have entered into the mind of the Australian aboriginals to cultivate the soil, their whole attention is given to securing game by hunting, and in this they are very expert. All their implements are fashioned for this purpose, and for self-defence. There seems to be very little, if any, inventive genius among them ; and, seeing that nearly all their arts are possessed equally by those on the whole coast line and by those in the interior, it all points to the conclusion that the aboriginals of Australia have come from a common stock, and that this stock must have possessed the same customs, manners, and traditions as are now possessed by their descendants, which have been retained ever since, without any improvement or otherwise, except in small and isolated instances.

There is probably no race of people which has done so little to leave behind it a record of its existence as the Australian aboriginal race, and no race has been so little able to cope with civilisation. After existing in their own savage state for an immense time, an intercourse of about half a century with a civilized race has been sufficient to almost remove them from the face of the earth. Other peoples have suffered and have gradually given way and become extinct, or almost so, before the advance of civilization, but in no case, I think, has the progress of extinction been so rapid.

It seems, therefore, in reviewing the present position of the aboriginal race of Australia, to be a great duty we owe to them and to Australia, not only to try to preserve the race from extinction, but also to preserve their history, laws, habits, traditions, and language, as far as is possible, and there is still sufficient time to do this as regards the interior of the continent.

I can only now, in these few words, urge upon all who have the means and the opportunity to use every endeavour to collect reliable information on this subject, for however unimportant particular details may appear, they may eventually prove of great value in dealing with the history of the aboriginal Australian race.

PRESIDENTIAL ADDRESS IN SECTION H.

(Sanitary Science and Hygiene).

ON THE PRACTICAL BASIS OF PREVENTIVE MEDICINE.

By J. ASHBURTON THOMPSON, M.D., D.P.H.

We are met for the advancement of science; and in this section for improvement in the branch of knowledge which teaches the causation of disease, and the conditions ancillary to disease which act by impairing functional efficiency. A sharp distinction is thus drawn between the science and the art of sanitation. The former regards the phenomena of life, and especially its duration, under observed conditions; the latter devises the means, which are sometimes political, sometimes mechanical, by which the teachings of science may be put into practice, and the circumstances favourable to life be provided or preserved. And I choose rather to say that our occupation is to learn the causes of disease than to prevent them for reasons which, if they are trite, are yet seldom enough mentioned to warrant me in recalling them. If it be assumed that the prevention of all diseases is possible, and that by preventing all diseases the average duration of life can be extended until death by decay become the common course, it needs no profound reflection to show that the change could be but temporary, that the truce could but serve to reinforce the destroyer. Probably the supposition is fallacious, since we are in thrall to our ancestors; but, at all events, success in that enterprise must ever involve failure.

If we pass from thought of disease as it affects mankind in general, to consider some kinds of disease in relation to some sections of mankind, however, it will at once appear that the effort to abate them is natural, and may be successful. The preventability of some diseases has now been demonstrated. Once that knowledge gained, systematic effort to prevent them follows of course. Self-preservation is an instinct; what man desires instinctively for himself civilised man desires strongly for others: thus he not only avoids injury for himself, but he warns and protects his fellows, although nothing of them be known to him but their threatened existence. Now, in learning the causes of some diseases we have also learned that their introduction to the body is for the most part accidental in no unusual sense; and, practically, it is the accidental conjunction between specific causes and susceptible organisms that we seek to prevent. We may, therefore, speak as justly of vaccinating, or of isolating a case of fever, to avoid accident—that is to say, to prevent communication of the cause of disease to persons unaware either of its propinquity or of its quality—as we speak of fencing a revolving shaft. It is thus inevitable that we should endeavour to prevent some diseases; all those, namely, which have been shown or in the future may be shown to be preventable.

And such endeavour may be successful. Experience in England is taken to show so much. By abatement of some diseases a large number of deaths have in that country been saved to persons chiefly between the ages of five and thirty-five years; and the average duration of life has been extended for persons by as much as two years and a tenth. Thus the diminution in deaths has brought about a numerical increase in population. It may be contended that, by so many lives saved, or by so many years of life added, the productive power of the nation has been increased. For reasons that will appear immediately, it seems most likely that it has been increased, although not to the full indicated extent; but it has been questioned whether such proximate increases will ultimately prove the substantial advantage which at first sight they seem to be. It has been said that disease attacks the weak, that by checking it many of the weak who would have died must be preserved, that these will survive to the reproductive ages, and will then either reproduce their like by intermarriage or, by union with the strong, will at last lower the general standard of vitality, so that the productive power of the nation will be diminished, and its tendency become towards extinction. And perhaps the following illustration might have been adduced in support of that view:—It might perhaps have been suggested that the natural term of life is still set at three score years and ten, and four score years is still regarded as an extension too seldom enjoyable to be generally coveted, just because disease has been left unrestrained during the last four thousand years, has steadily weeded out the weaker, and has left the strong to reproduce their like. In fact, it seems that there is at bottom much of highest importance in the view mentioned; but it is surely not the whole truth. In the first place, the diseases whose abatement has led to the saving of life in England which is represented by an increase in the average duration of life of two years and a tenth, are chiefly the specific contagious and the filth-diseases; and these are the diseases against which (in the main) preventive medicine is thus far engaged. It is not to these alone, however, that those who are of imperfect constitution succumb. If they escape these they still have other chances, of which some important ones are inherent to them, of extinction. But, secondly, the kinds of disease referred to do not kill all they attack; while they farther damage the constitutionally defective, and leave some of them to attain to reproductive ages still less fit for reproduction than they were born, they leave others in a damaged condition who were born sound. And lastly, while they are not seen to attack those of imperfect constitution alone, or even preferentially in any marked proportion, they do seize preferentially upon those who are weak merely from immaturity, and those who are weakened and depressed temporarily; while, when they become epidemic, or when their causes are introduced to the body in special ways, they seem to attack the weak and the strong nearly indiscriminately. In short, although disease is inevitable, all diseases are not so, and if we may not choose our mode of death, yet we may exclude some modes. We are rightly fixed, therefore, to prevent some diseases—we obey both instinct and reason therein; and if the near limit of the attainable oblige us to set our aim not very high, a measure of success both proximate and remote is thereby rendered certain.

I began by mentioning the problems which Sanitary Science seeks to elucidate: namely, the causation of disease, and the nature of the conditions which impair function, diminish vital efficiency, and so conduce to shorten the duration of life. The investigation is made by experiment; the results are found by induction. The experiment is performed without our active intervention, or is unplanned, the *corpus vile* being any body of men, and the conditions of experiment those under which they happen to live; the record of observation is the register of the facts of individual lives; and when these individual observations are accurate enough and numerous enough, they may be classified, and the work of induction may be begun. The method of collecting the observations may be indicated under three heads: first, enumeration of the people; secondly, record of their individual fertility; thirdly, record of the individual duration of life among them. Under these are included many different details; and the register must be so framed as to facilitate combination of the several particulars into more or less broad classes, and bring them into comparison with foods, with soils, and with climates. Few enquiries are more complicated than this, which seeks to estimate the vitality of nations; for trustworthy conclusions can be drawn only from the total phenomena, all of which are inter-dependent, and influence all the rest; and perhaps few are more difficult, because many conditions which modify the import of individual observations, and some that are of wider effect, are but accidental, and alter from time to time. The general lines upon which such an investigation is planned should therefore be broad; and if this arrangement render conclusion uncertain at first, it must be remembered that the facts and their classification are both the more likely to be accurate, and that lapse of time is alone necessary to render sound induction possible. And time—or what is in this case its equivalent for many purposes, multiude of accurate individual observations—is an indispensable condition. Impatience to arrive speedily at some result is fatal to soundness, and is actually the cause of much of the doubt with which the science of vital statistics especially is regarded by the many. Undue haste leads, on the one hand, to resort to calculation to supply the place of facts for direct observation of which in sufficient number time enough has not elapsed ; on the other to comparisons superficially warrantable, but really between unlike things. These errors are more than misleading ; they obstruct the truth.

If the lapse of long periods of time be necessary before the observations alluded to can accumulate in sufficient number to afford trustworthy indications of the vitality of a nation—to furnish, by comparison with the conditions under which its people live, indications of those habits and surroundings which are inimical to prolonged life in a state of full efficiency, the record which is at last to yield that information may be made to serve an immediate purpose in the meantime, namely, detection of some of those grosser conditions which result in marked or in specific disease. If the number and ages of the people living within defined areas are known ; if the plan of record allow smaller areas within those larger ones to be examined in the detail of neighbourhoods, of streets, and at last of that ultimate unit, the house ; if, while the machinery for ascertaining the causes of death with reasonable accuracy is sufficient, the registration of deaths under causes be prompt and complete ; lastly, if these particulars for every such district be recorded and analysed under supervision of a professed sanitarian (who, it seems necessary to add, must be of medical education), then the information becomes immediately available to direct the efforts of sanitary authorities, and to concentrate them upon those localities where they may be most profitably made. To a full measure of this immediate usefulness records of sickness are almost indispensable ; for death is but a variable incident of disease, or, in other words, current death-rates stand in no constant relation to sickness-rates. Registration of sickness, however, has as yet been done nowhere, I believe, on the national scale. But the register of illness from some diseases is now in a way to be kept universally in England, where it has already been kept for several years in many cities ; and by the enlightened action taken in this province a year ago, the registration of the zymotics is now universal in Victoria.

Having thus briefly indicated the kind of observation in which scientific hygiene has its foundation, three points may be distinguished as being of especial importance to us in Australia. These are separate record and analysis of the general facts of life regarding the native-born population, accurate and speedy information as to the causes of death, and information from year to year of the number, sex, and ages of the people by rough enumeration. Without the first the modification in old races which changed environment will inevitably, though very slowly, produce cannot be watched; without the second it is neither possible to observe similar changes in the character of disease which may be expected, nor to get early knowledge of the prevalence of such diseases as are preventable, nor to discriminate between such as are adventitious (or easily preventable) and such as are bound up with the more fixed conditions of life; while without the third it is impossible to make just comparison either between the sanitary state of this country and of others which may be considered in general respects like it, nor between one part of this country and another part, nor between separate districts within any one such part. While the general particulars registered must be nearly the same in all countries, these are points which in a new country demand special attention; they are vital to all the useful purposes, both proximate and remote, to which such records may be put. But if the laws under which statistical enquiry of this kind is carried on in Australia be examined, it will be found that they are either copied, or slightly altered, from the English law of 1837, except in one province, namely, in South Australia. We have adopted that law which, framed as it was for another and an old country, was a lawyer's Act. Useful for some legal purposes of great importance, it was defective in several respects for that other purpose for which it was used—enquiry into the conditions under which the people lived, and the vitality of the nation. It contained no reference at all to the cause of death; although it amply sufficed the legal object of facilitating and systematising registration of births and deaths for purposes relating to property, it was little calculated to procure that prompt and complete registration which is essential to observation of life. Generally, it is under this law that we try to observe and to work in Australia to-day. Secondly, although birth-place is a particular required, by regulations having the force of law, to be recorded in connection with the fact of death, in no province is that separate analysis and comment accorded to native-born decedents which it is important they should receive. Thirdly, we have in similar fashion adopted the decennial census, without regard for our special circumstances, and although the defects it is universally admitted to show in old countries are scarcely a tenth of the defects it has in new and growing countries. These three are points in which our present method of observation requires speedy reform, for want of which, as it seems to me, the elaborate returns annually made by our statists are far from possessing a practical value commensurate with the labour bestowed upon them.

Now, if our present methods of observation are thus defective, it may be enquired how it happened that we adopted them; and it seems worth while to attempt to answer this question. I believe it happened for reasons incidental to the population of a new country by emigrants from an old one. Perhaps this may be illustrated by discussing a remark which fell recently from that distinguished sanitarian, Sir Douglas Galton, K.C.B., F.R.S., in the course of an address he delivered before the Sanitary Institute. He said: "In colonies sites abound that, with ordinary prudence, might have been kept in a healthy condition, but in which ignorance and carelessness have in some cases produced, and in others may produce, conditions causing widespread disease and death." That remark has reference especially to the filth-diseases, and to fever, which has its mode of spread in conditions which would warrant the application to it of the same epithet; these are the distinctively preventable diseases, of distinctively local diffusion; and we know very well that they are among the most important of all the causes of death that swell our mortality, about one-ninth of the total deaths in urban districts being due to them alone. There is therefore something in the criticism, something to warrant it; but I venture to think that more appears to be at first sight than will stand analysis. Settlers do not enter into an inheritance. A hundred years ago a thousand persons sat down upon these shores, who by natural increase and by immigration have become three and a half millions to-day. That band when they landed began a struggle for the bare necessaries of life; and when, after long years, they had secured a measure of success, a similar struggle was undertaken again and again in distant parts of the continent by off-shoots from the original society. When, at last, production exceeded immediate requirements, and some revenue became available, it was spent upon those objects which are always among the first needs of a community thus established—I mean the maintenance of order and establishment of communications. These, and not sanitary measures, are the prime conditions of corporate life. But at all events sanitation could not early secure special attention in such a community, because the diseases most directly amenable to it do not begin to show themselves in recognisable form until the aggregation of men upon comparatively small areas has become considerable. Prevalence of that class of diseases is attendant upon city life, and so constantly that, of a people among whom that class of diseases is known to prevail, city life may be predicated. But, it will be observed, by the time a population has become urban, a certain organisation, or at least certain habits of life, have been devised or fallen into before the danger referred to is felt, and have become more or less fixed and difficult to alter by the time necessity for alteration becomes apparent. In themselves these constitute an obstacle to the reforms which are then seen to be required. That nearly, and in relation to that one class of diseases that precisely, is where we find ourselves to-day. We have not so much to insist upon preventability as to endeavour to reform rooted habits of life. Yet it may be suggested that the danger should have been foreseen and guarded against by suitable organisation, either at first or from a very early date of settlement. That, however, was impossible for still other and all-sufficient reasons. Immigrants to a new land do not often comprise many of the best-instructed in the mother country; but, whatever their quality, they can but bring with them the knowledge which was current at the time of their departure. Now, it is very easy to-day to speak of "filth-diseases," and to point out the certain and easy methods of preventing them; but the knowledge which warrants the epithet now applied to them has not long been established, and, above all, has not long been current. It is but sixteen years since Sir John Simon, K.C.B., F.R.S., found it expedient to recapitulate the knowledge regarding their causation which had slowly accumulated under his direction during the preceding twenty-five years, and to present it in a formal report to the English Local Government Board, of which he was at that time the medical officer. At so late a date as that he found it expedient to write that remarkable paper, to illustrate it with notable instances, and to enforce it with all the arts of logic and of rhetoric of which he is an acknowledged master, for guidance of the chief administrative body of that day in England. This was necessary in that country which has led and leads the world both in scientific and in executive sanitation, in 1874. But by that date the filth-diseases had already become established amongst us, and were even attracting our attention.

My first object in making that quotation was not to reply to the opinion expressed in it. I wished to show that we have thus far enjoyed all the advantages and all the disadvantages of inheritance, in order to point out in relation to the present subject (to which, however, the quotation is cognate) that we labour under inherited disadvantages almost exclusively. We have inherited a law for the registration of births and deaths which was no sooner passed than it was seen to be defective in a most important respect.* And we have inherited a habit of decennial censuses. The decennial census has been again and again condemned in England—in a country where population is not only established, but to a large extent settled in districts and in towns so old as to have become fixed in those conditions of occupation which almost govern age-distribution. Even in such a country decennial enumerations, when not supplemented by annual rough enumerations under sex, age, &c., have been found to lead to remarkable error when their results have been used together with deaths to gauge the sanitary condition of localities

* The omission of *penalties* from the original Act was in most cases supplied upon its adoption in Australia.

in inter-censual years. Yet here in Australia, in a new country, where the population is annually recruited by immigration, where, to speak of one province alone, I have during the past few years seen in one case about seven thousand, and in the other about fifteen thousand, persons accumulate within two or three years upon previously uninhabited areas, and where similar displacements of population are common; where in the eleven years, 1876 to 1886, the excess of arrivals over departures was more than 528,000, or more than one-sixth of the total population in the latter year. Under these circumstances we adhere to the decennial census, and strive to supply its defects in intervening years by calculation. It is plain that this course must often lead to serious error; and in point of fact it was found at the census of 1881 that the enumerated population fell short of the estimated population by more than 67,000 in Victoria, and by nearly 30,000 in New South Wales, upon enumerated totals of 862,346 and 751,468 respectively.* The death-rates published in these provinces for 1881 (and proportionately in former years) must have been considerably below the truth, since they were calculated upon these exaggerated estimates; and in certain cities or localities they must have been still more erroneous—here by excess, there by defect. False impressions of the state of the public health must have been given for that if for no other reasons.

But there are other reasons, and most important ones. We have adopted the laws and organisation which, good or bad, were devised to suit an old country. They are especially unsuited to our circumstances. We inhabit a favoured land. If a comparatively small and scarcely inhabited area be excepted, there is no malaria in Australia; and it is precisely the absence or presence of malaria which distinguishes a healthy from an unhealthy climate. The carnivora which in some other partly occupied countries levy a heavy tax upon mankind and hinder settlement are entirely wanting, while the reptiles, if they are not for the most part harmless, are at all events of but small practical consequence. And then the country, although continental in size, is separated from the rest of the world by wide seas; it presents great variety of climate, but extreme cold in no part; and it is so fertile that, while production has long been in excess of local needs, the natural limit to increase is clearly almost infinitely removed. Nor are special conditions less favourable to life. Ample food, varied and nutritious, is easily within the reach of all; the terms of labour are uniformly reasonable; occupations and amusements are chiefly out-door; the specific population is everywhere low, if some comparatively small areas of the larger cities be excepted; and the general population is youthful.

* "Wealth and Progress of New South Wales, 1888-9." Mr. T. A. Coghlan, Government Statistician.

Comparing the Age-Distribution of the People Living in 5 Provinces of Australia, and in England, enumerated at the Census of 1881.

—	Enumerated Population 1881.	Less Ages Unspecified.	Proportion to 1000 Borne by the Numbers Living, at Age-Groups among the Enumerated Population										
			0-	5-	10-	15-	20-	25-	35-	45-	55-	65-	75-
Victoria	862,346	Distributed	132	127	126	116	97	115	107	104	51	19	6
New South Wales	751,468	2,416	148	132	118	101	100	148	115	75	39	18	6
South Australia...	279,865	Distributed	149	124	115	106	110	157	107	69	39	18	6
Queensland	213,525	2,874	152	128	109	86	99	171	143	73	28	9	2
Tasmania............	115,705	Distributed	140	123	119	116	103	120	88	80	63	35	13
England			136	120	108	98	90	146	113	84	59	33	13

Note. The data for these calculations are taken from the Victorian Year Book, 1887-8, pp. 65 and 66, by Mr. Henry Heylyn Hayter, C.M.G., Government Statist.

Now these are very special and very favourable conditions. But we who enjoy them are not native to them. In the proportion of about one-third, I believe, the population is merely immigrant; and for the remaining two-thirds, although they are actually native born, but a very small proportion come of native-born parents, and still fewer can be in the third generation of native-birth. So that not only the immigrants but the parents of the greater part of the native-born population (who came, of course, mainly from northern European countries) entirely changed their conditions of life when they settled in Australia. That change of surroundings will at last produce changes in the constitution, habits, and modes of thought, which were prevalent in the old world among them. In the future characteristics will inevitably develope, which may be properly called Australian, or racial. But such changes are not made in a generation or two. Such as may be observed in the earlier generations of the native-born are not of the kind referred to—that is to say, are not characteristic nor permanent. They are such as may be observed in the individual long resident in an alien climate, and such as are ready to disappear after return to the land of his forefathers. It is most important that this slowly-approaching, this momentous change, should be watched. But how does the case stand? Have any steps at all been taken to observe and to record it? Does any register exist from which its beginnings may be ascertained, and its direction forecast? The only way in which this could be done would be by connecting the individual records of birth with the corresponding records of death. But in no province, nor in all the provinces (which together constitute but one country, and on any reasonable plan of vital statistics would be dealt with as a whole, as well as in parts distinguished by their geology and their climate) is there the organisation which would warrant the statement of which our politicians are fond, that "we assist at the birth of a nation." For want of the foresight which is the characteristic of statesmanship, we do but stand by while a nation evolves itself—a nation that may some day arouse to find its mode of government unsuited to the altered customs, the altered habits of thought, the altered views of morals, into which it has been imperceptibly moulded by surroundings alien to the race from which it sprang, and from which it took its laws.

And under the circumstances of life in Australia which I have described, I venture to say that the manner in which many of the particulars at present gathered are often dealt with is not only useless but misleading. As we have taken the Acts from the old world, so (though by no means necessarily) are we in the habit of comparing the results they afford us with old-world results. It seems to be forgotten, or at all events it is practically overlooked, that death-rates have appreciable value only in relation to various coincidental conditions—to race, feeding, climate, density, as well as to many others. We never tire of comparing our general death-rates with those of countries which differ from ours in nearly every condition of life as widely as, on the same globe, is well possible; and especially we refer our results to English standards. If unlike things may be compared, that is inevitable; for English statistics are at once fuller and, with the discount to which all such figures are liable, more accurate than those of any other country. But it is only like things that suffer comparison; and when from the contrast of unlike things we draw conclusions eminently flattering to our own country—we have the flattery for our pains. It is simply impossible, under the general conditions described, that our death-rates for provinces should approach those of older countries as a rule. I will try to make this clear by giving an example of the comparison between unlike things to which I allude, and I will point out the extravagant lengths to which it may lead those who indulge in it unreservedly; and as I draw it from the annual statistical report of one province among several, I beg that it may be noticed that all such reports are liable to a measure of the same criticism, although not to the same exactly. I choose this instance, in fact, partly on account of the deservedly eminent reputation of the Government Statist of Victoria (Mr. H. H. Hayter, C.M.G.), who is officially responsible for it, and partly because it is apter, rounder, and more suitable for quotation than any other of the kind I have seen. Mr. Hayter says (and he repeats the statement annually in several years) that "it has been held by high authority that in countries in which the climate is healthy, hygiene properly attended to, and the population in a normal condition as regards age, the ordinary mortality incident to human nature would probably cause the death-rate to be in the proportion of about 17 per 1000 persons living;" and he then goes on to point out that in the province with which he is dealing that rate has been exceeded only seven times in 27 years, and that the average death-rate over that long series of years has been only 15.57 per 1000 persons living. What inference must be drawn from that comparison, which seems to show that in Victoria the "ordinary mortality incident to human nature" has somehow been eluded? What must the general reader, what must the legislator, whose studies may chance not to have included the subject of vital statistics, infer from it? Must he not conclude that his province is in fact doing remarkably well; that it affords no scope for the operations of preventive medicine, and wonder within himself what all the stir about legislation for health means? But when I mention that the high authority alluded to is no less a person than the late Dr. Farr, C.B., F.R.S., it will be suspected that error has somewhere crept in; and I will explain it in order to introduce some remarks touching the search for a health-standard with which to compare our rates, to which, indeed, the present fallacy is at bottom due. What Dr. Farr really said was this:—He had been examining the mortality in 54 healthy districts of England, and had found it to be 17 in the 1000 living, and he had compared it with the mortality for all England, which he showed to be 22 in the 1000 living. Upon those local facts he ventured to base the following generalisation of local application and use. He said: "It will not, therefore, be pitching the standard of health too high to assert than any excess of mortality in English districts over 17 annual deaths per 1000 living is an excess not due to the mortality incident to human nature, but to foreign causes to be repelled, and by hygienic expedients conquered." There is a wide difference, it will be noted, between Dr. Farr's cautious, conditional statement, and the nett, positive terms of the quotation I first made. But the point to which I now direct attention with reference to the search for a health-standard for this country is that Dr. Farr is careful to limit the application of his generalisation to England, to the observed facts of life among that particular population living under the particular conditions presented by that country. And, in fact, all health-standards must be drawn from the very countries within which they are to be set up, unless the comparisons made with them are to be delusive, misleading, and obstructive to true progress.

In giving that example, I have shown that its logical conclusion is a *reductio ad absurdum.* But a defence might be set up—it might be said that want of correction for age explains the alleged phenomenon. That would be sound as far as it goes, although, of course, it would be destructive to the comparison instituted. It is, however, far from being the only correction needed, as may be easily shown from another part of the work, where it is made, or rather allowed for. Mr. Hayter there uses Mr. Sargent's plan for eliminating the disturbing influence which inequality in age-distribution has over such comparisons between two different countries or cities. This consists in finding the death-rates in the two places at the usual age-groups, and in ascertaining the absolute number of deaths they would afford in each place upon the supposition that an equal number of persons were living in each at each age-period; and then in striking a rate upon each total hypothetical population with the two absolute numbers of deaths. Mr. Sargent called this a method of ascertaining the specific mortality—Mr. Hayter prefers to call it the "adjusted death-rate." Its use appears to be in places where the ages of the people are *known*, to save the trouble of redistributing one of the populations under ages to agree with the other. Mr. Hayter compares in this manner the mortality at age-groups (calculated mainly upon *estimated* numbers living at ages) in Victoria with that in England; and the result is still vastly in favour of the former. The general reader will, then, get from this comparison confirmation of the opinion to which the first led him—that there is in reality very little for sanitation to do in his province. But what is the fact? It is that the comparison is false. It is instituted between places which are quite different in general respects, as I have already pointed out; but they are different in the following particulars especially, which alone are fatal to the supposed parallel:—Victoria is a province which carries an estimated number of 1,036,119 persons (1887) on 88,000 square miles, of which 497,000 live in five cities, the largest having a population of 391,000. England is a country which carries 28 millions on 58,172 square miles, of whom 9,244,099 live in 28 towns, of which the largest has a population of $4\frac{1}{4}$ millions. This difference in density, and a dozen other differences involved in it, render the comparison misleading; and indeed a careful reader would find food for reflection if he observed that, notwithstanding these flatteries, the infantile death-rate of Melbourne and suburbs is (mean of 10 years 1878-87) 169·7, and higher by 17·7 in the 1000 than that of London (mean of 10 years 1877-86, 152), although the latter city carries more than ten times as many people on less than half the area.*

I need not press these particular examples farther, having chosen them, indeed, chiefly because Mr. Hayter's eminence in several branches of statistical enquiry goes far to render them conclusive. After repeating, therefore, that all our statistical reports are open to similar criticism, I just mention those of the Registrar-General for Tasmania (Mr. Robert M. Johnston, F.L.S.) I regard the labours of this gentleman with respect, and all that I wish to say of them is this: he shows not only that he is very well aware of all the points to which I am now in cursory fashion drawing attention, but that while writing he has them constantly in mind; yet he falls, after all, into what I may call the familiar error of the professed statist. He strives to supply the place of observed facts, which are wanting, by allowance and by calculation. Now, I do not contend that such methods are unjustifiable or always profitless. Among statists they may sometimes serve a useful purpose; and indeed, were the facts unascertainable, we might all of us have to be content with cautious speculation, and we might derive from it that support which is afforded by theory when facts begin to fail. But that is not the present case: the facts are accessible, and their observation is in many respects a mere matter of suitable organisation. That being so, I do not know but our statists are seriously in error to amuse us with speculations which are largely of theoretical bases, and which those unacquainted with statistics cannot effectually scrutinise.

I just now called such errors the familiar errors of the professed statist; and they are not confined to the gentlemen who comment on our records here. The Government Statistician of New South Wales (Mr. T. A. Coghlan, Assoc. M. Inst. C.E.), reproduces in his volume of "The Wealth and Progress of New South Wales" for 1888-9 the mean after life-time at ages calculated for the people of Queensland, New South Wales, and Victoria, taken

* London: *scilicet*, Registration London; now the "County of London (for administrative purposes)."

together, by Mr. A. F. Burridge, F.I.A. I have not seen the original paper, but the table is apparently constructed from the deaths registered during the 12 years 1870 to 1881, and the census enumerations of 1871 and 1881 (assisted in Queensland by the enumeration of 1886), the age-distribution for intervening years being calculated. With the aid of the result Mr. Coghlan, like his *confrères*, draws comparisons between the expectation of life in these provinces of Australia and in other parts of the world, which are very flattering to the former. But, without going to the very bottom of the calculation, and there is much to be dug up thence and anxiously scrutinised in all countries in which decennial censuses are the rule, what is a life-table designed to do? Is it not designed to ascertain the after life-time at ages of a particular race living under particular conditions? The possibility of constructing a life-table for a population which increases by immigration as does that of Australia may well be questioned; but apart from that, of what value is such a table to Australia, or to the world, from which the racial or national or Australian element is absent, or in which it is present only in unrecognisable form and inappreciable amount? Are not all these comparisons between unlike things, and all these methods which use elaborate and hazardous calculations to supply the place of observable but neglected facts, distinctively unscientific? Direct observation of the fact, patient accumulation of recorded fact, self-restraint from speculation until the body of accumulated fact is sufficient to warrant induction, and, last of all, *induction* with aid of whatever mathematical formulæ may then seem useful —these are the essential conditions of experimental enquiry. In relation to vital statistics we neglect them at present, or make little more than a show of observing them.

Having now indicated the quality of the results which our modes of enumeration and registration furnish, and the practically futile character of some of the calculations, comparisons, and inferences which are based upon them, I proceed to touch upon the second branch of the topic which I mentioned at first. This is the use of the same set of observations (or of part of them) for the immediate purposes of practical sanitation. And just as record of the duration of life is the leading feature of the data from which it is proposed to deduce the vitality of a nation, so accurate record of the cause of death is the leading feature of the register which is used to give direction to sanitary organisations. But upon this essential point—accurate return of causes of death—I need not speak; most of us have already fully considered it in relation to the organisation at present sanctioned by our Governments, and most of us are of opinion that the returns the latter yields are in this respect seriously open to question. I therefore merely insert in a note some facts which are sufficiently suggestive.

In South Australia alone is a medical certificate of the cause of death required by law in cases in which a medical man has been in attendance. Elsewhere deputy or district registrars are instructed to enquire for the name of the medical attendant, and, if possible, to get a certificate from him; in some cases the form of register prescribed in schedules to the Act includes a column for this entry, in others it is required by regulations made by the Registrar-General; but when no medical man was in attendance, any person qualified or required to give information touching a death may assign a cause to it, and the Registrar is nowhere forbidden to enter causes so assigned. In the second place, the official nosology of the Royal College of Physicians was in one province used for the compilation of a list to assist district registrars in their duty, and there were included in it directions for dealing with causes of death which might be assigned in popular terms. The following are a few of these, taken almost at random:—"Cauliflower" is to be recorded under Order VI., Class 8, 2; "cold, a vague term; was it bronchitis? pneumonia? influenza? if undefined, Order I., Class 1, 8;" "collapse—what was the cause? class accordingly" (in these two instances it seems that the District-Registrar, who has not seen the case, and who would not be much the wiser if he had, is to ascertain and classify the cause of death, after consultation with other unqualified persons); "constriction of the brain—bad; Order VI., Class 1, 13;" "yellow fever (remittent fever), Order I., Class 1, 15;" "shivering fit (ague?) vague; Order I., Class 3, 2." This list was adopted in other provinces after its appearance in the first. It therefore seems to have supplied a want, and to have served a purpose. Thirdly, Registrars-General, under the older classification, returned deaths from unspecified causes in the proportion of about less than one per cent. to total deaths; and under the newer classification in the proportion of from about 8 to 10 per cent. to total deaths (the proportions, perhaps, having been nearly the same all along, but being now more easily seen.) Finally, since "certified" and "uncertified" deaths are in no province discriminated in the abstracts (nor, I believe, in the registers), there are no means of judging (unless the list quoted be taken to supply them) whether the 8 or 10 per cent. mentioned really include all the deaths which should, in a reasonably accurate sense, be returned as due to unspecified causes.

In South Australia a medical certificate of the cause of death is not only required in cases on which a medical man has been in attendance, but the latter is compelled by law to furnish it. That the cause of death should be ascertained in every case (as far as possible) by competent observers is, of course, essential; but a law under which a class of the people is compelled to render skilled or professional service to the rest gratuitously, and under penalties for failure, is obviously and grossly unjust. The Government of South Australia, on the one hand, neglects to oblige its paid officers (the coroners), who are especially appointed by it to ascertain the cause of death in doubtful or suspicious cases, to desist from returning such futile verdicts as "death from natural causes;" and on the other, goes out of its way to enforce under penalties return of the cause of death in cases to which no sort of suspicion attaches by members of one class of the people governed to whom it stands in no special relation whatever. The violation of liberty thus described is of infinitely greater moment than the injury inflicted on the particular class that in this case happens to suffer, and should be found of very general interest, as it is of general, and of the highest, importance.

Annual rough enumeration of the people living within defined areas of comparatively small size (which should be, of course, merely subdivisions of larger defined districts), with registration of births, and of deaths under causes, within the same areas, together with regular prompt return of the observations as they are made to the chief medico-sanitary authority of the country for analysis, is the life principle of practical hygiene. The more preventable diseases are, if not of local origin, at all events of local immediate causation; the measures to prevent them must, therefore, be of local application. Where this information is wanting, whatever the administrative and executive sanitary organisations may be, and whatever their possible efficiency, their efforts must in many most important respects be without system, diffused, wasteful, and must therefore yield results incommensurate with their cost in money, in labour, and in thought. It is possible to express the reason on which this statement rests in a sentence: Deaths are never distributed equally over districts. Preventable deaths occur where removable causes exist; not elsewhere.

Now, there is not in any province—I judge from official reports—the organisation here referred to; the numbers of the people are *estimated* from year to year; and this, which is a hazardous process when applied to the population of a whole province, becomes simply deceptive when applied to cities, and especially to parts of cities; the sex and age-distribution are brought on from the decennial census enumeration in a similar way, and in districts, at all events, are therefore in reality unknown; and the record, imperfect as it is, is not dealt with for purposes of local sanitation by the medical officer of any authority.* I will illustrate the result of this want of practical organisation—again a failure to refer to the fact, and so far a lack of scientific method—by a concluding comparison; it shows that the work of central health authorities is done under difficulties, or rather, not to mince the matter, for want of this kind of direction exactly, remains practically fruitless in a most fertile field. I choose for the test the proportion of deaths from filth-diseases† and enteric (or typhoid) fever, because it is now notorious that if sanitation can certainly do anything at all—and it can do very much—at all events its first and easiest successes are against that class of diseases. That is now a well-established fact; so that the efficiency of any sanitary organisation may be fairly gauged by the proportion of deaths that occur among the people living under it from those diseases. My comparison is, of course, between Victoria and New South Wales; not only because those provinces are similar in population and in many other respects, but because they differ distinctively in the most important point—in sanitary law and organisation. But the two provinces are not comparable as wholes, because they carry a similar population on widely different areas. I therefore select the metropolitan areas in each case; and that

* Dr. H. T. Whittell has for many years been Registrar-General for the province of South Australia, and for some time President of the Central Board of Health as well.

† By filth-diseases, diarrhœa, dysentery, and cholera are intended.

is the more suitable because the filth-diseases, &c., are diseases of urban life. The Melbourne metropolitan area is marked off by a circle of ten miles' radius described from the centre of Melbourne. It includes 256 square miles,* and it carried an estimated population of 391,546 persons in 1887. The Sydney metropolitan area measures 256 square miles, and is of irregular shape. It carried a population estimated at 350,866 in 1887. From this statement, and on inspection, the two areas seem fairly on a par as regards density, the people on both being chiefly centered at one part, and for the rest scattered irregularly over rural or quasi-rural districts. As to geological character, I am informed by the Government Geologist of New South Wales (Mr. W. C. Wilkinson), who has surveyed both areas, that as regards permeability of soil and retentiveness it may be taken that there is not much difference between the two; but although Melbourne stands on seven hills, these are but low, and of a conformation which distinguishes them from that of a part of the Sydney area where abrupt ridges abound. As to climate, in Melbourne the hot season is shorter than in Sydney, and the cold season when it comes is much colder. The yearly mean temperature (22 years) is 57°·2 F. in the former, and 63° F. (29 years) in the latter; the mean yearly rainfalls, 25·53 inches and 48·96; the mean yearly number of days on which rain fell, 130 and 154. Melbourne is near the sea on the south coast, Sydney near the sea on the fertile east or Pacific coast; the latitudes, 37° 49′ and 33° 5′ S. lat. All the difference as regards influence of climate on the diarrhœal diseases is in Melbourne's favour, and there is also an artificial difference between the two which is of especial importance as regards prevalence of fever. Melbourne has been supplied with excellent water from a very early date, and its distribution by pipes has more or less kept pace with the growth of population and the extension of suburbs. Sydney, on the other hand, until the third month of 1886, had but a scanty supply, drawn from a source which was (during the years presently dealt with) befouled. This imperfectly served the *city* (122,000 in 1885) and some districts adjacent to it. As far as enteric fever goes there was, therefore, during the period dealt with a very great advantage on the side of Melbourne. Next as to sewerage. It may at first sight be supposed that the *city* of Sydney (population 87,000 to 122,000, 1876-85) has in this respect an important advantage over Melbourne, since it has for many years been sewered. But these conduits are "imperfect sewers, constructed at different times, in various fashions, running in many instances on unrecorded and now forgotten lines, without ventilation, and discharging into the tidal waters of the harbour."† Many

* The circle encloses a part of the bay.
† See "A Record of the Sanitary State of New South Wales, on December 31st, 1887." Sydney, Charles Potter, Government Printer, by the present writer.

of them are in fact either natural channels covered over, or made-drains which have been converted to the use of sewers; and, as the manner in which house connections are made corresponds in point of defectiveness with the construction of the channels mentioned, each must judge for himself whether they are likely to be an advantage to the people using them, or the reverse. On the other hand, Melbourne has no system of sewers at all. Lastly, the age and sex distribution of the two populations cannot be compared (except by estimate, which in the case of any small area, at all events, is in my opinion more properly called a guess); but the birth-rate and the rate of natural increase are considerably higher in Sydney, and that, of course, gives her an advantage over Melbourne. So that in this comparison, while the two metropolitan areas are nearly on a level as regards population, specific population, and geological characteristic, Sydney has the general advantage of a higher birth-rate; Melbourne has the great advantage, as regards fever, of a pure and copious water supply, and as regards diarrhœal diseases, that of a colder climate. The balance between them may therefore be now struck. The difference as regards laws is as follows:—

Victoria enjoys a very complete set of health statutes, the earliest of which dates from 1865; it has a Public Health Department, within which is a Board of Health not only well known to be composed of earnest gentlemen, but having the advantage of the sagacious advice of its permanent President, Mr. A. P. Akehurst; and it has local medical officers of health and local boards of health. New South Wales also has a Health Department, within which is a Board of Health, which my position precludes me from more than mentioning; but that province as yet has not any health statute at all, and of special laws relating to health has only a Quarantine Act, a Dairies Supervision Act, and an Infectious Diseases Supervision Act, which applies to small-pox alone. That board has statutory powers under other Act whatsoever. So I describe closely similar areas in two provinces, in one of which elaborate health statutes, administered by able officers, are operative, while in the other are (as regards the class of diseases especially referred to) absolutely no legal powers at all. I repeat once again that if executive sanitary organisation can do anything, it can reduce the prevalence of fever and of filth diseases, and theretore—unless there be something wanting—that class of diseases might be expected to be rife in the Sydney area, but should be nearly absent from the Melbourne area. I shall not be misunderstood, I am sure, yet I will say distinctly that the question now under examination is why these diseases, notoriously too prevalent amongst us, continue to prevail; and although the circumstances detailed with regard to the two cities mentioned render their experience especially useful in finding the answer, I do not conclude upon a comparison between them, but upon a general inference which has application to every urban district in every province.

SHOWING THE AVERAGE DEATH-RATE PER 10,000 PERSONS LIVING IN THE METROPOLITAN AREAS SYDNEY, N.S.W., AND MELBOURNE, V., FOR THE TEN YEARS 1876-85, DUE TO ENTERIC FEVER AND THE DIARRHŒAL DISEASES.

Metropolitan Areas.	Average of estimated Mean Population.	Average Density.‡	Average Birth-rate per 1000 living.	Natural increase per cent.	Average Death-rate per 1000 living.	Average Death-rate due to Typhoid and Diarrhœal Diseases per 10,000 living.						Percentage Typhoid and Diarrhœal to Total Deaths.	Infantile Avrg. Death-rate.	Variation.
						Typhoid.	Variation.	Diarrhœal Diseases.	Variation.	Typhoid and Diarrhœal.	Variation.			
SYDNEY*	225,460		39·6	1·9	20·9	6·40	+ 2·66 – 2·32	18·58	+ 2·59 – 2·95	24·95	+ 4·41 – 5·24	11·98	172	+ 20 – 19
MELBOURNE†	284,525		33·2	1·3	20·1	7·31	+ 4·65 – 2·34	16·03	+ 4·13 – 3·48	23·34	+ 7·45 – 5·05	11·59	167	+ 20 – 17

* The data for these calculations are taken—for population, from the "Wealth and Progress of New South Wales" for the year 1886-7, by T. A. Coghlan, Esq., Government Statistician, the means being deduced from the estimated numbers at the end of each year: for other rates from the several Reports upon Vital Statistics made, for the years dealt with, by the Registrar-General.

† The data for these calculations are taken from the Statistical Register of Victoria, Part IV., Vital Statistics. 1887 (for 1886); but for infantile mortality from the Victorian Year Book, Vol. I., 1887-8, both by Henry Heylyn Hayter, Esq., C.M.G., Government Statist.

‡ The distribution of the two populations on their respective areas is such as renders statement under this head unimportant.

In 1886 the Sydney water supply was modified; a mixture of pure water with the foul was distributed. In the third quarter of 1887 the foul service was finally discontinued. A water of great purity was turned into existing mains, and, as it was at command far in excess of the needs of all the population within reach of it, extension of the service was thenceforward carried on with energy. The following table, which deals with the time elapsed since the close of 1885, has been obligingly furnished by the Government Statistician of New South Wales (Mr. T. A. Coghlan). The time is too short to warrant expression of opinion upon it in relation to water-supply; but apart from that, the fall it shows seems rather greater and more pronounced (on comparison with similar rates for former years) in deaths from the diarrhœal diseases than in those from fever. This points to some other influence at work as well as a supply of purer water, and the number of houses which during the same years have been properly connected with new, good sewers is not sufficient to constitute it. It is true, however, that during these years especial efforts have been most strenuously made in many municipal districts to abolish the once universal cesspit, and have been most successful; and this is an alteration which would tell against both diseases. Were it possible to compare different districts of Sydney on the lines indicated in the text, it might easily be judged to what extent this abolition of cesspits has been effectual; for there are some populous districts formerly (or down to about four years ago) riddled with them, which now have for all practical purposes none at all, while others have remained in this respect quite neglected.

Year.	Sydney.				Melbourne.			
	Typhoid Fever.	Death-rate per 10,000 of the mean population.	Diarrhœal Diseases.	Death-rate per 10,000 of the mean population.	Typhoid Fever.	Death-rate per 10,000 of the mean population.	Diarrhœal Diseases.	Death-rate per 10,000 of the mean population.
1886	299	9·22	469	14·46	294	7·91	642	17·27
1887	191	5·58	354	10·33	338	8·63	652	16·65
1888	182	5·07	429	11·96	326	7·77	546	13·00
1889	209	5·58	465	12·43	559	12·78	608	13·90

That is the comparison. I ask whether it shows any difference in preventable mortality from the diseases named, such as might fairly be expected under the different circumstances described? What is the reason? Is sanitation, after all, powerless? Far from that. Not in Victoria and New South Wales alone, but in all the provinces, the work of sanitation is being attempted in the dark for want of precisely the kind of direction which might be, but is not, got from a well-planned record of births and deaths.

For this purpose of preventing diseases—and especially for preventing those which prevail in special localities, whose spread is in the main due to local faults—the facts regarding death are useless when they are returned only for areas of large extent. We sometimes see, to take an extreme instance, death-rates from one or other cause of disease carefully struck upon the population of whole provinces, and compared together. We see comparisons drawn between the number of deaths from typhoid or from phthisis, for example, in different provinces, a rate being struck with the total estimated populations; and the results show that as regards them, Queensland heads the list. Of course such a comparison, if used as an indication of sanitary condition (and I do not see any other object in making it), is false for several reasons : as because typhoid fever is practically a disease of the first three *lustra* of adult life, and because new-comers to a neighbourhood or a country are its especial victims, while Queensland has for long received a steady stream of youthful immigrants, whose deaths (in such comparisons) are not distinguished from those of the residents ; and similarly with phthisis.* But suppose such

Birthplace of Deceased.	1884.	1885.	1886.	1887.
Queensland	32	45	31	32
Total Australia, Tasmania or New Zealand	51	65	45	42
India and China	15	13	10	17
Polynesia	261	271	188	159
Other Countries	236	234	244	220
Unspecified	9	10	7	3
Total	572	593	494	441

comparisons were fair : considering that typhoid is a disease of locality, of what practical use is a statement which represents it as prevalent among 367,000 persons, occupying 700,000 square miles of territory? Does it afford any other information at all than that typhoid is there? Clearly not. But let another course be taken. Let the locality of the deaths be known, and they would be seen to occur in urban districts chiefly; then in particular neighbourhoods of those districts; lastly in particular streets, and even especially in particular houses in those streets; and, armed with this local knowledge, the sanitary authority could ascertain the local cause, and fulfil the sole object of its creation by removing it. And the case is not far different when rates are returned

* The Registrar-General for Queensland records the birthplace of all decedents from phthisis, and with the following instructive results.

for whole cities, or even for municipal districts within them. Such rates teach nothing of practical importance to the prevention of disease.

Before accepting the invitation to occupy this chair with which the Council of the Association honoured me, I considered whether it were possible to indicate any particular work on which this section might profitably labour at once for advancement of the Science of Hygiene, and for the immediate benefit of the people of this continent. After looking in several directions I thought I descried one that stood forth pre-eminent. I have now striven to point it out; but if I may say that, following the custom usual on such occasions as this, I have indicated rather than described it, if for that reason I have not entered into great detail, nor spoken with complete fulness, I am aware in addition of very many deficiencies, for which I ask indulgence. I have endeavoured to say as much as will lead you to pursue the subject farther, and more deeply. I have tried to suggest that, as matters stand, we are not watching the growth of a race, but overlooking it for want (among other things) of connecting our registers of birth with our registers of death. And I have endeavoured to show that our sanitary organisations in general are wasteful and fruitless for want of the guide which annual rough-enumeration of the people under sex, age, and rateable value of the houses they respectively live in; return of causes of death by the medical profession, and registration of them under medical supervision; analysis of that information by the central health authority, and its frequent and speedy publication would furnish. I do not know of any work in any department of science which is more important to the welfare of the people of Australia, either for the immediate purpose of preventing disease here and now, or for the ultimate purposes of good government; and I venture to conclude by commending to your attention very earnestly the immediate necessity which exists for reforming in many respects our present methods of enumeration and of registration, and for procuring these to be done under one universal law, and one uniform plan, in every province of Australia.

PRESIDENTIAL ADDRESS IN SECTION I.

LITERATURE AND FINE ARTS.

By J. W. AGNEW, Esq., M.D.

I am conscious that many local members of this Association could fill the Presidential chair of the Section of Literature and Fine Arts much better than I can pretend to do. It is therefore necessary to mention that those members are ineligible for election, as the rules of the Association provide that no resident of the colony in which a General Meeting takes place shall hold the position of President. This rule alone has induced me, as a representative of Tasmania, to take the chair, although it is scarce necessary to say I feel deeply sensible of the honour of having been elected to it.

In formally opening the section, I propose to offer but few general remarks on the various subjects of which it takes cognisance, as I desire more particularly to consider the present condition and probable future development of these subjects in Australasia. The first which presents itself is Literature, but this alone, even if we regard only that of our own country, presents so vast a field for comment that it is clearly impossible, within the scope of a brief address, to do more than touch a very few of its more salient points. At no period in history have such floods of literature been poured forth for the instruction and delight of a reading public as we see at present. To those of us of an older generation it is marvellous to note the amazing amount of sterling work, formerly from its high price the heritage only of the few, which is now, owing to improvements in the mechanical arts and other causes, brought virtually within the reach of everyone. And it is not only in the supply and accessibility of books for the multitude that improvement is manifest; the same advance has taken place in the general excellence of literary work itself. History of all kinds, for instance, has ceased to be a mere compilation of dates, and bald and dry records of the more striking events of the time. Truth, myth, and fable have been relegated to their proper spheres. Evidence is more carefully weighed and sifted, and stricter accuracy, the result of original research in national archives and other collections freely thrown open to the enquiring student, has been more generally secured. Being written, too, in a more broad and philosophic spirit, and dealing with the inner life and habits of the people, history has become a far more instructive study, whilst the sidelights which are being continually thrown upon it by the increase of biographic and other literature add more and more to its value. Its boundaries also have been enlarged within comparatively recent times by the discovery of ancient records of surpassing interest, which, being deciphered by the acumen of Egyptian and Assyrian scholars, reveal to us the wonderful story of great, powerful, and civilised nations long buried in oblivion. And if the East has been compelled to give up her secrets, may we not hope that the western world will also be induced to do so, and that further researches in Central America among those mysterious cities of a vanished and forgotten race may result in the discovery of some key to their numerous hieroglyphic inscriptions, and thus furnish yet another fascinating chapter to the literature of the world. A hope may also perhaps be entertained that in this age of research, discoveries may even yet be made of a lost literature in the case of one of Europe's oldest civilisations. Our museums show many an exquisite production of Etruscan art; it would therefore be doubly interesting should some happy "find"—some Rosetta stone—introduce us to the literature itself of old Etruria, especially as, like its national art, this would probably afford evidence of ancient Greek and Egyptian influences, and possibly solve the mystery of their introduction. The literature of the Press, within my own recollection, which dates back to a period beyond half a century, when *The Times* itself boasted of but two leaves of modest dimensions, has made an enormous advance, that of the leading papers—Australian, we may be proud to say, as well as English—being now generally so excellent in tone and literary finish as to leave little or nothing to be desired. To this double excellence is due the admitted pre-eminence of the English newspaper, while to the energy and ability with which it is conducted may also be ascribed, among other matters, that comparatively recent development known as war correspondence. This is undoubtedly a peculiar field for literary work, yet the ubiquitous correspondent, animated with a fine courage and severe sense of duty, never fails, under the most desperate circumstances and exposed to all the deadly perils of war, to furnish us virtually from day to day with graphic pictures, Homeric in personal interest, of every passing incident of the campaign and battle-field. Compare these brilliant productions with the staid official reports of the same scenes and occurrences, and we realise how much we owe to the daily press for giving us a new and stirring literature of universal interest. The increase in periodic literature, teeming as this does both with lighter works of imagination and with weightiest matter by the foremost writers of the day, is a very notable fact, whilst the favourable terms on which it is supplied point, in a highly satisfactory manner, to an enormous demand on the part of a vast, reading, and well-to-do public. I can here only allude to the incessant issue of work of the severer type, scientific, philosophic, classical, theological, critical, &c., which supplies the requirements of a large and learned section of the community, and amply vindicates the science and scholarship of the day; but there is still another class of literature which, from its general acceptance, may warrant a brief special notice. I refer to the modern novel, which may truly be said to come upon us not in single spies but in battalions. Many novels no doubt are of little or no worth, yet in others, although no such transcendant genius as a Scott, a Thackeray or a Dickens writes at present, the amount of thoughtful and superior work which not only adorns the tale but points a moral, is a distinctly increasing quantity. Much of this work, too, has borne good fruit, as by its means, even since Dickens wrote, abuses of various kinds have been brought under the notice of an indignant public, with the effect of securing beneficial reforms. This advance in general tone and style affords a reason for the higher position now occupied by the novel than was the case, with few exceptions, in my early days, when its influence on the youthful mind was regarded as so objectionable, that in my own instance at least, which I presume was not exceptional, I was generally compelled to secure the much coveted volume by means of a somewhat questionable character, and snatch a fearful joy by devouring its contents in secret. This improvement in a large proportion of novels argues a healthier taste in a corresponding proportion of the community, and this again is but the natural result of that moral and material progress which is so generally evident. It has no doubt been the complaint of centuries, and the great Roman lyrist, from the frequency with which he is quoted, has perhaps something to answer for in this question, that the world is retrograde rather than progressive. But facts alone surely confute such a contention, for had every generation lived but to produce a successor worse than itself, it is clear that beings little better than savages should now have possession of the earth. Yet how different is the reality! Never has there been an age in which active and intelligent philanthropy has been so conspicuous, nor in which zeal, charity, self-denial, and even life itself, have been so freely expended on so vast a scale and on so many and such varied objects. It must certainly be admitted it cannot yet be said that this is "the best of all possible worlds," nor that the present is superior in every respect to some past ages that can boast the possession of those shining lights in art and literature which still glitter through the pages of history. But our incalculable superiority to the past is manifest in the diffusion of letters, not merely among the favoured few, but broad-cast throughout the masses, and it is clear that the cultured intelligence which is necessarily and increasingly the result, must prove a most powerful factor in raising the general level of humanity in the present, and in happily rendering a recurrence of "Dark Ages" impossible in the future. Yet, although the novel participates in this general advance, many worthy people still see in it a snare, and regard it with but scant toleration. The number of these objectors, however, steadily diminishes, and lighter reading, even if it convey no particular lesson, when pursued within due limits and as a relief from severer studies or occupations, is now generally regarded as not only harmless in itself, but as of actual benefit in lending an additional attraction to the home circle. It may also be recollected that our novel may prove in some distant future to be of historic value, in affording an accurate picture of the inner life, manners and customs of its age. We know something of "The glory that was Greece, and the grandeur that was Rome," but in addition to what we can gather from plays and other writings, what would we not give for such a full and accurate presentment as that afforded by the novel, of the social life and everyday walk and conversation of the people themselves? And here, as circumstances enable me to do so, I desire to couch a lance in behalf of one of our most brilliant delineators of modern life and character, George Eliot. In a public lecture delivered here not long ago, dealing in a very kind and appreciative spirit with George Eliot's writings, it was said that on reading her biography by Mr. Cross, the impression received was to the effect that almost all of the authoress was in her works, and that little or nothing was left for the friends of her social circle. If this be the case, I have good reason to say the biography, unwittingly no doubt by its author, conveys a very faulty impression. A few years ago I had the pleasure of knowing a personal friend of George Eliot, a man of exceptional culture and acquirements. He always spoke to me in most glowing terms of the social gifts and graces of the great authoress, of her amazing and charming power of ready sympathy, of her quick intuitive perception, clear judgment, and admirable common sense. With one expression in regard to her more serious conversation I was particularly struck—"In fact," he said, "when walking and talking with her I always felt as if I walked and talked with Plato." In connection with this supposititious failure of George Eliot as a social unit, a suggestion was also hazarded on the occasion already alluded to, that it may even be well we know so little of the social life of Shakespeare, as it was possible he may there have shown no indications of his genius, nor have risen above mediocrity. But when we see that George Eliot's supposed deficiencies were actually non-existent, this allusion to her case can have no weight. And when we consider the peculiar brilliancy and exuberance of Shakespeare's imagination, and take into account not only the admiration and respect, but the warm affection with which he is spoken of by such a learned and caustic writer as Ben Jonson, it is impossible, I think, to fancy he was not endowed with the fullest share of all those bright and genial gifts that enliven and sweeten social intercourse. Had there been a marked deficiency in this respect, it would have been so phenomenal in his case, that Jonson would surely have referred to it rather than to a matter of such small comparative interest as his friend's imperfect knowledge of Latin and Greek. But to come nearer home, it may be asked, What of the future of Australasian literature? Obviously the time has not yet arrived for the production by writers of Australian birth, of work requiring long literary apprenticeship, original research and learned leisure, but it may confidently be said our literature of a lighter character, whether periodic or otherwise, already indicates a very great amount of native ability. The weekly press, though dealing more largely with English fiction, affords a certain amount of publicity, encouragement, and training to native writers, several of whom have in consequence been enabled to undertake work of a more ambitious or permanent character. We have, for instance, seen of late that a novel by a former well-known contributor to the *Australasian* has had a wide acceptance even at home, and as its gifted authoress, "Tasma," resided in Tasmania from childhood, her book, which treats largely of local scenes and subjects, may truly be regarded as indigenous. The same may be said of other recent works by Rolf Boldrewood—a pseudonym familiar to readers of the local press—which from their wealth of startling incident, brilliant descriptive power and true local colouring, have secured a very large amount of public favour. Other native writers too, I have reason to know, are coming to the front. An authoress of world-wide repute at home, Mrs. Humphry Ward, is a native of Tasmania, but having left that colony at an early age, cannot be claimed as an Australian writer, nor do I think that other than home influences are visible in her works. Several novels, thoroughly Australian in scope and character, have been written locally, or from local experience, though not by native writers. Among the best known are: "Geoffrey Hamlyn," "His Natural Life," and "The Broad Arrow," all of which are likely to live, as they present well-drawn and interesting pictures of scenes peculiar to a past phase of colonial life. And as in prose so also in poetry, Australian influences have already inspired some admirable work, though for the most part the writers have been born and nurtured under other skies. Among these a foremost place will readily be accorded to Adam Lindsay Gordon, whose brilliant lyric and descriptive poems, many of them redolent of bush life, have taken a firm hold on the public mind, and will be long and deservedly held in appreciative memory. Some of them, indeed, will no doubt take permanent place in our national literature. A peculiar interest, at the same time, due to what is known of his unfortunate life and chequered career, attaches to much that Gordon wrote. Chivalrous feeling, refined taste, scholarship, and the true spirit of poetry are distinctly evident, but indications are not wanting that deep regret for what he had lost, and for what he ought to have been, was a frequent experience, and that he accepted his existing position only in a spirit of gloomy resignation—a condition which we know unhappily developed at last into despair. The somewhat complex philosophy of a character generous and unselfish in one phase, almost reckless in another, yet withal capable of attracting in a remarkable degree both sympathy and regard, is perhaps slightly shadowed forth in his own lines, which, under the circumstances of the writer, are not without pathos—

Question not, but live and labour
  Till yon goal be won,
Helping every feeble neighbour,
  Seeking help from none :
Life is mostly froth and bubble,
  Two things stand like stone—
KINDNESS in another's trouble,
  COURAGE in your own.

It must be admitted, however, that a large portion of Gordon's verse is inspired by English scenes, sentiment, and associations, and the same may be said of that of another poet, who is nevertheless to be considered in some degree as Australian, his best work having been done in the land of his adoption. I refer to Brunton Stephens. For sustained power, wealth of polished language, and felicity of diction, his longest poem, "Convict Once," stands, I think, alone in Australasian poetic literature. Local influences may be seen in such allusions as—

Out on the gem-pointed Cross and the glittering pomp of Orion
Flaming in measureless azure, the coronal jewels of God,

but many of his minor pieces are far more thoroughly Australian in subject, while several are characterised by a happy vein of humour not dissimilar to that of Calverley. Comparisons, I believe, have been made between his merits as a poet and those of Gordon. None of Gordon's verse, I think, equals "Convict Once" in fine sustained power, but English literature affords many proofs that the briefest emanations of genius, if they worthily appeal to human sentiment and feeling, frequently secure an enduring fame and popularity denied to apparently grander and more ambitious efforts. Brief and imperfect as this notice of our poets must necessarily be, mention must be made of one whom Australia can wholly claim as a son, namely, Henry Kendall. Imbued with a passionate love for the land of his birth, intensely sympathetic with the poetry of nature, especially perhaps in her wilder and weirder aspects, and gifted with uncommon power of vivid description, Kendall, on his first appearance as an author, was quickly recognised as a true Australian poet. His name indeed soon became known at home, and in an English magazine, I think the *Athenæum* a most complimentary notice was given of his poems, the reviewer even quoting several of them at length. It is singular that in a recent (1886) local edition of the poet's works, none of these pieces selected for favourable comment are included. In one of them I was much struck by the graphic rendering, in the space of a single line, of a moonlight effect,

> A white sail glimmers out at sea—a vessel walking in her sleep.

The mystic and dreamy picture here so well presented is very characteristic of some moods of the writer. But although Kendall has secured for himself a permanent place on the roll of Australia's poets, it is a subject for regret that his life was not further prolonged, and under circumstances more favourable for poetic work, for excellent as this is, the brilliant productions of his earlier years gave promise, I think, of something even still more so. The amount of published poetry by other writers in Australasia is very considerable, as is evidenced by the large, and apparently exhaustive, collection on the shelves of the Public Library of this city. Before leaving this subject, I may observe it is a matter for congratulation that our future poets and dramatists must always have an equal and common share with their English brethren in that peerless exemplar already alluded to of all that is greatest and best in literature—Shakespeare; of whom indeed many an enthusiastic student would probably venture to go even so far as to say:—

> Quo nihil majus meliusve terris
> Fata donavere, bonique Divi,
> Nec dabunt.

It may, in fact, be a question if English writers have not in this respect an exclusive privilege. Other nations certainly have our poet in their own vernacular, but when we know how well-nigh impossible it is to give in a strange tongue a perfect reflex of any supreme poetry, with all the subtle cadence and music of the words first married by the poet himself to his imaginings, it is clear that any attempt to render the finer issues of Shakespeare by a translation must practically end in failure. It may be noted, too, that the very perfection of our great dramatist not only renders him virtually impossible to the translator, but has probably the peculiar effect of preventing him from being even the founder of a school, as it has been well observed by an English writer: "If Shakespeare founded no school, that is because no school of Shakespeare is possible. It is only the artist whose perfections are not unapproachable who can found a school." Here it may not be out of place to refer to an article in the *Contemporary Review*, of October, 1889, which must go far to convince even the most stubborn sceptic of the real personality of Shakespeare. The argument that the writer whom we know by that name could not, owing to defective scholarship, have painted such scenes from ancient history as those given in his plays is proved to be utterly untenable, as it is shown that by available translations and other means a sufficient knowledge of any character in whom he was interested could easily have been acquired by Shakespeare. The wonderful alchemy of his own unrivalled creative genius did all the rest in transmuting those pale phantoms of Greek, Roman, or Egyptian story into living, speaking realities of like feelings and passions as ourselves. On the whole, the clear and satisfactory conviction left by the article is that the name of Shakespeare is rightly associated with his plays, and that it will therefore continue to burn as brightly in the future as it has done in the past, unaffected by fanciful and mysterious theories of Baconian or any other authorship. I may add, one special responsibility must always rest with our future writers, namely, that of preserving inviolate the priceless heritage of their mother-tongue. History has shown that "a corrupt and decaying language is an infallible sign of a corrupt and decaying civilisation," but fortunately as yet there is no indication of such decay in either our language or nation. As to the latter, we shall, no doubt, agree with the patriotic declaration of Lord Beaconsfield when he says: "I refuse to accept the theory of British decadence; England is capable of forming, not losing, empires." Neither in the former are symptoms of decay perceptible. In fact, when fairly used, the language has never hitherto exhibited a higher state of development, and has therefore never been more worthy of a jealous care. But as a boon when common property runs the risk of not being sufficiently appreciated and guarded, it may not be out of place to cite the opinion, not of an English and possibly prejudiced, but of a great foreign authority on the grandeur of our language. In a treatise read before the Berlin Academy by the late renowned German scholar and philologist, Jacob Ludwig Grimm, the following passage (translated) occurs:—"It (the English language) possesses through its abundance of free medial tones, which may be learnt indeed, but which no rules can teach, a power of expression such as perhaps has never been attained by any other human tongue. Its altogether intellectual and singularly happy foundations and developments have arisen from a surprising alliance between the two noblest languages of antiquity, the German and the Romanesque, the relations of which to each other is well known to be such that the former supplies the material foundation, the latter the abstract notions. Yes, truly may the English language with good reason call itself a universal language, and it seems chosen, like its people, to rule in future times to a still greater degree in all corners of the earth. In richness, sound reason and flexibility, no modern tongue can be compared to it, not even the German, which must strengthen many a weakness and shake off many encumbrances before it can take rank with the English." And on this subject the responsibilities of our American cousins are well expressed in the words or song of the poet :—

Beyond the vague Atlantic deep,
Far as the farthest prairies sweep,
Where mountain wastes the sense appal,
Where burns the radiant Western fall,
One duty lies on old and young—
With filial piety to guard,
As on its greenest native sward,
The glory of the English tongue !

Although literature other than that now referred to lies rather outside the present notice, I may observe that much of a most valuable character has been locally written, including, amongst other matter, narratives of early explorations, complete histories of several of the colonies, accounts of the aborigines, elaborate treatises on local geology and on various branches of natural history. For learned and exhaustive contributions to the botanical section of the last-named subject, I am sure there is no one whom this Association will more delight to honour than our learned and distinguished President, Baron Sir Ferdinand von Mueller, whose long and brilliant labours in connection with the special subject with which his name must be for ever associated, have secured for him both fame and honours in the old world, and, locally, have made not merely his own province but all Australasia his debtor.

Passing from Literature to the second division of our section, a brief allusion may be expected to that which in its highest expression reaches perhaps to the very ideal of art, namely, Sculpture. In this, resident artists of home or foreign nationality have done much ; but although a practical taste for it is already dawning in our midst, I am not aware that our youth have accomplished any original work requiring special mention. Nor is this strange. Much expenditure of time and means, with access to necessary models, are required for the attainment of proficiency in this difficult art, whilst rewards are precarious, as those whose means might enable them to afford encouragement to its higher efforts may prefer, for the present at least, to go to the great studios of the old world, where choice is so varied and so excellent, rather than limit themselves to the comparatively small field for selection afforded by the colonies.

For Drawing in all its branches a marked amount of native talent exists. Great facilities for study of the art are afforded by several of the colonies. In Victoria the sum of one thousand pounds is given yearly to the Art School in connection with the National Gallery, which itself obtains the very liberal annual grant of about seven thousand pounds. An additional impetus is given to the study of painting by the establishment of a Travelling Scholarship (of £150 per annum), tenable for three years, under the condition that the holder shall send back to the colony in each of the first two years a copy of some recognised painting by one of the old masters, and at the close of the third year an original one by himself. The present holder of this valuable prize, Mr. Longstaff, had shown great promise before proceeding to Europe; but the first picture sent back, "The Entombment of Christ" (Titian) indicates a marked advance, due no doubt in great measure to careful study of the works of those dead Sovereigns of Art "who still rule our spirits from their urns." Other Australian artists are making surprising progress in the home studios, one or more of their pictures, including one from the artist just named, having been honoured by admission to the Paris Salon. Locally, the names of the Tasmanian artists, Piguenit and Dowling (the latter not long deceased), are well known. In flower painting, the truly exquisite productions of Mrs. Rowan's pencil are deservedly appreciated, and "have found a fame" far beyond the range of the Australias, while the flora of Tasmania has worthy local exponents in Miss Hall and other native artists. The superior work of many home artists, either permanently or temporarily resident in our midst, claims public admiration at annual exhibitions, and finds a place in many a choice private collection; but special notice of this lies, of course, beyond the scope of these remarks. As Architectural Drawing, however, comes under this head, I should be glad to draw attention briefly to some instances of its practical application, which I venture to think indicate a violation of certain elementary canons of the art itself. We are authoritatively told by writers on the subject that ornamentation, when in the form of architectural features, should point to some practical purpose, or give the idea of utility as its very *raison d'être*. Pillars or Caryatides, for instance, when introduced merely as ornaments, should seem to support something, which, of course, must bear a due proportion to its supports. So also in the case of a balustrade or parapet. This no doubt is a very effective and imposing ornament along the sky-line, but as the essential and primary purpose of a balustrade or parapet must be to give protection to persons behind it, it is clear this idea should always be practically carried out by making the flanking walls at least to correspond with it in height; otherwise the raised front, unsupported, or but partially so, is visibly unfit for its essential function, and thus becomes a palpable sham and pretentious delusion. Yet in innumerable instances in every direction, owing to the absence of art to conceal art, we see this sham front rearing its painfully absurd elevation, and proclaiming itself to be a mere excrescence on the building, and not, as it should seem to be, a useful and integral portion of it. In some cases this inartistic front may have been designed with the idea that neighbouring buildings would eventually conceal the sham, but, as a rule, no such excuse or explanation is possible. Gable ends, again, are designed which would be artistic, were any apparent use assigned to them; but when this is absent, the structure itself becomes a visible pretence, and therefore false in art. In connection with this subject generally, it may be remarked, it is fortunate that the study of drawing and design should be so congenial to Australian taste, as in the future it must become a matter not merely of private but of national importance. From absence of the artistic element, the mother country, to within a recent period, suffered severely in the markets of the world in her competition with other nations more advanced in art-culture. But the cause of this commercial failure was recognised at last, and, owing to their beauty of design and ornamentation, combined with perfect workmanship, the fabrics of England, whether textile, fictile, or otherwise, are now rapidly assuming that high position to which they are so well entitled. In glass manufacture, indeed, England already outstrips all competitors, even her old rivals of Venice and Bohemia.

The remaining but not least important subject of the section is Music. It must be admitted that the genial environments and conditions of Australasian life are in some way peculiarly propitious to the development and cultivation of taste for the Fine Arts, because as in painting, so also in music, the outlook is all its most ardent votary could desire. We know that at home this delightful art has made astonishing progress within comparatively recent times. Probably the enthusiastic and judicious encouragement given to it by the Royal Family has contributed much to this advance, but the widespread culture of music throughout all classes must be due in part to increased pecuniary means and material prosperity, and partly also to the general education of the day rendering the masses more susceptible and more appreciative of all finer influences. Be this as it may, it can safely be affirmed that these colonies, in their devotion to music, are in no way behind the mother country, if they do not in fact even surpass her. Australian artists indeed have gained European distinction in both instrumental and vocal music. In the former, we learn that Johann Kruse, of Victoria, has more than fulfilled the brilliant promise of his youth, having already achieved that high position foreshadowed for him by endowments of no common order, whilst his young and gifted compatriot, Ernest Hutchinson, is steadily following in his footsteps, with every prospect of eventually securing for himself an equal meed of fame and of reflecting equal credit on the land of his birth. The attainments of Florence Menk-Meyer, pianiste and composer, are too well recognised by the public to require any very special mention. In vocal music, another daughter of Victoria, Madame Melba, has actually taken rank with the greatest singers of the day, having been acclaimed by enthusiastic audiences a queen of song on the operatic stage of the capitals both of France and England. And from this bright category, to which additions no doubt can be made by other members of the Association, the names of Amy Sherwin, the sweet singer of Tasmania, and of Alice Rees, so well known to Australian audiences, cannot be omitted. But although it is pleasant to contemplate these phenomenal cases as bright particular stars, the extraordinary love of the art which permeates the entire community presents a still more pleasing and satisfactory feature for observation, indicating as it does the pervading presence of that refinement which is so desirable an element of national character. Were visible proof required of this universal passion for music, we have only to look around, not only on private society, but on the great and apparently insatiable audiences which never fail to crowd our numerous and brilliantly conducted oratorios, liedertafels, operas and similar performances. The recent establishment, too, in Melbourne of a National Orchestra, under the management of one of the foremost English professors of music, is a noteworthy circumstance, as the local influence of such foundations on the music of the future can scarcely be over estimated.

In respect to Literature and Art generally, one other matter may be referred to. In biographies of eminent self-made men we meet with many cases in which, although success was eventually attained, the first efforts of genius were all but blighted by adverse circumstances. So infinitely narrow indeed has been the line between success and failure, it is safe to conclude that in many an instance these efforts have been altogether crushed, and the world consequently left so much the poorer by the loss of what might have been. It is pleasant, therefore, to think that in these favoured countries the education which is common to all cannot fail to discover and develop genius wherever it may lie hidden, and that neither "Poverty's unconquerable bar," nor other adverse influence, will keep in obscurity anyone gifted with exceptional abilities.

In fine, in these early days of Australasia's existence we may perhaps, with little stretch of imagination, regard the present generation of standing at the fountain-head of a great and enlightened nation. And if, without neglect of other and possibly sterner duties, we can, by means of such associations as this and otherwise, contribute to that fountain some tincture, some element calculated to still further promote and strengthen in the national character of the future that love of Literature and Art which refines manners, removes vulgar asperities, and makes life better worth living, then I think we shall be performing a duty clearly required of us, and shall be casting bread upon the waters, to be found haply after many days, if not by ourselves, at least by our successors.

PRESIDENTIAL ADDRESS IN SECTION J.

ENGINEERING AND ARCHITECTURE.

By W. H. WARREN, Wh.Sch., M. Inst. C.E., London, M. Soc. C.E., America,

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In the first place, I have to offer you my sincere thanks for the honour you have done me in electing me as your President; and, in accordance with a custom long established, it becomes my duty and my privilege to address you on one of the many subjects included in this important section. The material welfare and progress of the civilised world depends largely on the labours of engineers.

If we consider the work which has been accomplished during the last 50 years in connection with the arts and manufactures, in the construction, equipment, and safe navigation of ocean steamers, both for the navy and mercantile marine, the various works and appliances for defensive and offensive operations, the construction of docks and harbours, and the improvement of tidal rivers, railways, water supply and sewerage of cities and towns, electricity, mining—in fact, in all those cases in which the great sources of power in nature have been directed and controlled for the wants and conveniences of mankind, it must be admitted that engineering holds its own in the beneficent influence it exerts on the well-being of humanity.

Now, since the progress and development of engineering in the future will depend upon the character, knowledge, and ability of those men whose privilege it will be to carry on the work which has already become such an important factor in the history of the 19th century, it is clear that the education of our future engineers is a matter of momentous interest to the whole civilised world, and I have therefore chosen this theme as the subject of my address.

If we consider the various operations in the process of construction of large engineering works, and endeavour to ascertain what kinds of knowledge are necessary for the engineer to possess, whose special duty it is to design and carry out such work, we shall then be in a position to decide in what manner the particular knowledge referred to can be best obtained. Take, for example, the construction and working of railways. The railway civil engineer should understand the various conditions and circumstances in connection with the location of the railway, so that the returns obtainable from the traffic will bear the best possible proportion to the interest on the capital invested, added to the working expenses. He should also possess a thorough knowledge of surveying as applied to railways, and be able to prepare the working plans and sections of the line, showing necessary works, such as grades, curves, embankments, cuttings, tunnels, culverts, viaducts, and bridges. He should be able to design these works in detail, as well as the permanent way, including the switches, crossings, signals, and the various appliances which are necessary in order to ensure that the traffic may be carried over the line in a safe and economical manner. He should also be able to design the roadside and terminal stations to meet the requirements of the goods and passenger traffic. The railway mechanical engineer should be thoroughly acquainted with the design, manufacture, and repairs of locomotive engines and rolling stock, including the special appliances and machinery which are necessary for the economical performance of this class of work.

In a similar manner, we might detail the order of operations in connection with the construction of roads, sewerage works, water supply, harbour and dock works—*i.e.*, we should have, in the first place, the preliminary surveys, in order to decide the location of the works, and afterwards the design, construction, and maintenance of the works in question.

In Mechanical Engineering we have a complex matter to deal with, and one which is daily becoming more comprehensive in character; but it is clear that every mechanical engineer should possess a thorough knowledge of the chief constructive processes which are used in the manufacture of engines and machinery, and of the various natural forces and agents, such as heat, electricity, steam, air, and water. Do we provide efficiently for the acquisition of the knowledge referred to by merely articling a young man to an engineer, without having first educated him to understand the various works with which he is brought in contact? The whole civilised world has answered in the negative in establishing special engineering colleges all over Europe, America, and England, or engineering schools and departments in connection with existing universities.

Hence, you may be certain that the carefully drawn up and complete schemes of scientific and technical education, the result of the thought and discussion which has been devoted to the subject in Europe and America, and which is becoming daily more recognised in England, is the best course for us to adopt here in the colonies. That it is to some extent recognised in the colonies is shown by the establishment of engineering schools in connection with the universities of Sydney and Melbourne, and that the system has already been successful is proved by the number of important positions held by engineering graduates of both universities.

It was owing to a full appreciation of these facts that Mr. Bruce Smith, the present Minister for Public Works (New South Wales), in a recent minute, has restricted the purely professional appointments in the department over which he presides to graduates in engineering of the University of Sydney, instead of continuing the cadet system, which is acknowledged by the chief public officers to be most unsatisfactory. Mr. Bruce Smith's action in this matter is worthy of imitation, and I sincerely recommend it to the Government of Victoria with reference to the engineering graduates of the Melbourne University.

I may mention here, for the benefit of the Railway Commissioners of the various colonies, and the directors of companies where engineering knowledge and skill are required, that the properly-trained colonial engineer possesses many advantages over his English brother in designing and carrying out civil engineering works in the colonies. He understands better the nature of the materials of construction with which he has to deal; he has obtained his professional training in connection with works which have been constructed under conditions and circumstances which are essentially different from those existing in England. He is generally a much better surveyor, and I consider him to be equal in every other respect. In Mechanical Engineering, on the other hand, the engineer trained in England has an advantage, in consequence of the larger works and more complete machinery with with he is brought in contact.

I will now briefly describe the course of engineering education provided at the University of Sydney.

Candidates for the degree of Bachelor of Engineering must, in the first place, pass the Senior Public Examination, or an examination equivalent to the Senior Public Examination, in the following subjects, viz., Latin and one of the three languages, Greek, French, German, and three of the following subjects, viz., Arithmetic, Algebra, Geometry, Trigonometry, Elementary Surveying and Astronomy, Theoretical and Applied Mechanics, unless they have previously passed the first year of the Arts course. During the first year, the candidates are required to attend the courses of instruction and pass the examinations in the following subjects :—

1. Chemistry, Inorganic (with two terms laboratory practice).
2. Descriptive Geometry and Drawing.
3. Mathematics.
4. Mechanics.
5. Physics.
6. Physiography.

In the second year the candidates are required to attend the courses of instruction and pass the examinations in the following subjects :—

1. Applied Mechanics (with laboratory practice).
2. Geology.

3. Mechanical Drawing.
4. Mathematics.
5. Physics (with one term laboratory practice).
6. Surveying.

In the third year candidates are required to attend the courses of instruction and pass the examinations in the following subjects :—

1. Drawing and Design.
2. Materials and Structures (with laboratory practice).
3. Mathematics, and one of the following :—
    - A. Civil Engineering and Architecture.
    - B. Mechanical Engineering and Machine Design.

Every candidate is required to prepare and submit to the Board of Examiners an original set of working drawings and specifications of machinery or works.

In Mining Engineering, the candidates are required to attend (in addition to the foregoing), a more complete course in Chemistry and Metallurgy ; also a course in Mineralogy and Mining. It is proposed to add a Department of Architecture as soon as funds are available. The object of the entrance examination is to ensure that the student has received a good general education, and that he is capable of profiting by the professional courses of instruction which he is subsequently to attend. The chief feature in the courses of instruction is the attention paid to practical instruction in the various laboratories. The Physical and Chemical Laboratories have been specially designed for their work, and are equipped in a most complete manner with every modern appliance for teaching Physics and Chemistry. The Mechanical Laboratory, which is under my own direction, is at present not all that could be desired, but it is proposed to make considerable alterations and additions, which, when completed, will place it on a level with any similar laboratory in England. At present we possess a testing machine similar to the one in the Melbourne University, which is capable of testing in tension, compression, torsion, cross-breaking, &c., up to 100,000 pounds ; five lathes, drilling, planing, and shaping machines, driven by a pair of engines with overhead shafting. The engines are fitted up with apparatus for making complete tests of power developed, including Crosby and Richards' indicators, Elliott's tachometer and revolution counter, and an Appold brake dynamometer. There is also a vertical boiler, fitted with tanks and gauges for making experiments on evaporative efficiency. It is proposed to provide for experimental work of a complete character in connection with cement, friction and lost work in machinery, hydraulics, &c., and to add a hydraulic accumulator to the testing machine.

Up to the present, a considerable number of specimens have been tested (for each of which an autographic stress-strain diagram has been produced, in addition to the ordinary records of the tests), including 1,500 specimens of Australian timbers, which have been tested in tension, compression, cross-breaking and shearing, both for strength and elasticity. A variety of models, made to scale, of timber trusses and compound beams; 300 blocks of concrete of various proportions and ages; a series of experiments on the adhesion of cement mortar to bricks; a number of experiments on the crushing resistance of sewer pipes, bricks, stone, and asphalt; also a number of experiments on the tensile strength of iron, steel, bronzes, &c., chiefly used in Government works. In all these experiments the students take part.

A student having completed a course such as this is in a position to commence his practical duties—if a civil engineer, in the drawing office, and afterwards on the works in progress of construction; if a mechanical engineer, first in the workshops and afterwards in the drawing office—and generally he will make decided progress in acquiring a knowledge of all those practical details which will daily come under his notice. Having received a complete scientific training in the underlying principles of his profession, and having acquired the habit of thinking accurately, he will be able to observe, analyse, and classify the various operations in the process of construction of the works he is engaged upon. A good student will be anxious to extend his experience in every possible way, and will study closely the engineering practice on works other than those he is engaged upon; and, in general, he will acquire more valuable practical experience in three years after the completion of his theoretical studies than could possibly be obtained in a lifetime without such preliminary training.

The advantages of a training such as the one I have referred to is more conspicuous when it is attempted to design works where no previous examples of a similar character are available. Here an engineer who is deficient in scientific training may endanger life and property, and is almost certain to incur unnecessary expense.

Again, it will be at once conceded that an engineer, if he is to progress with the times, must diligently study the various professional journals and the proceedings of our principal engineering societies, in order that he may be acquainted with the works of other engineers in the special branch in which he is interested; but unless he has received a training such as the one referred to he cannot derive one half of the real benefit obtainable. For example, he cannot follow completely the various papers in connection with the steam and gas engine without a sound knowledge of thermodynamics; neither can he follow the development of engineering practice in bridge-building unless he thoroughly understands the scientific basis of that practice.

In Electrical Engineering the necessity for scientific training is so clear that I need not refer to it, only to point out that every electrical engineer, besides posessing as sound knowledge of physical science, should be a good mechanical engineer. I am aware of the fact that many of the leading members of the profession have not received such a complete scientific training as the one I have referred to.

These may be divided into two classes. On the one hand we have men who have succeeded by their knowledge of processes and their practical knowledge of materials, tact in business matters, capacity to organise and manage workmen; and in such cases the real engineering knowledge and ability is supplied by a partner or assistant, who has generally acquired that knowledge in the manner indicated.

On the other hand, we have had men who have been indefatigable students, bent above all things on self-improvement, whose labours were actuated by a spirit as truth-loving and with a zeal as keen as that of any of the purely scientific investigators. I refer to such men as John Smeaton, born in 1724; James Watt, born in 1736; Thomas Telford, born in 1757; John Rennie, Sir William Fairbairn, George and Robert Stevenson, Dr. Roebuck, Muschet, Nielson, Sir Charles William Siemens, Sydney Thomas Gilchrist, Sir Joseph Whitworth, and others. The time at my disposal for this address will not permit me to give even a brief account of their lives; but you will find a most interesting account of some of their labours in Smiles' "Lives of the Engineers." We still hear in the colonies the terms "theory" and "practice" grossly misapplied. For instance, Mr. A is designated a theorist, while Mr. B is said to be a thoroughly practical man. We have also heard it stated "that one ounce of practice is worth a pound of theory." And, on the other hand, the late Sir John Anderson, Superintendent of the Arsenal at Woolwich, said, with reference to this subject, "that one ounce of theory thoroughly understood was worth any amount of practice which was not based upon scientific principles." Now, it is clear to everyone that if you require to do a thing which you have not done before, and which probably no one else has done before, you must first of all think out carefully how you are to do it before you can commence.

So, also, an engineer, if he wishes to design a structure of an original type, or which differs in its dimensions, or loads which it has to carry, forces which may be brought to bear upon it, or in any other respect from existing structures, he must first carefully think out and design the structure, taking into account all the conditions and circumstances which govern the case, before he can finally build the structure.

I have mentioned the case of a structure, but the same course should be followed with regard to machinery—the one part is theory, the other practice; *either* is incomplete without the other, and an accurate knowledge of *both* is essential to the successful completion of the work. Then how can the one be antagonistic to the other?

The late Professor Rankine, in his admirable dissertation on the "Harmony of Theory and Practice in Mechanics," traces the origin of the opposition of theory to practice to the ancient Greeks. He says:—"Their notions were generally pervaded by a great fallacy, which attained its complete and most mischievous development amongst the mediæval schoolmen, the remains of whose influence can be traced even at the present day." It arose, in the first instance, from the imperfections of a theory which was unable to explain ordinary natural phenomena, and was not recognised as false until the time of Newton, when the science of mechanics became better understood.

Again: "This prejudice, as I have stated, is not to be found at the present day in the form of a definite and avowed principle; it is to be traced only in its pernicious effects in the progress both of speculative science and of practice, and sometimes in a sort of tacit influence which it exerts upon the forms of expressions of writers who have assuredly no intention of perpetuating a delusion."

A great deal has been written during the last few years on Technical Education, and the subiect is an important one in the colonies; but I think considerable misconception has arisen both here and in England. The articles of Sir Lyon Playfair, Lord Armstrong, and those in the leading professional journals show an apparent want of unanimity, which could only have arisen, in my opinion, from a misunderstanding. In speaking of technical education, as applied to engineering, it is necessary to state exactly what we mean.

In carrying out engineering works, a great number of artisans are employed. We have pattern-makers, moulders, fitters, turners, smiths, boiler-makers, and others. I have a great respect for the hand-skill of the artisan, and for the intelligence which directs it; but I think you will agree with me that it is neither desirable nor expedient for any but the most distinguished of the artisan class to go through a course of training as complete as that which I have shown to be necessary for engineers. There is a wide difference between the education necessary for the engineer, whose function it is to work with his brain, and that of the artisan, who works with his hands. A knowledge of drawing, physics, chemistry, mathematics, and mechanics, supplemented by laboratory demonstrations and workshop practice, of such a character as to enable an artisan or an apprentice to understand the scientific principles which underlie their respective trades, will, in my opinion, completely meet their requirements so far as the engineering trades are concerned; and such instruction is provided in the Sydney Technical College and in the Working Men's College, Melbourne.

I submit, however, to the Governments of New South Wales and Victoria the desirability of establishing scholarships for the most distinguished students of these colleges, in order that they may complete their education by attending the Engineering and Science courses at their own university.

It is the function of the technical colleges (such as those in Sydney and Melbourne) to deal with the technical education of the artisans, and for the universities to deal with the professions. Both are equally important, and each should be encouraged by government and other endowments, in order to enable it to do its especial work efficiently; and the two should be united in such a manner that they will work harmoniously together.

The time at my disposal will not allow me to do more than briefly refer to the professional training of architects.

I submit, however, for the consideration of the architectural profession the following question, viz., Is the present system of pupilage satisfactory, under which a young man, fresh from school and without any special training, enters the office of an architect, where he generally remains as a pupil for five years? I am convinced if a young man, after leaving school, were to go through a similar course of training to that recommended for engineers, modified in order to meet the requirements of the architects, that not only might his period of pupilage be reduced to three years, but that he would be (other things being equal) a much better architect at the end of that time than he would be by spending the same time under the present system.

I do not think the day is far distant when we shall have complete courses of instruction in Architecture at our universities, and Chairs of Architecture established.

The progress of science has generally been responded to by that of invention—an engineer has frequently merely to acquire certain scientific facts and principles in order to perceive their application. The recent practical applications of electricity have followed closely upon the discovery of the natural laws upon which these applications depend.

Improvements in metallurgical operations and a greater knowledge of the alloys of metals have given rise to a more extensive use of these metals; and those of us who have lived long enough in the colonies to appreciate the magnitude of their resources and their future development can see in every direction unlimited scope and opportunities for the inventive faculties, skill, and energy of the engineer.

Let us, therefore, realise the necessity of training our sons who choose to become the future engineers of Australia in such a manner as to enable them to perform, in a satisfactory manner, the important duties which will be entrusted to them.

REPORT OF COMMITTEE No. 7.

Mineral Census of Australasia.

Members of Committee:—Mr. A. W. Clarke, Sir James Hector, Mr. R. L. Jack, Mr. E. B. Lindon, Professor Masson, Mr. O. R. Rule, Mr. W. Skey, Mr. C. S. Wilkinson, Professor Liversidge (*Secretary*).

The Report includes the following Colonies:—New South Wales, South Australia, Queensland, and New Zealand.

[illegible]

MINERALS OF NEW SOUTH WALES.

NOTE.— ! *After the name of a Mineral signifies that it is rare.*
! ! *That it is common.*
! ! ! *That it is in workable quantity.*

This Census of the Minerals of New South Wales is not intended to be a complete one, but to supplement the list contained in the "Minerals of New South Wales," by A. Liversidge, F.R.S., published in 1888. (L.) is a symbol meaning "*Liversidge, Roy. Soc., N.S.W., 1888.*"

ALUM.—Crossing Place, Oaky Creek, 4 miles from Cobbadah ! !, shales highly aluminous, and would answer well for manufacture of alum; (Stutchbury's Report, 1st July, 1853, p. 8).

ANGLESITE.—Severn River !, with galena and mispickel; New Lewis Ponds Silver Mine, near Orange ! !, with cerussite and silver ores; (Geo. Sur., Dept. of Mines, Sydney).

ANTIMONY (NATIVE)—Nambucca !; (Geo. Sur., Dept. of Mines, Sydney). Native antimony occurs in calcite with gold, blende, mispickel, &c., at the New Reform Gold Mine, Lucknow (L.).

BARKLYITE !—The opaque more or less magenta coloured variety of ruby known as barklyite, has been sent me for identification by Mr. D. A. Porter from New England. This had previously been found at Two Mile Flat, Cudgegong (L.).

BARYTES.—Braidwood District, massive, containing galena; Pudman's Creek, Rye Park, Burrowa District; Humewood, near Yass ! ! !; (Geo. Sur., Dept. of Mines, Sydney).

BISMUTHINITE.—Nimitybelle, in quartz; Kingsgate, near Glen Innes, with native bismuth; (Geo. Sur., Dept. of Mines, Sydney).

BISMUTHITE.—Molong ! !, in felspathic lodestuff; (Geo. Sur., Dept. of Mines, Sydney).

CALAMINE.—Broken Hill Silver Mine ! !, associated with manganite, cerussite, &c., and silver ores; Castleray Proprietary Silver Mine, near Deepwater; (Geo. Sur., Dept. of Mines, Sydney).

CASSITERITE.—Broken Dam, Mandamah ! !, alluvial and lode; Jindabyne, Cooma District ! !, lode; near Tumut ! !, alluvial with gold; Tarago !, alluvial; Barrier Ranges ! ! !, in granite dykes traversing slates and schists; Bombala District (Tin Fields of New South Wales). Carri Mountain, 10 miles south-west from Long Flat Station, and Long Flat Station, Macleay River, associated with gold, zircons, topaz, &c.; (Geo. Sur., Dept. of Mines, Sydney). A very finely divided tin-stone occurs in elvan at Bellandean, Tenterfield, and might easily be overlooked by miners who are only used to the ordinary appearance of tinstone as it occurs in New South Wales, since this form, from its grey colour and finely divided condition, is liable to escape recognition. Associated with it are occasional scales of glistening pearly white gilbertite mica (L.).

CERUSSITE.—Barrier Range Silver Field ! ! !, New Lewis Ponds Silver Mine, Mount Costigan Silver Mine, Tuena, Wallah Wallah Silver Mine, Pudmann's Creek, near Yass, Mount Stewart Silver Mine, Denisontown; common in the silver lodes of the colony; (Geo. Sur., Dept. of Mines, Sydney).

CHESSYLITE.—New Mount Hope Copper Mine, Lachlan District, Girilambone, Barrier Ranges, Nymagee; common in copper lodes of the colony; (Geo. Sur., Dept. of Mines, Sydney).

CHROMITE.—Bingera ! ! !, near Tumut ! !, in serpentine; (Geo. Sur., Dept. of Mines, Sydney).

CINNABAR.—Near Bingera !, loose water-worn pebbles on surface; near Scone, reported in lodestuff and loose pebble from surface; (Geo. Sur., Dept. of Mines, Sydney).

COBALT SESQUI-OXIDE.—Boro, in concretionary manganese oxide.

Assay: Sesqui-oxide of cobalt ... 5·79
,, ,, nickel ... 1·37

(Ann. Rept, Dept. of Mines, 1887, p. 46.)

COPPER, NATIVE.—Broken Hill Mines ! !, associated with native silver in lead ores and quartz; Shellharbour, in grains disseminated through diorite; Bulli (an outcrop), Newington (diamond-drill bore), Heathcote (diamond-drill bore), Holt Sutherland (diamond-drill bore*), in tuffaceous shales at a depth of 1728ft. 11in., and out of a total thickness of 71ft. three feet showed native copper more or less freely. The rock is a dark

* See David on Cupriferous Tuffs.—*Aus. Assoc. for Adv. of Science.* Vol. I., p. 275.

purplish-black or greenish-purple tufaceous shale, and contains scales of native copper from one-twentieth to one-quarter of an inch in longest diameter, averaging one-tenth and about one-fortieth thick. Their prevailing shape is circular, more or less. The following analysis was made by Mr. J. C. H. Mingaye, analyst and assayer, Dept. of Mines, Sydney :—

Combined moisture	5·32
Moisture	3·38
Silica	56·28
Alumina	24·21
Oxide of iron	7·34
Metallic copper	·08
Lime	1·10
Magnesia	2·36

Two large assays were made for gold and silver, and neither of these metals found present. See also Jour. Roy. Soc. N.S.W., p. 215, 1880.

COVELLINE.—This mineral occurs with redruthite, the copper sub-sulphid Cu_2S and other sulphur ores of copper at Cobar and other copper mines in New South Wales (L.).

CUPRITE.—Broken Hill Mines, associated with silver ores; common in copper lodes of the colony; (Geo. Sur., Dept. of Mines, Sydney).

EMBOLITE.—Barrier Ranges Silver Field ! ! !, New Lewis Ponds Silver Mine, near Orange ! !, Captain's Flat !, Molonglo !, Billagoe, Cobar District !; (Geo. Sur., Dept. of Mines, Sydney).

ERYTHRITE. — Hydrated arseniate of cobalt obtained by Mr. J. A. McKillop, near Carcoar, where it occurs in association with cobaltine, molybdenite, &c. The erythrite is present in groups of silky radiating acicular crystals of a beautiful peach colour. Also in globular and uniform masses, and in incrustations which present a remarkable pearly pink lustre on the freshly fractured surfaces. It is clearly an oxidation product of the cobaltine which accompanies it. (L.).

FLUORSPAR.—Allah Mine, Purnamoota, with galena; Pheasant's Creek, New England; Pye's Creek, near Bolivia, with mispickel; Seaforth Mine, Severn River, near Emmaville; (Geo. Sur., Dept. of Mines, Sydney).

GAHNITE—Zinc spinel—A lavender coloured specimen was sent me for identification ten or twelve years ago, but without locality. Mr. D. A. Porter also sent me a specimen of this mineral from near Tenterfield for identification in 1885, and another from Tingha in 1887, so that the mineral probably occurs in several localities (L.).

Garnet (Rubicelle and Almandine).—Barrier Ranges, in schist and detritus, also in quartz obtained by diamond drill bore at Broken Hill; Monaro, with sapphires; (Geo. Sur, Dept. of Mines, Sydney).

Garnets (so-called Australian rubies).—Silverton. Analysis:

Silica	37·41
Alumina	26·81
Protoxide of iron (FeO) ...	33·33
Peroxide of iron (Fe_2O_3) ...	nil
Protoxide of manganese (MnO)...	2·14
Oxide of chromium	nil
Lime	nil
Magnesia	nil
	99·69

S.G. 3·887 to 4·32 (Ann. Rept., Dept. Mines, 1888, p. 53). Garnets occur in the New England district, on the borders of Queensland. These are the ordinary red garnets (iron-alumina garnet), but like those found in Queensland have been mistaken for rubies. The Bohemian garnet, magnesia alumina garnet, is said to occur in large quantities near Maryland Creek, Co. Buller (L).

Glaucodot.—Three-quarters of a mile south-easterly from Carcoar Railway Station, with erythrite, molydenite, and thin films of an apple-green to dark-green mineral, determined by Mr. J. C. H. Mingaye, F.C.S., to be annabergite. The ore, as far as at present proved, consists of a succession of lens-shaped bunches. The deposit of cobalt appears to have been formed in a line of fissure, which, for some distance, followed the line of junction of the diorite with the slate, and was probably directly due to the intrusion of the diorite, being formed either by the thrust of its upheaval, or by the contraction consequent upon the cooling of the mass of igneous rock. Towards its north-east end this fissure was partly filled by a dyke of fine-grained diorite, closely resembling the chlorite slate, which it has penetrated. The cobalt ore was then concentrated into the irregular hollows along this line of fissure by some process of segregation, for its intimate admixture with the dyke rock is difficult of explanation on any other hypothesis. Analysis made in the Department of Mines Laboratory by Mr. J. C. H. Mingaye, F.C.S. :—

No. 1.

Moisture	·120
Metallic arsenic	51·810
„ cobalt	10·447
„ nickel	·590
„ iron	11·860
„ manganese	nil
CaO	„
MgO	1·480
Gold	trace
Silver	„
Sulphur	1·520
(Insol. in acids) gangue ...	22·078
	99·905

Specific gravity, 5·430.

No. 2

Moisture	2·180
Metallic arsenic	29·010
„ cobalt	13·830*
„ nickel	·390
„ iron	15·78
Alumina	trace
Manganese	nil
CaO	·71
MgO	·22
Sulphur	11·24
Gangue	26·31
	99·66

* $Co_2O_3 = 19{\cdot}45\%$

Traces of gold, copper, and antimony.

Authority: See T. W. E. David's Report, Ann. Rept., Dept. Mines, Sydney, 1888, p. 175.

GOLD.—Gold occurs at the New Reform Gold Mine, Lucknow, in calcite as the vein stuff, and in association with native antimony, mispickel, zinc blende, pyrites, and silver-bearing galena. The vein apparently runs through diorite and serpentine. Some of the serpentine is of the foliated variety known as marmolite, and in places a little asbestos is present, especially at the deeper levels. The native antimony is present in places in considerable quantity, and came in first at about 350 feet. The gold is very pale in colour and of a greenish tint, and occurs in the form of very thin films and strings, which follow the cracks in the calcite and junctions of the crystals rather than the cleavage planes of the crystals. The calcite cleaves well, is white, but shows iron stains in parts (L.)

GRAPHITE.—Undercliff, between Wilson's Downfall and Rivertree, New England; Analyses, Dept. of Mines Laboratory, 1888 :—

Moisture (at red heat) ...	8·77
Silica	27·96
Alumina	15·93
Oxide of iron	trace
Lime	·96
Magnesia	nil
Carbon	46·28
	99·90

Moisture	7·35
Carbon	34·40
Gangue	58·25
	100·00

See also " Minerals of N.S.W.," Liversidge, p. 121. The graphite mined at the Undercliff Station looks of very good quality when rubbed and polished, but on breaking the nodules open they are seen to contain a good deal of earthy matter, one nodule examined for me by Dr. G. S. Mackenzie in the university chemical laboratory was found to contain only 30 per cent. of carbon, hence for most commercial purposes the graphite would require purifying before it could be used. Associated with the graphite are rolled pebbles of quartz and rock crystal (L.).

KAOLIN ! ! !.—Shaking Bog, near Tumut; Analysis, Dept. of Mines Laboratory, 1888 :—

Moisture at 100 C	6·10
Combined moisture	10·19
Silica	44·46
Alumina	37·85
Oxide of iron ...	minute trace
Lime	·22
Magnesia	trace
Alkalies, etc.	1·18
	100·00

LEUCITE.—(1) Byrock, County Cowper, (T. W. E. David and W. Anderson); (2) El Capitan, County Cambelego, in a basaltic lava sheet, (See Records Geol. Sur. N. S. Wales, vol. i. part iii.) Analyses:

	(1)	(2)
Silica	46·43	47·31
Alumina	15·99	18·51
Oxide of iron (Fe_2O_3) ..	15·04	14·56
Lime (CaO)	9·27	7·57
Magnesia (MgO) ...	1·74	2·28
Potash (K_2O) ...	6·93	6·14
Soda (Na_2O)... ...	·51	·98
Phosphoric Anhydride (P_2O_5)	·73	·55
Moisture	3·20	2·31
	99·84	100·21
Specific gravity of mineral	2·890	2·910

(Ann. Rept. Dept. of Mines, 1887, p. 177.)

MALACHITE.—New Mount Hope, Nymagee, Great Barrier Copper Mine, Gorilambone; common in copper lodes of the colony; (Geo. Sur., Dept. Mines, Sydney).

MANGANITE.—Bendemeer ! ! !, Glanmire, near Bathurst ! ! !, Bogan District, Molong; (Geo. Sur., Dept. of Mines, Sydney).

MARMOLITE—This foliated variety of serpentine occurs with massive serpentine on Jones' Creek, Gundagai (L.).

MOLYBDENITE.—Found with cobaltine and erythrite at Carcoar in fairly well deve loped platy crystals (L.).

MONTANITE.*—Molongo, near Captain's Flat. (1) Pale greenish yellow variety. This mineral encrusts the tetradymite, and does not show any crystalline structure. Green tints are observable wherever the particles of half-decomposed tetradymite become abundant, the green being due to the steel-grey tetradymite showing through the yellow coating of montanite. (2) Ferruginous dark-brownish red variety. This variety occurs in cubical pseudomorphs, single or aggregated, and about $\frac{1}{8}$-inch in diameter. The colour is dark brownish red, excepting on thin edges, where the mineral is semi-translucent and of a deep claret colour. Analysis of a few broken pieces of the cubes (b) about 2 grammes in weight, though they were not thoroughly free from tetradymite :—

* See Mingaye and David on Tellurium in N.S.W. ores.—*Aust. Assoc. for Advancement of Science*, Vol. I., p. 116.

Bismuth oxide (Bi_2O_3)	...	50·68
Tellurium oxide (TeO_3)	...	27·65
Iron oxide (Fe_2O_3 ...	...	14·38
Water	...	6·16
Gangue (silica) ...	...	1·00
		99·87

OLIVINE.—Uralla, Bulli; common in basaltic rocks of the colony; (Geo. Sur., Dept. of Mines, Sydney).

OPAL.—*Precious*—Albert District ! ! !, in cretaceous sandstone opal silica filling cavities from which fossils have been removed, very suitable for inlaying work, matrix takes a good polish; (Geo. Sur., Dept., of Mines, Sydney).

OPAL.—*Common*—The Battery, Lachlan River, green; Moulder's Paddock, Orange, greenish; Gundagai, green and white; (Geo. Sur., Dept. of Mines, Sydney).

PLATINUM.—Beach sands between Clarence and Tweed Rivers—! !, in basaltic detritus, and associated with gold; one-and-a-half miles south of Evan's Creek, Richmond River Heads, from beach sand; Broken Hill, in ochreous felspathic lodestuff—yielding 1 oz. 9 dwts. 9 grs. per ton; Bogan district, in alluvial wash with gold; about 60 miles N.W. of Parkes; Mittagong District, from gold and diamond workings eight miles from Mittagong; (Geo. Sur., Dept. of Mines, Sydney).

PLATINUM, OSMIUM, AND IRIDIUM—Associated with gold, are found on the head waters of the Bogan and Lachlan rivers, north-east of Condobolin. I am informed by Mr. Harding, of Grafton, that gold, platinum, and osmi-iridium occur in the sea sands at Jamba, Clarence Heads, and generally in the north ends of the bays and reaches along the New South Wales coast. The "platinum" consists principally of osmium and iridium, and contains only about 30per cent. of platinum; hence it is only worth a few shillings an ounce (L.).

PLUMBAGO CLAY.—Mudgee; (Dept. of Mines Laboratory, 1888).

PREHNITE.—This zeolite has been found in the basalt at the Prospect reservoir. Some imperfect and small crystals were also sent to me by Mr. D. A. Porter for identification, who had obtained them from serpentine in New England in 1887. The sp. grs. of two specimens from New England were 2·89 and 2·90 (L.); Wollongong (Geo. Sur., Dept. of Mines, Sydney).

PYROMORPHITE.—Broken Hill Silver Mines ! !, with carbonate of lead and zinc; Burrowa, near Braidwood; (Geo. Sur., Dept. of Mines, Sydney).

PYRRHOTINE—The Revd. J. Milne Curran reports the presence of this mineral at Cobar in the massive condition (L.).

REDRUTHITE.—Cobar, Bingera.

SALT—Ellalong !, Scone !, Mittagong District !, as an efflorescence in sheltered caves ; (Geo. Sur. Dept. of Mines, Sydney).

SCHEELITE—Cordillera Hill Silver Mine, near Tuena ! !, associated with stolzite, cerussite, and silver ores ; (Geo. Sur., Dept. of Mines, Sydney).

SIDERITE—Some fairly good crystals of this mineral have been found at the Cobar Copper Mines (L.).

SILVER (NATIVE)—Broken Hill Silver Lodes, Barrier Range ! !, New Lewis Ponds Silver Mine, near Orange !, Sunny Corner Mitchell !, White Rock Silver Mine, Fairfield, New England ! ; (Geo. Sur., Dept. of Mines, Sydney).

Leaf silver occurs on schist at Sunny Corner.

Crystallised silver on silver chloride is found at Lewis Ponds. The Revd. J. Milne Curran states that he has found silver in scales on redruthite at the Cobar Copper Mine (L.).

SILVER CHLORIDE—Occurs at Silverton in fairly well-formed branching groups of crystals. All the New South Wales silver chloride specimens which I have examined so far contain iodine, some only traces, but others a fair percentage (L.).

STANNITE—Mr. Theodore Ranft states that he found this mineral in the Ottery Lode, Tent Hill, New England (L.).

STEPHANITE—Sunny Corner, Mitchell.

STRONTIUM—30 miles north of Cobar, small nodules of magnesian limestone ; strong traces (under 1 p.c.) of strontium detected ; (Geo. Sur. Dept. of Mines, Sydney.) (See also Liversidge, "Minerals of N.S.W.," p. 160, analysis of strontium bearing limestone, Minumurra Creek, N.S.W).

SULPHUR (NATIVE)—From a reef on the range which divides the head waters of the Catler and Coodraddigbee Rivers, in small cavities in quartz, associated with iron pyrites ; (Geo. Sur., Dept. of Mines, Sydney).

TETRADYMITE*—Molongo near Captain's Flat, in granular crystalline masses of a steel-grey colour and bright metallic lustre. Under the microscope the crystals are seen to have a very perfect basal cleavage, over one

* See Mingaye and David on Tellurium in N.S.W. ores. *Aus. Assoc. for Adv. of Science*, Vol. I., p. 116.

hundred laminæ being visible in one crystal within the space of 1-20th inch. Most of the crystals appear to be tabular.

Metallic bismuth	59·66
Tellurium	33·16
Selenium	nil
Sulphur	4·52
Iron	·42 } *
Silica	·40 }
	98·18

TOPAZ—Water-worn crystals and fragments occur in Scrubby Gully, New England District, some are of fair size, clear, free from flaws, and would cut very well (L.).

WAVELLITE.—Near Gundagai; (Geo. Sur., Dept. of Mines Sydney).

WILLEMITE.—Temora District; (Geo. Sur., Dept. of Mines, Sydney).

WULFENITE.—Broken Hill Silver Mines, with cerussite and calamine; (Geo. Sur., Dept. of Mines, Sydney).

* These two elements are no doubt impurities, it being found difficult to detach the mineral from the matrix.

MINERALS OF SOUTH AUSTRALIA.

By T. C. CLOUD, F.I.C., F.C.S.

Associate of the Royal School of Mines, London.

Authorities Quoted:

Thos. Burr, Deputy Surveyor-General in the year 1846	written Burr.
H. Y. L. Brown	written Brown.
T. C. Cloud	written Cloud, or T. C. C.
G. Goyder, Jun., Government Assayer	written Goyder.
A. R. C. Selwyn	written Selwyn.
Prof. R. Tate, University, Adelaide ...	written Tate.
Geo. H. F. Ulrich	written Ulrich.

The marks placed after the name of the minerals have the following significance :—!, that the mineral is rare : ! !, that it is common ; ! ! !, that it occurs in workable quantity. Varieties are indicated by italics.

Albite !—Oolabidnie Creek, near Franklin Harbour, in veins in the metamorphic rocks there exposed (T. C. C.); forms the chief constituent of the granites of the above-named district (T. C. C.).

Allophane !—In the form of a blue deposit in the miocene rocks of the south-east (J. E. T. Woods.).

Amphibole ! ! (Hornblende)—Various localities on Yorke's Peninsula, also at Tanunda Creek, Angaston, and in district round about Franklin Harbour, Mount Crawford (T. C. C.); Tungkillo (Tate).

Asbestos—New Mecklenburg, Tungkillo, Angaston (T. C. C.); Lobethal Mine (Tate); near Mengo Town (Selwyn); Mount Barker, Belvidere Range (Burr).

Actinolite—Wallaroo Bay (T. C. C.); Yudanamutana Mine (Ulrich); Lyndoch Valley, Flaxman Valley, near Strathalbyn (Burr).

Anglesite !—Wilpena Pound, both massive and in the form of small crystals (T. C. C.).

Ankerite ! Gill's Bluff, near Mount Lyndhurst (Brown); Wallaroo Mine (T. C. C.). Analysis by T. C. Cloud of specimen from Wallaroo Mine:—

$FeCO_3$	20·68
$MnCO_3$	2·08
$CaCO_3$	52·57
$MgCO_3$	24·76
	100·09

ANNABERGITE ! (Nickel Ochre)—Gill's Bluff, Mount Lyndhurst (Tate); Mount Ogilvie (Goyder).

APATITE !—Wallaroo and Kurilla Mines, as isolated crystals embedded in yellow copper ore (T. C. C.).

ARAGONITE—Wallaroo Mine, associated with native copper and chalcocite (T. C. C.); Armagh, near Clare, in form of long, prismatic crystals (T. C. C.); Blinman Mine, Oratunga Mine (Ulrich).

ARSENOPYRITE ! (Mispickel)—Glen Bar Mine, near Strathalbyn, Talisker Mine, between Victor Harbour and Encounter Bay (T. C. C.); two miles east of Woodside Gold Mine (Brown).

ATACAMITE !—This mineral is found in every copper mine on Yorke's Peninsula, and splendid crystals, several inches in length, have been obtained from the New Cornwall Mine (T. C. C.); Yudanamutana, Daly Mine (T. C. C.); Rhondda Mine, in the form of pseudomorphs after cuprite (T. C. C.); Kapunda Mine (Burr); Nuccaleena Mine, Mount Lyndhurst (Ulrich); Mount Norwest, Kingston Copper Mines (Brown). Analysis by Cloud of specimen from Wallaroo Mine:—

Copper	13·73
Chlorine	15·38
Cupric oxide	55·91
Water	13·51 (by diff.)
Insoluble silicious residue ...	1·47
	100·00

AZURITE ! ! ! (Blue carbonate of copper) — Occurs very generally in the copper lodes of the colony, with the exception of those on Yorke's Peninsula, where it is only rarely met with (T. C. C.); Moonta Mine, Wallaroo Mine, Burra Burra Mine, Kapunda Mine, Blinman Mine, Yudanamutana Mine, &c., &c., near Franklin Harbour, and various localities on the west coast of Spencer's Gulf (T. C. C.); Daly Mine, Stanley Mine, Mount Bold Mine, Cherry Gardens, near Adelaide (Brown).

BARITE ! !—Wheal Coglin Mine, Rapid Bay, at Apoinga, also at the Burra Burra, Great Gladstone, and Rhondda Mines (T. C. C.); Emu Flat Copper Mine (A. R. C. Selwyn); Blinman Mine (G. H. F. Ulrich): of frequent occurrence, associated with copper ores, in the northern and central portions of South Australia (Cloud).

BERYL !—Mount Crawford, various colours (T. C. C.).

Aquamarine—Mount Crawford (T. C. C.).

Beryl—Barossa Range (Burr).

BIOTITE (Mica) !—Of frequent occurrence in the mines on Yorke's Peninsula (T. C. C.); Williamstown (Selwyn). Analysis of specimen from Yelta Mine by T. C. C.

Silica	40·28
Magnesia	17·38
Alumina	11·30
Ferric oxide	5·24
Ferrous oxide	11·65
Manganous oxide ...	0·30
Lime	0·82
Potash	8·56
Soda	1·64
Water	1·95
Fluorine	trace
	99·12

Specific gravity, 2·9; colour, dark greenish black.

BISMUTH ! (NATIVE)—Balhannah Mine, Murninnie Mine, about 20 miles north of Franklin Harbour (T. C. C.).

BISMUTHITE !—Balhannah Mine, associated with native gold and chalcopyrite (T. C. C.); Stanley Mine (Ulrich); New Era Mine, with gold (Brown); Teetulpa Goldfield, at the "Ironclad" Mine (Brown); Murninnie Mine, Mount McDonnell, N. T. (T. C. C.).

BISMUTHINITE !—Balhannah Mine, Mount McDonnell, N. T. (T. C. C.); New Era Gold Mine, Forest Range Gold Mine (Goyder); near Blinman (Goyder).

BORNITE ! ! ! (Purple Copper Ore)—Massive at several of the copper mines of the colony, generally associated with chalcopyrite. The most notable locality is the Moonta Mine (T. C. C.); Lady Alice Mine, Barossa Mine, Burra Burra Mine, Try Again Mine (T. C. C.); Kapunda Mine (Burr); Mount Searle (Brown); near the Peake, Central Australia, in the quartz veins in the metamorphic rocks (Tate). Analysis of a specimen of massive bornite from the Moonta Mine, by Cloud, yielded the following result:—

	I.	II.	III.
Copper ...	59·84	62·00	61·87
Iron ...	11·73	12·15	12·13
Sulphur ...	24·95	25·85	26·00
Insoluble silicious residue ...	4·03		
	100·55	100·00	100·00

Column II. shows the composition of the specimen after deducting the insoluble residue, and column III. is the percentage composition calculated from the formula $9Cu_2S, 2Fe_2S_3$

CALCITE ! ! !—Wallaroo Mine, finely crystallised (T. C. C.); Yudanamutana Mine (T. C. C.); Blinman Mine (Ulrich); Mounts Parry and Playfair, Central Australia (Tate); Cape Jervis, in stalactitic form (Tate); New Mecklenburg, near Lyndoch, massive and in scalenohedrons (Tate); near the Peake, Central Australia, in quartz veins in metamorphic rock (Tate); as a cellular calcereous tufa forming the top crust of the Mouna Springs, at the Peake, Central Australia (Tate); Mount Crawford, Ardrossan, Rapid Bay, Mount Gambier, Point Curtis, Macclesfield, Mattawarrangala, in largely crystalline masses (T. C. C.); Whyte-Yarcowie, black, largely crystalline, in a vein in a dark coloured slate (Tate); colour due to contained organic matter (Tate); Cape Borda (T.C.C.); Barrossa Range, Flinders Range, Mount Lofty Range, Rapid Bay, Crystal Brook, Rivoli Bay, on plains near Mount Hawdon (Burr).

Iceland spar—Angaston (T. C. C.); Kapunda (T. C. C.); Franklin Harbour: in thin veins in metamorphic rocks (T. C. C.).

CASSITERITE ! ! !—No authentic specimen has been found in the southern part of this province, but it occurs in the Northern Territory on the McKinlay River, Mount Wells, &c. (T. C. C.); Howley Creek, Twelve Mile Camp (Goyder).

CELESTITE !—In the form of radiated crystalline nodules in clay; Hundred of Wallaroo (Cloud).

CERUSSITE ! !—Glen Osmond: massive in stone quarries (T. C. C.); western side of Spencer's Gulf: crystallized with phosgenite (T. C. C.); Beltana Mine: lining druses (Ulrich); Strathalbyn Mine (L. Seeger); Avondale Lead Mine (Brown).

CHALCANTHITE ! (Copper Sulphate)—Wallaroo Mine, Murtooroo Mine, near Cockburn (T.C.C.).

CHALCOCITE ! ! ! (Redruthite)—The massive variety is of frequent occurrence in the copper mines of Yorke's Peninsula, fine specimens being obtained from the Moonta Mine (T. C. C.); Kapunda Mine, Montacute Mine, Burra Burra Mines, Mount Barker (Burr).

CHALCOPYRITE ! ! ! (Copper Pyrites) — Is of pretty general occurrence in the lower parts of the copper lodes of the province (T. C. C.); Wallaroo Mine, crystallized (T. C. C.); Moonta Mine (T. C. C.); near the Peak, Central Australia, in quartz veins in the metamorphic rock (Tate); Montacute Mine, and all lodes in its vicinity, Rapid Bay, Flaxman Valley, Hutt River, and various other places (Burr). Analyses of specimens from Moonta Mine, by Cloud :—

	I.	II.	III.
Copper ...	34·21	34·04	34·57
Iron	30·65	31·14	30·53
Sulphur ...	35·16	34·34	34·90
Insoluble silicious residue ...	0·50	0·63	
	100·52	100·15	100·00

Column I. is the analysis of the untarnished variety, and column II. that of the "peacock ore," column III. shows the theoretical composition of pyrite deduced from the formula Cu_2S, FeS_2, FeS.

CHRYSOCOLLA ! ! !—Burra Burra Mine, associated with azurite and malachite (T. C. C.); Wallaroo Mines, Kurilla Mine, Mount Gunson Mine, about 80 miles N.N.W. of Port Augusta (T. C. C.); Nuccaleena Mine, Yudanamutana, Mount Lyndhurst (Ulrich); Mount Barker Mine (Burr).

CHRYSOLITE !

Olivine — Mount Schanck (J. E. T. Woods); Mount Gambier, extensively in the volcanic lavas (J. E. T. Woods).

Hyalosiderite — Mount Schanck, in the basalt (J. E. T. Woods).

COAL !

Lignite — Murray Flat (Brown); Pedinga, near Fowler's Bay, Leigh's Creek (Brown).

COBALTITE ! (Cobalt Glance)—Glen Bar Mine: associated with Mispickel (L. Seeger).

COPIAPITE—Alice Springs (Goyder).

COPPER ! ! (NATIVE)—This species is represented in great variety of forms in the upper parts of the lodes of the Wallaroo and Moonta mining districts of Yorke's Peninsula. Some specimens exhibit well-defined though distorted crystals, and some very fine examples of the arborescent form have also been found. At the Sliding Rock Mine it occurs disseminated in grains of varying size. It is also found at Angaston, and to greater or less extent in several of the other copper-bearing lodes of the colony (T. C. C.).

COVELLITE ! (Indigo Copper Ore)—Fine specimens in the massive form are obtained chiefly from the southern part of the mining district of Yorke's Peninsula. An impure variety, black in colour, is not unfrequently found, especially in the northern part of the same district (T. C. C.) ; Kapunda Mine (Burr).

CROCIDOLITE ! (Blue Asbestus)—Wirrawilka Mine (Ulrich).

CUPRITE ! ! !—This mineral is of very general occurrence in the upper portions of the copper lodes of this colony, most frequently in the massive form, but finely crystallized specimens have been obtained from the following localities :—Moonta Mine, Spring Creek Mine, Kapunda Mine, Burra Burra Mine (T. C. C.) ; near Rhondda Mine, north of Port Augusta, crystals converted into atacamite (T. C. C.) ; Burra Burra Mine, crystals more or less converted into malachite (T. C. C.)

Chalcotrichite—A specimen of this variety of cuprite has been met with in this province, precise locality unknown, occurring in groups of small acicular crystals with native copper (T. C. C.) ; Mount Barker Mine (Burr).

CYANITE !—Nuriootpa, in quartz (T. C. C.) ; near Menge Town, Mount Crawford (Selwyn).

DIAMOND !—Echunga (Cloud) ; the largest specimen of which I am aware weighed before cutting $5\frac{1}{4}$ carats, its present weight being $2\frac{3}{32}$ carats. It is cut in the form of a brilliant, and is of a sherry-yellow colour. It is now in the Adelaide Museum.

DIOPTASE !—Appialina Mine (Selwyn).

DOLOMITE ! !—Victoria Creek, Williamstown (Selwyn) ; Mount Gambier, associated with limestone (J. E. T. Woods) ; Belvidere Range, Barossa Range, Rapid Bay, and near Mount Barker (Burr).

Pearl Spar—At Rapid Bay and N.E. of Adelaide (Burr).

Dolomite — From Central Australia, as a pseudomorph (T. C. C.).

EPIDOTE !—Barossa Range (Burr); Yudanamutana Mine (Ulrich).

ERYTHRITE ! (Cobalt Bloom)—Glen Bar Mine (T. C. C.); near Blinman, crystallized in needles (T. C. C.); Mount Ogilvie (Goyder).

FLUORITE ! (Fluor Spar)—Parramatta Mine and Moonta Mine on Yorke's Peninsula (T. C. C.); on the Field River, between Reynella and the coast, in a silicious limestone of Pre-silurian age (Tate); at Parara, near Ardrossan, Yorke's Peninsula, in Lower Silurian limestone (Tate); Kapunda Mine (Burr).

GALENITE ! ! !—Wallaroo Mine, both crystallized and massive (T. C. C.); Waukaringa (Tate); Talisker Mine, Glen Osmond Mine, Blinman Mine (Ulrich); Kangarilla Mine, Avondale Mine, Mount Bold Mine, Two-in-the-Bush Mine, Mount Searle (Brown); Wininnie (Goyder); Rapid Bay, Lyndoch Valley, 20 miles east of Mount Barker (Burr); North Rhine, near Normanville, near Yudenamutana (T. C. C.); Glen Osmond stone quarries, on the Oalnina station, about 150 miles north-east of the Burra, and the Murray Flats. The foregoing are perhaps the most noticeable of numerous localities (T. C. C.)

GARNET ! ! !—Kanmantoo, red crystals in white talc (T. C. C.); Bundaleer, black garnet (T. C. C.); Monarto, garnet rock (T. C. C.); Yadmana, in the Hundred of Hawker, iron garnet in granite rocks (T. C. C.); Belvidere Range, near Mount Barker, red garnet (Burr).

Cinnamon Stone—Belvidere Range (Brown).

Almanaite (Noble Garnet)—MacDonnell Ranges, Northern Territory, in the form of rolled pebbles in the creeks (T. C. C.) Analysis by Dr. Rennie of specimens of noble garnet from Hale River, MacDonnell Ranges :—

Silica	38·48
Alumina	27·09
Ferrous oxide	26·28
Lime	1·99
Magnesia	4·20
Manganese oxide ...	·35
	98·39

GERSDORFFITE—Mount Ogilvie (Goyder).

GILLINGITE !—Government Farm, near Bellair (Goyder).

GLAUCONITE !—In the limestone rocks of the Aldinga Cliffs and the Bunda Cliffs of the Great Australian Bight (Tate).

GOLD, NATIVE ! ! !—The geological distribution of gold in South Australia is restricted to the Pre-silurian, certain gravels of the Miocene period, and to drifts of later age. In the first it occurs disseminated in veins of quartz; in the second and third cases as alluvial gold (Tate); the following are some of the localities in which gold has been found in one or other of the conditions named above:—Onkaparinga River, South Para River, Torrens River, in sand (T. C. C.); Bremer Range, Barossa Range, Nairne, Woodside, Strathalbyn, Mount Barker, Clarendon, Noarlunga, Currency Creek, Mount Pleasant, Jupiter Creek, Echunga (T.C.C.); Ulooloo, Waukaringa, Bigg's Flat, near Echunga; Balhannah Mine, associated with native bismuth and bismuthinite; Teetulpa, Mount Ogilvie, Lady Alice Mine, with bornite; Moonta Mine, with bornite (T.C.C.); Bird-in-the-hand Mine, Echunga Mine, Fountain Head Mine; Kangaroo Mine, near Oakbank, in psilomelane; Mount Victoria, with copper ore; Yudanamutana, Mount Wells, N. T., Old Blackfellow's Reef, N. T. (Brown). In the Northern Territory gold is widely distributed over that portion of Arnheim Land occupied by metamorphic rocks. The fields extend from the River Stapleton to the Driffield. The chief centres of gold-reefing are the Howley, Twelve Mile, McKinlay, Union, and Pine Creek (Tate).

GRAPHITE !—Warrow, County Flinders, and one or two places on west coast of Spencer's Gulf (T. C. C.); Mount Charles (G. Francis); Mount Torrens (C. Thomas); Belvidere Range, and about 23 miles N.E. of Adelaide (T. Burr); Blanchewater (Professor R. Tate); Hundred of Koppio (Government Geologist, H. Y. L. Brown).

GYPSUM ! ! !—*Selenite* is frequently met with in the form of isolated lenticular-shaped crystals, imbedded in the mud of the salt lakes, notably those of Southern Yorke's Peninsula. It also occurs massive in the salt lakes (Cloud); Wailaroo Mine, Hummocks Range, Kanyacka, Kapunda, near Point Riley, Yorke's Peninsula, on the Wirryalpa Run, Central Australia, Stuart's Range, Central Australia: satin spar (T. C. C.); Lady Alice Mine (Tate); cliffs of River Murray (Tate); near the Springs at The Peak, Central Australia, with red ochre (Tate); N.E. shores of Lake Alexandrina, in curious rock form, composed of slightly coherent grains (Tate); Beltana Mine, in veins (Ulrich); Brighton (Burr); Burra Burra Mine, with malachite (T. C. C.); near Kadina, in form of fine powder like flour, under the microscope each grain shows as a distinct crystal

(T. C. C.); Nichols' Nob (Brown); Nonning, Gawler Ranges (Brown).

HÆMATITE ! ! ! (*Micaceous Hæmatite*)—Angaston, Port Lincoln, near Inglewood, Yudanamutana Mine and Paramatta Mine, Yorke's Peninsula, Ulooloo, Hundred of Hallett, Mount Jagged, Pewsey Vale, Bugle Ranges (T. C. C.): The Peake, Central Australia, Tennant Creek, Central Australia, in the quartz veins running through the metamorphic rocks (Tate); Blinman Mine, in druses in close proximity to the copper deposits (Ulrich).

Compact Columnar (Red Hæmatite)—near Port Lincoln; Wallaroo Mine, Barossa Range, Angaston, and numerous other places (T. C. C.); Eudunda, Tennant Creek, and neighbourhood of The Peake, Central Australia (Tate).

Red Ochre—Parachilna (T. C. C.); vicinity of The Peake, Central Australia (Tate); between Avondale Lead Mine and Lesley's Well, near Mount Victoria, Ethindna Hill, Quorn, between Tooth's Nob and Passmore Range (Brown).

Martite (sub-species)—Carey's Gully, Mount Lofty, in the form of octahedral crystals imbedded in micaceous hæmatite (T. C. C.).

HALITE ! ! ! (Common Salt)—Occurs in beds near to and on the shores of the various salt lakes in the colony (Cloud); cliffs of the River Murray, in the form of an efflorescence (Tate).

HALLOYSITE !—Near Mount Morgan (Goyder).

HYALITE (Wood Opal)—Munno Para Hills, near Smithfield (Tate); Mulligan Springs (Brown); Nairne (T. C. C.).

IRON, (NATIVE) !—The only specimen of native iron which has been found, or at least scientifically made known, up to the present time, is in the form of a mass of meteoric iron obtained in the Gawler Ranges in November, 1875. The form is bounded by a series of more or less concave and irregularly-shaped planes. The surface is, for the most part, coated with a somewhat shining, dark brown oxide of iron. This meteorite consists of metallic iron, and contains a small proportion of nickel. It weighs 3268·7 grains, or 7 lbs. 3¼ oz. As originally found it was a trifle heavier, a small piece having been broken off by the finder, and the long chisel mark to the right hand on the top shows where an attempt was made to cut off a larger piece. The locality and circumstances attending the discovery of the meteorite are thus described by

Mr. James Martlew :—"I found the stone on the flat in a mallee scrub about half-a-mile from the northern foot of the range, being distant four miles south of Yardea Station. It was about 15 inches under the surface, and was surrounded for about 3 feet by limestone broken into small pieces. All around this there was from 4 to 8 inches of soil covering the limestone" (T. C. C.).

JAMESONITE !—Aclare Mine (T. C. C.).

KAOLINITE ! ! !—All varities of this mineral are to be found in the colony, while ordinary clays, consisting of kaolinite more or less intimately mixed with impurities, are abundant. The following are a few of the many localities for the pure white kaolin :—Wallaroo Mining District, Tanunda, Ardrossan, Hummock's Range, Teatree Gully, near Charlotte Waters, Central Australia (T. C. C.); Port Vincent (Tate). The following are the results of the analyses of two specimens of white kaolin dried at 100° C by T. C. C., A from near Wallaroo, B from Teatree Gully, the former comprising an aggregation of pearly scales easily seen under the microscope with a low power :—

	A	B
Alumina	36·18	55·32
Silica	47·53	28·67
Magnesia	·50	·72
Lime	trace	1·39
Ferric oxide	2·18	1·31
Titanic acid	——	1·62
Alkalies	1·17	1·48
Loss on ignition (water)	13·31	9·95
	100·87	100·46

In A the alkalies, being chiefly soda, are calculated as such; in B they were principally potass, and are so calculated.

LAZULITE !—near Mowarto, in small veins in granite (T. C. C.).

LIMONITE ! ! ! (Brown Hæmatite)—Near Montacute Copper Mine, Rapid Bay, Mount Barker (Burr); Nichol's Nob, Koonamore Station, Mount Coffin (Brown); Angaston, Waukaringa, Blinman Mine, Nunjibbie, Yorke's Peninsula, Sixth Creek, near Inglewood, Macclesfield, Hindmarsh Valley, near Kanmantoo, Nuccaleena Mine and numerous other localities in the province (T. C. C.); near Mount Lyndhurst it occurs in the form of pentagonal dodacahedral crystals, pseudomorphs after pyrite (T. C. C.); Eudunda, near Mount Pleasant, in auriferous quartz veins (Tate). Analysis of a specimen from Hindmarsh Valley, by Wallace, of Glasgow :—

Ferric oxide ...	76·71	= Iron, 53·7 %
Magnanic oxide ..	trace	
Magnesia ...	0·30	
Lime	0·45	
Phosphoric acid ...	1·20	
Sulphuric acid ...	0·42	
Alumina ...	3·05	
Silica	5·88	
Water (combined)	10·91	
Moisture ...	1·08	
	100·00	

Limonite pseudomorphs after pyrite, occur in the form of isolated and grouped cubical crystals in various parts of Central Australia, and near Lake Eyre it is very plentiful on the surface. It is also found in cubes at Mount Margaret and Blinman (T. C. C.); cubes also occur on the surface 8 miles north of the Peake, under Mount Kingston, Central Australia (Tate); also near Yunta Station (T.C.C.).

MAGNESITE ! !—Flinders Range, near Port Pirie, more or less weathered masses (T. C. C.); northern part of the Hundred of Cunningham, scattered about in medium-sized masses on hills of crystalline lime-stone (T. C. C.); banks of Oolabidnie Creek in the Hundred of Playford (T. C. C.); Blinman (T. C. C.); Mount Lofty and Barossa Ranges (Burr).

MAGNETITE ! ! !—Near Mount Jagged, Mount Lofty (T. C. C.); Mount Torrens, Mount Victoria (Brown); Winninnie (Goyder); The Peake, Central Australia, Hundred of Cunningham (Tate); crystalised and massive varieties are of very general occurrence from Cape Jervis to Black Rock Hill (Burr). The following analysis of a sample of ore from Mount Lofty is by Wallace, of Glasgow :—

Ferric oxide	88·22	Iron, 66·34 %
Ferrous oxide	5·66	
Manganic oxide ...	·20	
Sulphur	·20	
Iron, combined with sulphur	·18	
Phosphoric acid ...	·05	
Alumina, &c.	3·24	
Magnesia	1·33	
Silica	·92	
	100·00	

MALACHITE ! ! !—Rhondda Mine, in acicular crystals; Wallaroo Mine, in brown iron ore; Yudanamutana Mine, in the so-called "red jasper rock"; North of Port Augusta, in nodular and lenticular-shaped masses, with a radiated crystalline structure (T. C. C.); Kapunda Mine, Burra Burra Mine (T. C. C.); near Beltana, in perfectly round nodules, about three-quarters of an inch in diameter, on and near the surface (T. C. C.); near The Peake, Central Australia, in the quartz veins in the metamorphic rock (Tate); Mount Barker, Montacute Mine, Rapid Bay, Wakefield, near the Horseshoe on the Onkaparinga (Burr); Daly Mine, Stanley Mine, Mount Lyndhurst, Nichol's Nob, Tarlton's Nob, Mount Victoria, between Temple Bar and Blinman, between Avondale and Lesley's Well (Brown); Mount Wells, Northern Territory (Goyder).

MANGANITE ! ! !—Near Gordon, between Quorn and Hawker: in large quantities (T. C. C.) Oxides of manganese of various composition occur in the Port Lincoln district, at Wonna Pandappa Dam and at various localities in Central Australia. Burr reports manganese ores at Rapid Bay, Myponga, Noarlunga, River Light, Borossa Range and Mount Bryan.

MARGARITE !—Woodside (Brown).

MENACCANITE !

Ilmenite—Victoria Creek, Williamstown (Selwyn.)

MOLYBDENITE !—Yelta Mine, Moonta Mine, Wallaroo Mine, Kurilla and other mines in the same district (T. C. C.); near Franklin Harbour, in gneiss (Tate).

MUSCOVITE ! ! ! (common mica)—Of frequent occurrence in the granite rocks. The following localities may be specially noted:— Mount Pleasant, Williamstown, Barossa Ranges, Mount Crawford (T. C. C.); Macdonnell Ranges, in very large plates (Tate); River Gawler, Valley of the Nixon, Yunkalilla (Burr).

MYSORIN ! (sub-species)—Yudanamutana Mine, with crystallised malachite in red opal rock (T. C. C.).

OPAL ! ! *Precious opal*—Innamincka (Tate).

Girasol—Near Arkaba (T. C. C.).

Common opal—Angaston, Mount Crawford, all varieties of colour (T. C. C.); Nuriootpa (T. C. C.); Yudananmutana, enclosing a fine network of oxide of iron (T. C. C.); Kelly's Well, 30 miles south of Tennant's Creek, vicinity of the Peake (Tate); Flaxman Valley, Belvidere Range (Burr).

ORTHOCLASE ! !—Generally distributed, well crystallised specimens occur at Angaston (T. C. C.); Wallaroo Mine, Angaston, Ardrossan; Wallaroo, massive and crystalline (T. C. C.); Barossa Range, east of Mount Barker (Burr).

PENNINITE !—Near Beltana (T. C. C.).

PHOSGENITE ! (Plumbic chloro-carbonate)—This mineral, associated with cerussite, has been obtained from the west coast of Spencer's Gulf, the exact locality being unknown (T. C. C.); Glen Osmond Lead Mines (Burr).

PISTOMESITE !—Balhannah Mine (T.C.C.); Nuccaleena (Tate). Analysis by Cloud of specimen from Balhannah Mine :—

Hardness, 3·5; specific gravity, 3·5.

Ferrous oxide	33·31
Magnesia	20·66
Manganous oxide	3·49
Carbonic acid	43·52
	99·98

PSILOMELANE.—Sleaford Bay, Port Lincoln, Elder's Nob (G. A. Goyder).

PYRITE ! ! ! (Iron pyrites)—This species is to be found in most of the lodes of the Yorke's Peninsula mining district (T. C. C.); Wallaroo Mine and Parramatta Mine, in finely-crystallised specimens, exhibiting the form of the pentagonal dodacahedron (T. C. C.); Rapid Bay, Encounter Bay, Montacute Mine, Bundaleer, Talisker Mine, and in the various ranges (Burr); Bird-in-hand Mine, Echunga, Queen Gold Mine, Kingston Mine, Snowtown, Waukaringa, Yudanamutana (Brown); this mineral also occurs in a stalactitic form at the Wallaroo Mine (T. C. C.).

PYROLUSITE !—Near Wallaro Mines, both massive and stalactitic (T. C. C.); Wonna Pandappa Dam (Tate); Waukaringa, impure variety (Tate); Tintara (Brown); Central Australia, on the surface (T. C. C.); Penang (T. C. C.).

PYROMORPHITE !—Massive specimens of this mineral have been obtained from the west coast of Spencer's Gulf, the exact locality being uncertain. In a private communication J. E. T. Woods mentions that he has found phosphate of lead at the Strathalbyn Mine (T.C.C.); Avondale Mine, Hahndorf (Brown).

PYROPE.—Mount Babbage (Brown); Hamilton Creek (Brown).

PYROXENE ! (Augite)—Mount Schank (Tate); Mount Gambier (Burr.)

Coccolite—Mount Gambier (Burr).

Smaragdite—Woodside (Brown).

QUARTZ ! ! *Rock Crystal*—Various parts of the colony, among which the following may be named:—Yorke's Peninsula, Angaston, Green's Plains, Highbury, Barossa Range, Emu Flat, near Clare, Lyndoch Valley, Coonato (T. C. C.); Williamstown, Morialta, Tanunda Creek, Pekina (Tate); Central Australia, notably near Lake Hope and Charlotte Water, in the form of rolled pebbles of clear rock crystal (T. C. C.); Encounter Bay, Montacute Mine, Flaxman Valley, Mount Barker, Belvidere Range (Burr).

Amethystine quartz—Wallaroo Mine and near Point Riley, Yorke's Peninsula (T. C. C.).

Rose quartz—Hundred of Cunningham (T. C. C.); near Montacute Mine (Burr).

Smoky quartz—Wallaroo Mine, Angaston, Mount Crawford (T. C. C.).; Belvidere Range (Burr).

Milky quartz—Wallaroo Mine and other places (T. C. C.); Peake, Central Australia (Tate).

Bronze-coloured crystals (the colour due to a thin coating of ferric oxide) occur at the Stanley Mine (T. C. C.).

Chalcedony—Redruth, Wallaroo Mine, Angaston, North Para, near Gawler (T. C. C.); Peake, Central Australia, mouth of Onkaparinga River in miocene cliffs, Ardrossan, as fossil casts (Tate); Flaxman Valley, Mount Barker, Barossa Range, near Kapunda Mine (Burr); Blanchewater (Brown).

Carnelian— Stuart's Creek, Central Australia (Tate).

Heliotrope—Stuart's Creek, Central Australia (Tate).

Agate—Stuart's Creek, near Charlotte Water, near Catherine Telegraph Station, and various places in Central Australia and Northern Territory—in the form of pebbles (T. C. C.); Flaxman Valley (Burr); Innamincka (Brown).

Silicious sinter—Angaston (T. C. C.); Barossa Range, Mount Barker (Burr).

Flint— In the older tertiary rocks of Mount Gambier, MacDonnell Bay and Bunda Cliffs (Tate); Eucla, in the limestone cliffs (Brown).

Hornstone—Crinnis Mine (T. C. C.); Barossa Range, Flaxman Valley (Burr).

Jasper—Stuart Range, Greenock, Ardrossan, Burra Range (T. C. C.); Angaston, near the Peake (Tate); Barossa Range, Belvidere Range (Burr); Innamincka (Brown).

Lydian Stone—Innamincka (Brown).

Plasma—Near Mount Morgan (Goyder).

RHODONITE—Elder's Nob (G. A. Goyder).

RUTILE ! !—Lyndoch, Collingrove, Tanunda Creek; Mount Crawford, near Encounter Bay, in the form of fair-sized crystals (T. C. C.); near Balhannah, with quartz sand (T. C. C.); Angaston (T. C. C.); Echunga, near Oonata Water (Brown); near Victor Harbour, with feldspar and quartz (Goyder).

SERPENTINE !—Mount Crawford (T. C. C.).

SIDERITE !—Crinnis Mine (Selwyn); Oratunga Mine (Ulrich); Eudunda (Tate); Karkulto Mine (T. C. C.); Rapid Bay, Barossa Range, Mount Lofty Range, and various other places (Burr); near Blinman (Brown.) Analysis by T. C. Cloud of a specimen from the Karkulto Mine, in the form of a largely crystalline mass of a brownish-grey colour; hardness, 3·5; and specific gravity, 3·9 :—

Ferrous oxide	51·75
Manganous oxide	1·56
Magnesia	7·31
Carbonic acid (by difference) ...	39·38
	100·00

SILVER—Although silver occurs in considerable quantities in some of the lead ores of the colony, so far as I am aware, no isolated species containing this metal as an essential constituent has yet been discovered (T. C. C.).

SMALTITE—Mount Ogilvie (Goyder).

SPHALERITE ! ! ! (Zinc Blende)—Wallaroo Mine, Aclare Mine, between Point Pearce and Coxney Point, Yorke's Peninsula (T. C. C.); Two-in-the-bush Gold Mine (Brown); North Rhine (Tate); Wheal Ellen Mine, in large quantities (L. Seeger).

STAUROLITE !—Angaston (T. C. C.); Mount Barker (Goyder).

STEATITE—New Mecklenberg (Tate).

STIBNITE—Aclare Mine (Goyder).

STILPNOMELANE !—Near Oakbank, with gold (Brown).

SULPHUR !—Echunga, in quartz, associated with pyrite (Cloud); near Montacute Copper Mine, in quartz, associated with pyrite (Burr); Wheal Ellen Mine, associated with sphalerite and galenite (L. Seeger).

TALC ! !—Flanks of the Kaiserstuhl (Tate); near Menge Town, Mount Crawford (Selwyn); Belvidere Range, River

Hutt, Lyndoch Valley (Burr); Yorke's Peninsula, Barossa Range, Kanmantoo (T. C. C.).

TITANITE (Sphene) !—Mount Barker (Tate).

TOPAZ !—Near Blanchewater, and elsewhere near Lake Eyre, in Central Australia; in the form of rolled pebbles, white and pale green in color.

TOURMALINE ! !—Moonta Mine, Parramatta Mine, Mount Crawford, Angaston, Ardrossan (T. C. C.); Mount Boothby, Barrow's Creek, and neighbourhood of The Peake, in Central Australia (Tate); Valley of the Nixon, Barossa Range, Encounter Bay, Rapid Bay (Burr).

Rubellite.—Valley of the Nixon (Burr).

ULLMANNITE !—Gill's Bluff, Mount Lyndhurst (T. C. C.).

VIVIANITE !—Angaston, massive (T. C. C.); near Mount Rufus, near Strathalbyn, earthy (Burr).

WAD (*Asbolite*)—Wooltana (Brown).

WOLFRAMITE ! — Onkaparinga, massive (G. Francis); near Royston Head, Southern Yorke's Peninsula (Tate).

WULFENITE ! (Molybdate of Lead)—Mount Lyndhurst, crystallised in double tetragonal pyramids (T. C. C.); Avondale Mine, near Farina (Brown).

MINERALS OF QUEENSLAND.

! after the name of a mineral, or before a locality signifies that it is rare; ! ! that it is common; ! ! ! that it is in workable quantity.

C.	A. W. Clarke.
D.	R. Daintree.
G.	A. C. Gregory.
J.	R. L. Jack.
L.	E. B. Lindon.
M. or A. G. M. ...	A. Gibb Maitland.
R.	W. H. Rands.
C. I. E	Report of Examiners on Minerals in Colonial and Indian Exhibition, by A. W. Clarke.
Cat. C. I. E. ...	Catalogue of Minerals in C. I. E.
Q. M. C. ..	Queensland Museum Catalogue.
g. f.	gold-field.

Notes.

This list has been compiled by the Queensland members of Committee No. 7 (who constituted themselves a sub-committee, of which Mr. R. L. Jack acted as Secretary), with the co-operation of Mr. A. Gibb Maitland, of the Geological Survey of Queensland, and other gentlemen whose names are appended to the information furnished by them.

Most of the localities named will be found in the 16-mile map published by the Lands Department.

Rock-forming minerals, as such, have been purposely omitted, except in cases where some peculiarity in their mode of occurrence required to be pointed out.

The occurrence of certain common minerals, *e.g.* Quartz and Calcite, is only noted in such cases as present features of scientific or economic importance.

To enumerate every locality where gold is found would be an endless task. The list includes the chief gold fields, with a reference to their geological characteristics, and a few cases in which the metal occurs under specially noteworthy circumstances.

Occasionally the occurrence of a mineral at a certain place is referred to by two or three observers, each of whom has something different to record regarding the mineral or the conditions under which it occurs. Mere duplicate observations have been struck out by the Secretary in editing the list.

It may be said that the prominence given to a mineral is not always proportionate to its importance. Unfortunately the amount of information to hand regarding minerals bears no ratio to their scientific or economic value.

The list is necessarily incomplete, but if the emendation of the "Census" is to be from year to year the care of a Committee of the Association, the present list, it is hoped, will form a useful basis for future operations.

A. W. CLARKE, Charters Towers,
E. B. LINDON, Brisbane,
ROBERT L. JACK, Townsville,
WILLIAM H. RANDS, Maryborough,
} *Queensland Sub-Committee.*

Actinolite—Cloncurry !, on calcite (Q. M. C.); Mount Perry district ! ! !, actinolite rock, and as green radiating crystal in actinolite rock (R.); Charters Towers !, in "Day Dawn Extended" quartz reef (J.), also in country rock (syenite) of "North Australian Block," (C.).

Agate—Agate Creek, Etheridge ! !, in large quantities (L.); Burnett district ! !, over a wide area (N. Bartley); Narrango district ! ! (R.); Mount Toussaint and Mount Macedon ! !, in geodes in epidote rock (J.); Agate Creek, Gilbert ! ! !, occurring "in thousands of tons" in river gravels (J.).

Amalgam—Kilkivan, in hard dark quartzose rock (R.).

Amethyst—Logan River ! (R.); Upper Coomera, Albert district (R.); Cloncurry (Upper Camp ?) !, in alluvial (C.).

Analcime—Strathmore Creek and Bowen River ! !, in geodes in epidote rock (J.).

Anglesite—Silver Hill Mine, Mount Albion !, transparent pyramidal crystals (J.); at all the silver-lead mines, especially Argentine, Dry River, and Mount Albion ! ! !, argentiferous, enveloping argentiferous galena, and apparently derived from its decomposition (J.).

Argentite—Cumnor Lease, Silverfield, Tinaroo district—"It is probable that in argentiferous galena from here, assaying 1400oz. silver to the ton, a good deal of this silver is distributed through the galena in the form of free sulphide" (C. I. E.); Emu Plains, Bowen River, intimately mixed with cuprite and tenorite, especially the latter, the mixed ore containing 2299oz. silver per ton (J.).

Asbestos—Mount Wheeler, 18 miles from Rockhampton ! !, in serpentine (D.) and (C.); Cloncurry !, in "The Contra" copper lode; near Gympie !, in serpentine (R.); Gympie !, with quartz in reefs (R.); Woodonga ! !, Glastonbury, Wide Bay district, in serpentine (R.); Mount Alma, Charters Towers ! !, in diorite rock, the vein cropping out at surface from 4in. to 5in. thick (C.) —perfectly white and silky in part, but bulk stony: silky portion lost no weight on treatment with warm hydrochloric acid, and was unaltered by blow-pipe or Bunsen flame (C.).

Asbolite—Kilkivan, in a lode running nearly N. and S. in light-coloured serpentine, occurs sometimes in solid veins, sometimes in large botryoidal masses, but generally running in an irregular manner through the gangue (R.), [Analyses: undressed ore, Co 7·50 per cent., Ni 2·12 per cent., (K. T. Staiger); fair sample of lode, Co 7·50 per cent., Ni 2·25 per cent., Mn 18·00 per cent., (K. T. Staiger); surface ore, Co 2·75 per cent., Ni 2·25 per cent., Mn 65·00 per cent. (W. Vivian and Sons, Swansea).]; Kilkivan ! ! !, believed to be from lode referred to by (R.); "specimens of asbolite from same locality in Queensland Museum, where it is termed cobaltiferous wad, have the following assays appended: —Cobalt 22·207 per cent., nickel 3·510 per cent, iron 29·130 per cent., manganese 2·360 per cent., copper 0·103 per cent. (Cat. C. I. E.); Mountain Home !, in copper lode, associated with green carbonate of copper, ferruginous red oxide of copper, pyrolusite and garnets (J.).

ATACAMITE—Mount Perry district (Q. M. C.); Cloncurry, pseudomorphous after cuprite (Q. M. C.).

AZURITE—Great Kennedy Copper Mine ! ! !, in rhombic prisms and pyramids and in radiating botryoidal masses in a large lode (J.); Keelbottom Copper Mine ! !, in quartz veins in porphyrite country (J.); Contra Lode, Cloncurry !, in large copper lode in diorite country (J.); Pumpkin Gully, Cloncurry ! !, in ferruginous cup of copper lode (J.); Great Australian Copper Mine, Cloncurry ! !, in large lode with cuprite, native copper and malachite (J.); Ironclad Mine, Watsonville ! !, with cassiterite and malachite (J.); Clan Ronald, Eureka Creek, Tinaroo ! !, with malachite and cassiterite, from 20 feet below surface (C.); Mount Garnet, Tinaroo district ! !, with malachite (C.); Peak Downs Copper Mine !, near Clermont, not so common as malachite (L.); Mount Perry district !, with other copper ores (L.); Mount Orange Copper Mine, Nebo, accompanying malachite, hæmatite and black oxide of copper (W. J. C. Adrian); Pine Vale, 25 miles S.W. of Mackay ! !, massive in reefs, also as alteration product of copper pyrites, associated with quartz, zinc-blende, malachite, galena and quartz (M.).

BARYTES—Three miles from Mary River along Kilkivan Road ! ! !, as a large vein (R.); near Miva, Wide Bay ! ! (G.); 30 miles west of Milo Station, near Adavale ! !, also Maxwelton, near Hughenden !, as radiated nodules in shales of the Rolling Downs (cretaceous) formation (J.).

BISMUTH—Narrango !, in auriferous lode in a matrix of steatite (L.); Mount Biggenden, Degilbo, Wide Bay district ! ! !, (R.); Stanthorpe, in tin-wash (Q. M. C.); Pumpkin Gully, Cloncurry ! !, in auriferous drift (J.); Mary

Douglas Reef, Cloncurry ! !, associated with quartz, limonite and gold (J.); Herberton Tin Mines !, in Home Rule, Herbertina and other mines, associated with cassiterite (J.).

BISMUTH OXIDE—Mount Shamrock, Wide Bay district, veins of oxide of bismuth are exceptionally rich in gold (R.), assaying 62 per cent. of bismuth and 252oz. of gold (Mr. Hamilton, reported by R.).

BISMUTHINITE—Mount Shamrock !, in fine acicular crystals (R.); Mount Biggenden ! ! (R.); Coolgarra, Tinaroo ! ! !, with native bismuth in lode in granite (C.); Gilbert River ! !, in lode (J.); Great Britain Mine, Coolgarra ! !, in lode associated with cassiterite, galena and sphalerite (J.); Southern Tin Mine, Irvinebank ! !, in lode associated with cassiterite (J.).

BISMUTHITE—Cloncurry !, containing visible gold (Q. M. C.); Sellheim ! !, in lodes (L.), containing a good deal of copper and iron and probably derived from decomposition of Wittichenite (J.); Mount Biggenden, Degilbo ! ! ! (R.); Mount Shamrock ! !, (R.); Coolgarra, Tinaroo !, alluvial associated with cassiterite (C.); Percy River ! ! !, in gullies worked for alluvial gold, containing over 72 per cent of metallic bismuth (W. M. Mowbray); Percy River ! ! !, in alluvial gravels (J.).—[Analyses, Bi 72·61, CO_3 12·77, iron oxide 12·80, sand, mica, &c. 1·82, sp. gr. 6·4 (K. T. Staiger); Kangaroo Hill ! !, in alluvial gravels (J.); Head of Severn River ! !, in alluvial gravels (J.).

BORNITE—Blue Mountains near Eton !, associated with tenorite and cuprite (J.); Mount Perry district ! !, associated with other copper ores, sometimes in steatite, (R.); Cloncurry ! ! (Q. M. C.).

BOURNONITE—Mount Albion ! ! !, argentiferous: "The recent discovery of bournonite at Mount Albion proves to be more important the more fully the deposit is opened up. It is calculated that there is in sight at the present time fully 2000 tons of black ore, which at £60 per ton amounts to the encouraging total of £120,000. As the copper, antimony, &c., in the ore pays all expenses, this means that the whole £120,000 is clear profit.—(*Herberton Advertiser*, June, 1889).

CACOXENITE—Watts' Selection, Logan district !, on limonite (R.).

CALCITE—Sellheim River ! ! !, large veins in shale and sandstone country (Gympie Beds), (J.); Hector Claim, Ravenswoop ! !, on hanging wall of auriferous quartz reef, 85 feet from surface (C.); Markham's Claim, Ravenswood ! !, associated with galena from 120 feet from surface (C) ; Ravenswood ! !, on foot-wall of a lode carrying chalcopyrite, sphalerite, iron pyrites, mispickel with gold and quartz (C.) ; Golden Bar, Rosewood, Rockhampton, with auriferous quartz 86 feet from surface (C.) ; Advance Reef, Norton Goldfield, Gladstone ! !, with iron pyrites and sphalerite from 180 feet. The same vien occurs in the adjacent claims on this line of reef, sometimes the calcite vain is on the hanging, less often on the foot-wall of the reef (C.) : some of this calcite is nearly transparent, one small piece was sufficiently clear to exhibit double refraction. The calcite vein is about 3″ thick ; Gympie Goldfield ! !, with auriferous quartz and iron pyrites : "The manner in which the crystals of quartz, calespar and pyrites cut into each other and are indented by the gold which is in other parts moulded to the angles of the crystals, shows that they were all deposited at the same period ; while the lime, taking the form of calespar, indicates that the deposition was at a low temperature" (A. C. Gregory) ; Victory Lease, Charters Towers ! !, in pellucid crystals in fissures and vughs in the walls of the lode or reef : these crystals are so grouped together that only one set of facets is perfect. These facets are curved. Three of them grouped round the principal axis and termining in a point form the only part of the crystals that are visible among the whole sample raised, (C.) ; Victory Lease, Charters Towers ! !, in opaque rhombohedral crystals, on auriferous quartz (C.) ; Gympie ! !, with quartz associated with gold and gold-bearing sulphides (L.) ; Kilkivan ! !, with quartz and auriferous and argentiferous sulphides (L.) ; Glenlyon, near Stanthorpe ! !, large beds of limestone containing caverns with stalactites and stalagmites (L.) ; Warwick ! !, black and white limestone (C.) ; analysis by (C.) :

	WHITE	BLACK
Moisture	1·10	1·29
Carbonic acid ...	43·05	43·05
Lime	54·66	54·72
Peroxide of iron ...	0·35	0·37
Magnesia	0·18	0·55
Insoluble residue ...	1·59	0·97
	100·93	100·95 ;

Potosi claim, Tinaroo district ! ! !, limestone used as a flux for silver-lead ores (C.) ; analysis by (C.) :

Moisture	... ...	1·07
Carbonate of lime	... ...	95·83
Silica	... ...	2·41
Peroxide of iron	... ...	0·78
Carbonate of magnesia	...	0·47
		100·56 ;

Gladstone ! !, white and coloured marbles (R.), (Q. M. C); in very many auriferous reefs ! !, a common form of gangue (L.); Toowoomba district ! !, in cavities in basalt (L.).

CASSITERITE—Stanthorpe district ! ! !, stream tin in drifts, generally in small water-worn crystals, with a large proportion of the *ruby* and *amber* varieties, sometimes together with water-worn gold (J.), as crystals in quartz reefs, and in dykes of greisen in granite country (J.); Pascoe River ! ! !, as stream tin ore (L.); Mount Spurgeon ! ! !, principally stream tin (J.); Kangaroo Hills ! ! !, stream and lode tin (J.); associated with bismuth (Pears); samples of the pannned-off ore contain absolutely white water-worn grains of tin oxide (10-15mm. diameter). *Ruby* and *amber* tin also occur (C.); Running Creek, Star River ! ! !, stream tin, associated with garnet and topaz (J.); Granite Creek, Palmer Goldfield ! ! !, as stream tin associated with gold, latter having been derived from the slates which abut on the western banks of the creek, while the granitic eastern banks supplied the tin (Sellheim); Cannibal Creek ! ! !, stream and lode tin, the latter in large quartz reefs in slate and greywacke country (J.); Annan and Bloomfield ! ! !, stream and lode tin, the latter associated with quartz, tourmaline, hornblende, and wolfram,—principal mines are Mount Leswell, Lion's Den, Mount Amos, Mount Romeo (J.); Mount Leswell, Cooktown ! ! !, with tourmaline crystals, under the microscope the panned-off ore is mainly honey-yellow, with a little opaque black tin and a little *ruby* tin, the tourmaline is of a greyish blue and markedly pleochroic parallel to principal axis (C.); a specimen of schorl and tin ore assayed 55 per cent. of metallic tin (L.); Mount Amos, Cooktown ! ! !, with tourmaline crystals, under the microscope the cassiterite appears to be mainly transparent and of amber or honey-yellow colour, the tourmalines are greyish-blue and strongly pleochroic, parallel to principal axis (C.); Lion's Den, Cooktown, ! ! !, with tourmaline crystals, microscopic examination reveals nothing of interest (C.), some of these Cooktown tin ores are rich, we having had samples of ½-cwt. assaying 30·25 per cent. metallic tin, while, on the other hand, some samples have only yielded 5 per cent. metal on assay (Coane and Clarke); The Bloomfield River, Cooktown ! ! !, grey very water-worn stream tin ore, a boulder from this river, exhibited in the Colonial and Indian Exhibition (1886), was nearly pure tin-stone (cassiterite), and weighed 82lbs. (C.); Rose of England, Eureka Creek, Tinaroo ! ! !, associated with fluor spar, quartz, and iron pyrites (C.); Clan Ronald, Eureka Creek, Tinaroo ! ! !, with azurite and malachite, 20 feet from surface (C.); Lass of Gowrie, Eureka Creek, Tinaroo ! ! !, with white mica, 60 feet from surface (C.); Black Rock, Eureka Creek, Tinaroo ! ! !, with red hæmatite, 70 feet from surface (C.); Lancewood Creek, 9 miles from Brooklands Head Station ! ! !; Etheridge Goldfield ! ! ! (Hodgkinson); Krombit, Port Curtis district !, water-worn crystals in creek (R.); Christmas Eve, Irvine Bank, Tinaroo ! ! !, with quartz, the two minerals occurring in alternate layers, about 15 times in 1″, the whole having a pink cast (C.); General Gordon Tin Mine, &c., Thompson's Creek ! ! !, in lodes (J.); Return Creek ! ! !, lode and stream (J.); Emu Creek ! ! !, lode (J.); Halpin's Creek ! ! !, lode and stream (J.); Pinnacle Creek, near Thompson's Creek ! ! !, stream (J.); Oakey Creek, near Thompson's Creek ! ! !, stream (J.); Bachelor's Reef, Eidsvold !, in auriferous quartz reef, associated with tourmaline (R.); Dry River ! ! !, stream (J.); Aunitt or Nettles Creek ! ! !, stream (J.); Rudd Creek ! ! !, stream (J.); California Gully, near Herberton ! ! !, lode and stream (J.); Irvinebank ! ! !, in lodes in sedimentary rock, in Great Southern the cassiterite is associated with arsenical pyrites, native bismuth, stibnite, &c. (J.); Walsh River ! ! !, very fine crystals of tin ore disseminated through a chloritic matrix in lodes which coincide with the bedding of the country rock (pebbly grits), (J.); Gordon Mine, Glenhinedale ! ! !, the ore impregnating a country rock of hard, fine-grained, silicious, and talcose sandstone (J.); Koorboora, Tate River ! ! !, lode (J.); Watsonville ! ! !, in lodes in a country rock of shales and greywackes, associated in Ironclad Mine with copper pyrites and copper carbonates (J.); Spinifex Creek, near Herberton ! ! !, as stream tin (J.); Herberton ! ! !, in leads below the basalt and in recent stream beds (J.); rarely in "elvan dykes"; at "Three Star" Mine, &c., in dykes of quartzose chlorite, and quartzose serpentine, and in chlorite rock-country, rock quartz-porphyry (J.), sometimes associated with chlorite, orthoclase, pyrites, schorl, wolfram, garnet and topaz (L.); Watsonville ! ! !, in dykes of quartzose chlorite, and quartzose serpentine in a country rock of quartz-porphyry (J.); Eureka Creek ! ! !, lode (J.); The Tate River, 60 miles from Herberton, Tinaroo ! ! !, stream (C.); Tornado, Newellton, Tinaroo ! ! !, with kaolin, sphalerite, chalcopyrite, mispickel, galena and quartz (C.); Bolton's Folly, Watsonville, Tinaroo ! ! !, with garnets, 30 feet from surface, in green chlorite (C.); Return Creek, Coolgarra, Tinaroo ! ! !, as stream tin: "I have seen nearly (300 grains short) 2lbs. of coarse tin washed out of a dish full of dirt" (C.); Crœsus Claim, Tinaroo ! ! !, with fluor spar crystals from 80ft. level (C.); Denny's Claim, near Watsonville ! ! !, with bright red hæmatite (C.); Bonnie Dundee, Coolgarra, Tinaroo ! ! !, in red chlorite with wolfram and mica (C.); Pinnacle Lease, Gregory's Gully, Tinaroo ! ! !, with a light pink orthoclase and quartz crystals (C.); Adventure Claim, Tinaroo ! ! !, with kaolin and quartz (C.); Cosmopolitan, Tinaroo ! ! !, with kaolin and quartz (C.).

CERUSSITE—Argentine Silver Field ! ! !, argentiferous in upper levels of argentiferous galena lodes (J.); Flagstone Creek, Bowen district; with decomposing galena (L.); Lawn Hill ! !, in galena lode (J.); Scrubby Creek, Broad Sound ! !, argentiferous in lode (J.); Star of the South Gold Mine, Ravenswood !, in auriferous quartz reef (J.); Ravenswood Silver Field ! ! ! argentiferous, in argentiferous galena lodes (J.); Curlew, about 12 miles south of Charters Towers ! !, associated with galena, gold, quartz, malachite, chrysocolla and pyromorphite (C.); Dry River Silver Field ! ! ! argentiferous, in argentiferous galena lodes (J.); Rainbow Claim, Newellton, Tinaroo ! !, with galena and quartz in very perfect crystals and macles (C.); First Shot Claim, Coolgarra, Tinaroo !, with hæmatite and galena (C.); Mount Garnet, Tinaroo !, in minute crystals with copper stained quartz and galena, very much decomposed (C.); Mount Albion Silver Field ! ! ! argentiferous, in argentiferous galena lodes (J.); Sellheim Silver Field ! ! ! argentiferous, in argentiferous galena lodes (J.).

CHABASITE—Main Range, below Toowoomba !, lining cavities in basalt (L.); Darling Downs, Toowoomba !, lining cavities in basalt (A. C. Gregory): a sample submitted to me by Mr. Gregory contained 21·76 per cent water (C.).

CHALCEDONY—Clermont Plains ! !, in basalt (R.); Mount Toussaint and Mount Macedon ! !, in geodes in epidote rock (J.); Westwood ! in geodes in basalt (J.).

CHALCOPYRITE—Tinaroo district ! !, associated with marcasite, galena, mispickel, and sphalerite (J.); Mount Perry district ! ! ! generally auriferous, lodes in granite and schistose country, often associated with bornite (L.); Copperfield, Clermont, Peak Downs ! !, accompanying iron pyrites (L.); Ravenswood ! ! auriferous with iron pyrites (L.); Charters Towers ! ! associated with iron pyrites and galena (C.); Carnarvon Castle Claim, Blackfellow's Gully, Rockhampton ! ! ! auriferous in quartz and calcite (L.), assays from 2 to 5 oz. gold per ton (L.); Mount Morgan (London), Extended Crocodile Goldfield ! ! ! readily decomposing, slightly auriferous (L.); Yabba Station between Nanango and Gympie ! ! !, lode, auriferous (L.): assays from 5dwts. to 4½oz. of gold per ton (L.); Mount Orange Copper Mine, Nebo ! !, lode (L.); Pine Vale, Merani, Mackay ! !, with bornite in quartz, lode in granite country (L.); Pine Vale, 25 miles south-west of Mackay ! ! ! occurs in quartz reef in small veins and isolated masses, showing often a beautiful iridesence on the surface, associated with malachite, azurite, and tetrahedrite (A. G. M.); Kangaroo Mine, Crocodile Goldfield, 3 miles from Mount Morgan Mine ! ! ! in quartz lode, auriferous (L.); Copper pyrites occurs ! ! associated with pyrites and mispickel, more or less plentifully in the majority of the auriferous reefs of Queensland (J.).

CHALYBITE—Normanby Goldfield (Bowen) ! !, in Glengarry Reef and others (J.); Cloncurry Goldfield ! ! (J.); Mount Perry district !, associated with iron pyrites, galena and sphalerite (R.).

CHERT—Brookfield, Brisbane (Q. M. C.); Springsure (Q. M. C.).

CHROMITE—Near Ipswich ! !, in serpentine (C.); Mount Wheeler, Rockhampton ! !, in serpentine (D.); Kilkivan !, in serpentine (R.); Pine Mountain ! !, (G.); Gladstone district ! !, in serpentine (D.); Cawarral ! !, in serpentine (D.).

CHRYSOCOLLA—Burdekin River, near Mount Keelbottom !, in lode in quartz, porphyry country (J.); Curlew, about twelve miles south of Charters Towers !, with galena, malachite, gold, quartz and pyromorphite (C.); Townsville Road, near Dalrymple, with native copper and malachite (J.).

CHRYSOTILE—Mount Coora !, in serpentine (R.).

CINNABAR—Kilkivan ! !, in limestone, also with tetrahedrite (L.), [Analysis by (C.) of limestone containing cinnabar, the cinnabar being determined by the use of Sonstadt's solution :—Carbonate of lime, 50·83 per cent., carbonate of iron 26·00 per cent, silica 15·13 per cent., sulphide of mercury 7·01 per cent., total 98·97]; Manumbar, Brisbane River ! !, reported by Mr. S. L. Hester; Kilkivan district ! ! !, in lodes, country rock, micaceous, chlorite and serpentinous schists, also conglomerates, sandstones and shales, 70 tons treated, yielded 6000lbs of mercury (R.).

COAL—*Note.*—Although a complete list of coal seams with their analyses hardly comes within the scope of a "Mineral Census," a list is given of localities where coal is, or has been, profitably worked.)—Burrum ! ! !, the coalfield appears to be intermediate in age between the Bowen River Field (Carbonifero-Permian) and the Ipswich (Jurassic?) (J.); Ipswich ! ! !, the coalfield is the equivalent of the Clarence River beds of New South Wales (Jurassic?) (J.); Clifton ! ! !, part of the Ipswich coalfield (J.); Jimbour ! ! !, part of the Ipswich coalfield (J.); Cooktown, Townsville, Bowen River, Nebo, MacKenzie River, Dawson River ! ! !, coal of Carbonifero-Permian age extending over wide areas, but not worked (J.); Styx and St. Lawrance ! ! !, Coal seams (Burrum beds) now being opened up (J.).

COPPER (NATIVE)—Peak Downs ! !, with quartz (Salmon); Mount Perry district ! ! (R.); Alliance Mine, Morinish, Rockhampton ! !, in auriferous quartz, the whole being crushed together and yielding 1oz. of gold per ton (L.); Gympie !, in amygdaloidal volcanic rock (R.); Keelbottom Copper Mine ! !, in quartz veins in porphyrite country (J.); Mount Leyshon, 17 miles south of Charters Towers !, in fine microscopic octahedral crystals, grouped together among decomposing felspars, kaolin, hæmatite, &c., the volcanic ash described by R. L. Jack, Gov. Geol., in his report on Mount Leyshon (C.); Peak Downs !, in fine threads permeating quartz, so as to render it difficult to powder (Salmon); Great Australian Copper Mine, Cloncurry ! ! !, with cuprite in large lodes (J.); Cloncurry ! ! !, altering to cuprite (L.); Argylla Copper Mine, Leichardt River ! !, in large lode with cuprite and malachite (J.); Dugald River ! !, in large lode with cuprite and malachite (J.); No. 1 Copper Selection, Dugald River ! !, forming veins through cuprite (J.); Cottais' Tin Mine, Herberton !, on joint planes of an intrusive amphibolic rock (J.); Kirk River, near Ravenswood !, in an auriferous reef (J.); Burdekin River, near Mount Keelbottom ! !, in lode in quartz porphyry country (J.).

COPPERAS—Ironclad Mine, Herberton, crystallises from water trickling from the mine associated with blue vitriol, ratio between the copper and iron in these mixed sulphates is very variable, some crystals being deep blue, and consequently rich in copper, while others are a pale green and poor in copper (C.).

CUPRITE—Great Australian Copper Mine, Cloncurry ! ! !, in large lode with native copper, tenorite, azurite and malachite (J.); No. 1 Copper Selection, Dugald River ! ! !, in large lode, with malachite and native copper, the cuprite very fine, and much of it is of the *ruby* variety (J.); Cloncurry Copper Smelting Co.'s Mines, Cloncurry ! !, very fine crystals associated with hæmatite, some ½-inch in diameter, being combinations of the cube with the pentagonal dodecahedron, the most minute microscopic crystals exhibiting the same combination of forms (Sheaffe); Contra Lode, Cloncurry ! ! !, in large lode in diorite country, with malachite and azurite (J.); Pumpkin Gully, Cloncurry ! ! in cap of large lode (J.); Homeward Bound, Cloncurry ! !, in lode, with malachite and azurite (auriferous), (J.); Copper Mines at Duck and Malbon Creeks, Cloncurry ! ! !, in lodes (J.); Chillagoe ! ! !, large copper lodes (cuprite ?), (Moffat); two miles north of Great Australian Copper Mine, Cloncurry ! ! !, group of lodes (J.); Argylla Copper Mine ! ! !, in large lode with native copper and malachite (J.); Leichardt River ! ! !, Crusader and other lodes (J.); Dugald River, 45 miles north-west of Cloncurry ! !, with native copper, calcite and melaconite (Sheaffe); Great Kennedy Copper Mine ! ! !, in a large lode with azurite and malachite (J.); Moreton Island ! ! (Q. M. C.); Mount Perry district ! ! !, associated with other copper ores (L.); Texas, Stanthorpe district ! ! !, with other copper ores (Gunn); Blue Mountains, near Eton ! ! (J.); Emu Plains, Bowen River ! ! (J.).

Tile Ore—A brick red or earthy variety of cuprite generally containing peroxide of iron, the term is little used, but is convenient for a variety of cuprite very common in Queensland (J.); Great Kennedy Copper mine ! !, in a large lode with azurite, malachite and cuprite (J.); Copper Mines at Duck Creek, Cloncurry ! !, in lode No. 9; near Tierrawomba, Mackay !, in cap of lode, with malachite (J.); Gregory River !, in a quartz reef with malachite (J.); Cloncurry Copper Smelting Co.'s Mines, Cloncurry ! ! !, associated with hæmatite and minute crystals of cuprite (Sheaffe).

CYANOSITE—Mount Morgan (London) Extended Mine, Crocodile Goldfield ! !, on chalcopyrite (L.).

DIAMOND—Yandina !, Tabragalba !, (I have been informed that diamonds have been found in these localities, but cannot vouch for the accuracy of the information), (J.); Gilbert River !;—Mr. Warden Samwell in Report of the Dept. of Mines for 1883 says: It is stated in the prospectus of a gold mining company, that a "diamond of the first water" from the Gilbert, was in possession of "one of the earliest Commissioners." I am informed that Mr. T. R. Hackett is referred to. The same prospectus quotes Mr. W. O. Hodgkinson, late Minister for Mines, as having written:—"If similarity of strata, associated mineralogical deposits and general characteristics, argues anything, Agate Creek holds out inducements for a vigorous search for the king of gems" (J.)

FLUORITE—Crœsus Claim, Tinaroo !, with cassiterite in small cubical crystals (C.); Rose of England, Eureka Creek, Tinaroo !, with cassiterite, quartz and iron pyrites, crystals octahedral and cubical (C.); Herberton Tin Mines ! !, with cassiterite in lodes (J.); Irvinebank Tin Mines ! !, with cassiterite &c., (J.).

FRENCH CHALK (Steatite)—Mount Morgan ! ! (J.).

GALENA—Etheridge Goldfield !, in auriferous reefs with pyrites, arsenical pyrites, copper pyrites and sphalerite (J.); Hodgkinson Goldfield !, in auriferous reefs (J.); Gilbert River ! ! !, argentiferous, in large lodes (Mowbray); Mount Garnet, Tinaroo district ! !, cupriferous, decomposing (C.); Black Bull, Hodgkinson, with visible gold (C.); Ravenswood Goldfield ! !, in auriferous reefs, with pyrites, arsenical pyrites, copper pyrites, sphalerite, &c. (J.); Mount Albion Silver Field ! ! !, argentiferous, in lodes associated with anglesite, cerussite, cerargyrite, &c. (J.); Chillagoe ! ! !, very large out-crop of lead ore (galena ?) Girofla Mine (J. Moffatt); Degilbo ! ! !, argentiferous, in lodes, with gold, arsenical pyrites and sphalerite (R.); Eidsvold Goldfield !, with pyrites (R.); Norton Goldfield ! with gold, pyrites, sphalerite, quartz and calcite (R.); Yarrol ! ! !, in lode, poor in silver (R.); Norton Goldfield ! !, lode in granite (R.); Gympie ! !, with free gold (R.); Eungalla, Broken River, North Kennedy ! ! !, in crystals, also massive in reef with quartz, galena, carbonate of zinc and iron pyrites, very argentiferous (M.); Flagstone Creek, Bowen district ! ! !, in a lode having an out-crop composed mostly of wolfram and quartz, assays 76 oz. of silver per ton (L.); Yarrol, Burnett district ! ! (L.); near Merani, Mackay district !, in small veins in granite (L.); Potosi Lode, Mount Perry district ! !, associated with iron and copper pyrites and a little sphalerite in a gangue of quartz and barytes (R.); Allendale Lode, Chowey Creek, Wide Bay district ! ! !, with iron pyrites, mispickel and sphalerite, assaying 39oz. of silver and 1oz. of gold to the ton (R.); Argentine Silver Field ! ! !, argentiferous, in numerous lodes (J.); Sellheim Silver Field ! ! !, argentiferous, in lodes associated with sphalerite and pyrites (J.); Pyramid Lease, Sellheim ! ! !, argentiferous, with sphalerite. [Analyses, zinc 34·23 per cent., lead 42·01 per cent., sulphur 22·80 per cent., iron 1·11 per cent., total, 100·15 (C.); Charters Towers Goldfield ! with pyrites in auriferous reefs (J.); Charters Towers !, nearly always occurring with calcite and sphalerite in the auriferous quartz on this field (C.); Curlew, about 12 miles south of Charters Towers !, with cerussite, gold, quartz, malachite, pyromorphite, chrysocolla (C.); Silver King Tin Mine, Herberton !, with cassiterite (J.); Northcote ! !, argentiferous (Towner); Return Creek ! !, silver lodes (argentiferous galena?), (J.); Lawn Hill ! ! !, argentiferous, in large lode (J.); Coen River, south ! !, argentiferous, in small lode (J.); Croydon Goldfield !, in auriferous reefs with pyrites, sphalerite and graphite (J.); Koh-i-noor, Tinaroo ! ! !, with mispickel and sphalerite (C.); Tornado Claim, Silverfield, Tinaroo district ! ! ! with iron pyrites and sphalerite (C.), assay silver 1oz. 2dwts. per ton (L.). [Analyses, zinc 13·42 per cent., copper 5·10 per cent., lead 6·06 per cent., arsenic 11·99 per cent., iron 29·06 per cent., sulphur 32·74 per cent., silica 2·11 per cent., total, 100·48 (C.); Dry River ! ! ! argentiferous, with pyrites, marcasite, chalcopyrite, sphalerite, anglesite, cerussite and malachite (J.); Target Mine, Newelltown, Tinaroo ! ! !, the lode is much decomposed, the galena can be picked out in nodules as big as a cricket ball, on cracking open these nodules, a zoned structure is seen consisting of carbonate of sulphate and oxide of lead in concentric layers, with perhaps a nucleus of clean fresh galena. In other cases the decomposition is complete and there is no trace of nucleus. I have seen such nodules in other galena lodes throughout the Tinaroo district, but they always occur in the lodes above water level (C.); Silverfield, Tinaroo ! ! ! similar to the Target Mine galenas described above (C.); Ravenswood Silver Field ! ! ! argentiferous, in lodes, associated with cerussite, sphalerite, stibnite, pyrites, &c. (J.).

GARNET—Eungella Goldfield ! !, with wolfram and iron glance in large lode in granite country (J.); *Pyrope*, Running Creek, Star River ! !, in tin wash, associated with topaz (J.); Coen River Diggings ! !, in auriferous wash-dirt (J.); Cloncurry ! ! (G.); west of Mount Eurie, Cloncurry ! (J.); Mountain Home !, in copper lode, in ferruginous red oxide of copper, associated with green carbonate of copper, asbolite and pyrolusite (J.); Bolton's Folly Tin Mine, Watsonville ! !, in chlorite rock, with cassiterite (J.); Woolgar Goldfield ! !, in auriferous wash-dirt (J.); Bolton's Folly, Watsonville ! !, in green chlorite rock, imbedded so softly as to be removable by tapping the specimens smartly with a hammer, when the garnets drop out, with cassiterite (C.).

GOLD—Etheridge g. f. ! ! !, in quartz reefs with calcite, iron pyrites, copper pyrites, arsenical pyrites, sphalerite and galena, mainly in granite country, but at Goldsmith's in schist and slate country (J.); Woolgar g. f. ! ! !, in quartz reefs, under conditions similar to those of the Gilbert Goldfield (J.); Gilbert g. f. ! ! !, in quartz reefs in slates, shales and metamorphic mica schists of supposed Lower Silurian age, penetrated by numerous dykes of elvanite, diorite, hornblende rocks, &c.,—"Where these dykes penetrate slates payable gold is usually obtained" (D.); Hodgkinson g. f. ! ! !, in quartz reefs in highly inclined shales and sandstones (J.), sometimes accompanied by galena and iron and copper pyrites (L); Palmer g. f. ! ! !, in reefs in highly inclined shales and sandstones, also alluvial gold (J.); Coen g. f. ! ! !, reef and alluvial gold, the gold being much alloyed with silver (J.); Croydon g. f. ! ! !, in quartz with oxide of iron, native silver and cerargyrite (L.); in reefs in a country rock partly granitic and partly metamorphic (J.); Pikedale ! !, in lodes with copper pyrites (J.); Jimna g. f. ! ! !, reefs in granite country and in alluvial drifts (A.); Gooroomjum g. f. ! ! !, in alluvial drifts (A.); Black Snake ! ! !, in reefs in micaceous porphyry country, with iron, copper and arsenical pyrites, argentiferons galena and stibnite (R.); Kilkivan g. f. ! ! !—"The country around Kilkivan consists entirely of metamorphic rocks, such as serpentine and hornblende and micaceous schists. All the reefs found in the district occur in these rocks. From the Rise and Shine Reef very good specimens of gold were obtained in the upper part; lower down the stone changes to a mundic consisting greatly of zinc-blende, with some iron pyrites and a little galena." . . "Most of the work at Kilkivan has been the driving of tunnels in a sheet of white porphyry which occurs in the face of a range running north and south. There are no defined reefs at all in the porphyry, but only minute veins of quartz, with oxides of iron and manganese. Where the manganese di-oxide occurs, the veins are the richest in gold. In some parts of the porphyry these veins are very numerous, and the veins are very patchy. Where these patches occur, however, the whole of the mass will pay to crush" (R.); Kilkivan ! !, associated with oxide of manganese in a white felspar (R.); Gympie g. f. ! ! !, in reefs traversing grey shales, black pyritous shales, greywackes, sandstones, grits, and conglomerates of Carbonifero-Permian age, the richest deposits of gold occur where the reefs intersect the pyritous black shales (J.); No. 1 N. Lucknow Mine, Gympie !, associated with asbestos (R.); Brovinia g. f. ! ! !, in reefs (J.); Eidsvold g. f. ! ! !, in reefs in granite country, with galena, pyrites, arsenical pyrites and stibnite (R.); Mount Shamrock g. f. ! ! !, in lodes containing quartz, hæmatite and bismuth oxide,—"The gold appears to be especially associated with the bismuth, for the veins of oxide of bismuth are exceptionally rich. A small sample of the oxide assayed by Mr. Hamilton contined 62 per cent. of metallic bismuth and 252oz. of gold per ton of the material" (R.); Mount Shamrock !, in molybdenite (L.); Old Chowey Reefs, Wide Bay ! !, in molybdenite in quartz (R.); Crocodile g. f. ! ! !, reefs partly in granite and syenite country and partly in slates, greywackes, grits, and conglomerates intersected by diorite dykes (J.); Rosewood g. f. ! ! !, Golden Bar Reef, of calcspar, with chlorite in pockets and coating calcite crystals, occasionally a good deal of quartz, some very rich specimens of gold in calcspar, the reef occurs in a diorite dyke for the most part altered to chlorite—Caledonian Reef, quartz with patches and pockets of chlorite, country rock altered sandstone (J.); Blackfellow' Gully ! ! ! (J.); New Zealand Gully ! ! !, North Star Mine, in porphyry country (J.); Last Chance Reef, gold disseminated through a mass of chloride of silver (D.); Cawarral ! ! !, in serpentine country, also alluvial gold (J.); Canoona g. f. ! ! !, "when (in alluvial workings) found with the matrix attached, matrix was serpentine" (R.); Mount

Morgan ! ! !,—Finely disseminated throughout a deposit varying from red and brown hæmatite to a frothy, spongy, cellular silicious sinter, rising into a mountain mass through a country rock of quartzites, hardened sandstones, greywackes and shales of Carbonifero-Permian age. I believe the deposit to be due to a geyser, but different explanations have been offered by Messrs. Macdonald, Cameron, Ranft and others. The gold is extracted by chlorination. The gold is of remarkable purity, assaying, according to Dr. Leibins, 99·7 per cent., worth £4 4s. 8d. per ounce (J.); Norton g. f. ! ! !, reefs in an erupted boss of grey granite passing into syenite and porphyry, and intersected by dykes of diorite, dolerite and porphyry, reefs containing, besides gold, pyrites, arsenical pyrites, sphalerite, galena, stibnite, quartz and calcite, gold is extracted by chlorination (R.); Cania g. f. ! ! !, in reefs of quartz and calcite, and in alluvium, country rock sandstone, slate and limestone, probably Carbonifero-Permian (R.); Raglan g. f. ! ! !, reefs and alluvial, country rock slates, hardened sandstones or quartzites with occasional conglomerates and limestones, probably of the age of the Gympie beds (Carbonifero-Permian), (R.); Calliope g. f. ! ! !, reefs and alluvial, country rock chiefly altered slates with limestone and marble, intersected by dykes and patches of serpentine, diorite and porphyry (R.); Mount Britten g. f. ! ! !, reefs, partly in diorite and partly in grey and black shales and sandstone of the "Gympie" series (Carbonifero-Permian), alluvial gold in large nuggets, with hardly any fine gold (J.); Yatton g. f. ! ! !, in reefs in diorite country, intersected by dykes of silicated felstone, the gangue-stuff (generally composed of fragments of diorite) is veined with calcite and decomposed concretionary carbonate of lime, while occasional aggregations of siderite and decomposed orthoclase are met with, some of the stone, composed of mixed quartz and reddish ferruginous carbonate of lime shows gold very freely, the gold is flaky, like gold-leaf (J.); Kroombit g. f. ! ! !, alluvial gold in Recent and Post Tertiary (?) drifts (R.); Peak Downs g. f. ! ! !, reefs in crumpled and fissured metamorphic schists, slates, &c., of supposed Lower Silurian age (D.), alluvial gold from recent drifts, also from deep leads covered by basalt, and supposed by Daintree to be Miocene, alluvial gold also in a drift of Carbonifero-Permian age (R.); Normanby g. f., near Bowen ! ! !, reefs and alluvial, country rock, a porphyry consisting of quartz, black mica (sparsely) and schorl passing into greywacke, much pyrites below water level (J.); Marengo g. f. ! ! in reefs, country rock essentially a white granite in which the mica is sometimes supplemented and occasionally replaced by hornblende, frequent bosses of intrusive felspar-prophyry, and occasional small areas of gneiss, mica schist, shales and greywackes, gold in reefs associated with quartz, calcite, malachite, pyrites and chalcopyrites (J.); Cape River g. f. ! ! !, filiform, in threads and hairs, which, under the microscope, resemble in a marked degree, the roots of fine grass, and in the matted mass small particles of opaque iron-stained quartz are observable. As much as 53 oz. at a time have been melted into a bar by us, the bar which weighed 52oz. 1dwt. 6gr., assayed £3 16s. 10d. per oz. (Coane and Clarke); alloyed with a large proportion of silver, &c., and often takes a peculiar form, combining a thread-like structure with a semi-crystalline surface, which is technically known among Queensland diggers as "spider-leg" gold (D.); in reef in metamorphic schist country, also in recent alluvium and older fragmentary drifts, supposed to be Pliocene (D),—[Analysis by Mr. Richard Smith, of the School of Mines, London:—Gold 89·920, silver 9·688, copper 0·128, lead 0·026, iron 0·070, total 99·832]; Paddy's Gully, Cape River ! !, alluvial (D.), [Analysis by Mr. Richard Smith, School of Mines, London:—gold 92·800, silver 6·774, copper 0·048, lead 0·048, bismuth traces, iron 0·014, total 99·684]; Charters Towers g. f. ! ! !, throughout the goldfield, generally associated with galena, sphalerite, calcite, and quartz and iron pyrites (C.); the principal mines in a granitic area in and around the town, others in a country rock of quartzites, greywackes, slates and shales, field also yielding a small and annualy decreasing proportion of alluvial gold (J.); Curlew, about 12 miles south of Charters Towers ! ! !, associated with cerussite, quartz, pyromorphite, chrysocolla, malachite and galena (C.); Ravenswood g. f. !, free gold in galena, in cerussite and in limonite (L.); Ravenswood ! ! !, in reefs associated with quartz, iron, copper and arsenical pyrites, sphalerite, galena, &c., country rock, grey syenitic granite, a fair proportion of alluvial gold also obtained (J.); Mulgrave g. f. ! ! !, in reefs in a country rock of greywacke, slate and quartzite (J.); Russell Terraces ! ! !, alluvial, in old high-level terraces, probably Tertiary (J.); Cloncurry g. f. !, in schorl, in malachite, in limonite, in sandstone, in malachite and cuprite, in carbonate of bismuth (L.), in reefs among highly-inclined slates, quartzites, and greywackes, with quartz, calcite and siderite, and in some cases with limonite, some reefs below the water level highly charged with pyrites, also in alluvial drifts with native bismuth and bismuthite, the alluvial gold generally coated with iron peroxide, gold mostly in large nuggets (J.); Reid's Creek, 4 miles south-east of Mount Perry ! ! !, in reefs in granite country, associated with iron pyrites, arsenical pyrites, spahlerite and galena (R.); Boolboonda ! ! !, in reefs in gneiss country (R.); Molangul ! ! !, in reefs and alluvial (R.); Normanby (Wide Bay) ! ! !, in reefs and alluvial (R.); Lucky Valley ! ! !, in alluvial drifts (A.); Lucky Valley, Duffer Gully !, imbedded in "small, bright, foliated, metallic plates with scales of tellurium" (A.); McKinlay g. f. ! ! !, reefs and alluvial, country rock, gneiss and mica and talc schists,—"The associated minerals are gold and copper, the presence of 'dykes' of intrusive material seeming to be the chief cause of mineralisation" (D.); Enoggera Ranges, Brisbane !, in quartz (L.)

GRAPHITE—Mount Bopple ! ! !, in micaceous granite (C.); Gympie ! !, with gold on "slickensides" (L.); Cape Upstart ! !, (J.); Croydon Goldfield ! ! ! common throughout the field (B.).

GYPSUM—Near Mount Albion, Tinaroo ! !, cropping out at surface (C.); Victory Lease, Charters Towers !, pellucid crystals in vughs in auriferous quartz reef, (C.); between Fanning Old Station, and Ravenswood Junction ! ! !, three feet vein in granite country (J.); 18 miles west of Collingwood ! ! !, described as occurring in very thick beds in the "Rolling Downs" (Cretaceous), (J.); Bulimbu, near Brisbane !, as selenite (L.); Warrego district ! ! fibrous and foliated varieties (L.); Mount Gregory ! !, Clermont (R.)

HALITE—Sylvester Creek, Herbert River ! !, (Q. M. C.).

HÆMITITE—

Specular iron ore—Kelvin Grove, 30 miles south of MacKay !, occurs in thin leaders and isolated kernels in a rock made up mainly of actinolite and clear and pellucid grains of quartz (M.); Mount Leviathan and Mount Pisa, Cloncurry ! ! !, hills of pure ironstone near the Cloncurry copper lodes in slate, greywacke and quartzite country, micaceous iron ore, plentiful in the same neighbourhood (J.); Kangaroo Hills, near Townsville ! ! !, very large lodes of very pure ore (J.); Wild River ! ! !, very large lodes of very pure ore (J.); Cabbage Tree Creek ! ! !, very large lodes of very pure ore (J.); Gunpowder Creek ! !, vein in slate and quartz ore, greywacke (J.); Gilbert River (Q. M. C.).

Micaceous iron ore—Rosslyn, Burnett district !, (R.); Cloncurry district ! ! (J.); Mount Morgan ! ! (auriferous), with hæmatite and silicious sinter (J.); Mary Douglas Reef, Cloncurry ! ! (auriferous), associated with quartz and native bismuth (J.); Warwick, (Q. M. C.); Ravenswood, ochreous (Q. M. C.); Ipswich, (Q. M. C.); Kilkivan, pseudomorphous after pyrites (Q. M. C.); near Calliope, Gladstone ! ! (R.); Mount Morgan ! ! (auriferous), with brown hæmatite and silicious sinter (J.); Cloncurry !, as pseudomorphs after iron pyrites (L.); Calliope ! ! (R.); Duck Creek, Cloncurry, ochreous, cementing a breccia (Q. M. C.); Yatton Goldfield, pseudomorphous after pyrites (Q. M. C.); MacKinlay Range, Cloncurry !, pseudomorphs after iron pyrites, in perfect cubes and in pentagonal dodecahedra (Sheaffe).

HYALITE—Stanthorpe district !, encrusting smoky quartz (L.); Northern Downs (Q. M. C.).

INFUSORIAL EARTH—Logan district (R.),—[Analysis by W. A. Dixon :—Moisture and traces of organic matter 10·31, oxide of iron and traces of alumina 0·59, lime traces silica 89·10, total 100·00]; Upper Coomera, Albert district (R.).

IRONSTONE BLACKBAND—Fourteen miles up Cockatoo Creek !, thin seams in Carbonifero-Permian formation (J.).

JASPER—Diamantina, Springsure (B.); Kilkivan, in veins, both red and green (R.); Tableland, Peak Downs (R.).

KAOLIN—Stanthorpe district ! !, in the tin-drift (L.); Mount Morgan Extended of Brisbane (Callan's Knob) ! !, apparently in dykes and of a very pure character (L.); Mount Morgan and elsewhere ! ! !, common as a result of decomposition of acidic felspars in dykes and of granites, &c., in reefs (J.).

KERARGYRITE—Mount Albion ! !, large "slugs" in Albion Mine at surface and at 19 feet, and in Lady Jane Mine at 130 and 180 feet, associated with galena (J.); Croydon Goldfield ! !, Queen (auriferous) reef, No. 2 south (B.); Last Chance, New Zealand Gully, Rockhampton !, in reef; the kerargyrite contains specks of gold (D.); Puzzler Reef, 8 miles north-east of Charters Towers !, in small slugs with quartz, native silver, and very much decomposed galena (C.). This sample assayed for silver 618oz. 7dwt. 13gr. per ton (Coane and Clarke).

LABRADORITE—West of Mount Eurie, Cloncurry !, iridescent (J.).

LAUMONITE—Strathmore Creek and Bowen River ! !, in geodes in epidote rock (J.).

LIEVRITE—Endeavour River !, in geodes in basalt (J.).

MAGNESITE—Western half of Queensland ! ! !, in extensive beds, part of the "desert sandstone" formation (W.); Waverley Creek, St. Lawrence ! ! !, cimolitic fire-clays or magnesites, with films of coal and fragments of silicified tree stems, in Styx Coalfield (D.); Islaport, Rockhampton,—[Analysis :—Silica 7·23, carbonic acid 49·08, peroxide of iron 1·66, magnesia 43.70, lime traces, total 101.67.] (C.).

MAGNETITE—Newelltown, Tinaroo ! ! !, the lump in my possession exhibits marked magnetic polarity and will support a fine sewing needle. The powdered mineral can be lifted up in long strings or brushes on a lump of the mineral (J.),—This is a very pure iron ore and it was being raised in large quantities when I was at Newelltown for the Mount Albion Silver Smelting Co., who used it in conjunction with limestone (which abounds in this neighbourhood) as a flux in their Pacific smelters (C.); Wild River, five miles below Herberton ! !, sand in tin wash (J.); Hinchinbrook Island !, fine octahedral crystals in chlorite schist (J.); Percy Island No. 2 ! !, fine sand on beach (J.); Great Northern Mine, Star River (Q. M. C.); Nundubbermere, near Stanthorpe ! !, in granite (R.); Mount Victoria, near Mount Perry ! !, in granite (R.); Mount Webster, Mount Perry district, crystalline and granular, massive (L.); Chowey Creek, Wide Bay district, in bluish grey quartzite (R.); Kroombit, with carbonates of copper (Q. M. C.).

MALACHITE—Flying Dutchman Reef, Cloncurry !, in auriferous quartz reef (J.); Homeward Bound, Cloncurry ! ! !, auriferous copper lode (J.); Mountain Home ! !, with ferruginous cuprite, pyrolusite, garnets and asbolane (J.); Duck Creek Copper Mines, Cloncurry ! ! !, in lodes (J.); Argylla Copper Mines ! ! !, in large lode with native copper and cuprite (J.); Leichhardt River ! ! !, in lodes (J.); No. 1 Copper Selection, Dugald River ! !, in large lode with cuprite and native copper (J.); Iron Clad Mine, Herberton ! !, with azurite and iron pyrites (C.); Mount Garnet, Tinaroo ! !, with cerussite and galena and hæmatite, in some portions of the lode very perfect crystals of azurite, measuring 12-15mm. in the longest axis, occur in vughs in the malachite (C.); Mount Garnet, Tinaroo district ! !, with azurite (C.); Cloncurry ! ! !, frequent in "gossan" often in large masses (L.); Cloncurry ! ! !, containing free gold; also pseudomorphs after cuprite, azurite and siderite (Q. M. C.); Great Australian Copper Mine, Cloncurry ! ! !, in large lode with native copper, cuprite, tenorite and azurite (J.); Bau Bau, Burnett district !, coating serpentine (Aplin); Taromeo, near Narrango (Q. M. C.); Curlew, about 12 miles south of Charters Towers !, with galena, gold quartz, chrysocolla and pyromorphite (C.); Burdekin River, near Mount Keelbottom ! !, in lode in quartz porphyry country (J.); Great Kennedy Copper Mine ! ! !, in a large lode, with azurite and cuprite (J.); Keelbottom Copper Mine ! !, in quartz veins in porphyry (J.); Mount Perry ! ! !, disseminated through granite (R.); Mount Perry district ! !, in copper lodes, but not of very frequent occurrence (L.); Peak Downs Copper Mine, near Clermont ! ! !, in fine botryoidal masses (L.); Mount Gotthard, near Lake Elphinstone, 100 miles west of Mackay ! !, in "gossan" and in small veins (L.); Mount Orange Copper Mine ! !, with other copper ores (L.); Pine Vale, 25 miles south-west of Mackay ! !, massive, in reefs, and as stains in quartz, also as an alteration product of copper pyrites (M).

MASSICOT—Stanton Harcourt, Burnett district, from decomposing galena (R.); Argentine Silverfield ! ! !, (argentiferous), from decomposition of galena (J.); Dugald River ! !, in large lode, contains according to assays by K. T. Staiger, antimony and silver (J.); in small quantities at all the silver-lead mines ! ! (J.).

MELACONITE—Great Australian Copper Mine, Cloncurry !, occasional crystals, with cuprite and native copper (J.); Great Kennedy Copper Mine ! !, in a large lode, associated with azurite and malachite (J.); Ironclad Mine, Herberton !, with sulphates of iron and copper, and iron pyrites, hæmatite, &c., &c. (C.); Mount Leyshon, 17 miles south of Charters Towers !, with pyrites in the country rock of the mount; country rock has been identified by Mr. Jack, the Government Geologist, as a volcanic ash (C.); Pine Vale, 25 miles south-west of Mackay !, an alteration product of copper pyrites, in a quartzose matrix (M.); Blue Mountains, near Eton ! ! (J.); Emu Plains, Bowen River, mixed with argentite (J.); Mount Perry district ! !, with chalcopyrite (L.); Texas, Stanthorpe district ! !, with other copper ores (G.).

MERCURY—Kilkivan district !, in a hard, dark quartzose rock (R.).

MISPICKEL ! ! !—Arsenical pyrites occurs in nearly all the auriferous reefs in Queensland, especially those in which the country rock is granite, conspicuously at the Etheridge, Ravenswood and Norton (J.); Stanthorpe! (Q. M. C.); Allendale lode, Chowey Creek, Wide Bay district ! !, with galena, sphalerite and iron pyrites (R.); Mount Witty, Beenleigh ! !, in dark quartz, auriferous (L.); Reid's Creek, Mount Perry ! !, auriferous (R.).

MOLYBDENITE — Stanthorpe district ! in greisen dykes, with wolfram and cassiterite (R.), also in quartz at Noble Tin Mine and at Greenups (J.); Townsville district! (D.); Halifax Bay, near Townsville ! (J.); Herberton district ! (J.); Ravenswood Goldfield !, in quartz (J.); Herberton, Young American Claim !, with wolfram (J.); Cania Goldfield !, with gold in calcite (R.); Ipswich (Q.M.C.); Walsh River ! (J.); Eidsvold Goldfield !, in "Moonlight" Reef, auriferous, in quartz (R.); Stanthorpe !, in quartz, sometimes with arsenical pyrites and with tin ore (L.); 30 miles west of Mackay ! ! !, large blocks obtainable (Staiger); Mount Ophir, Chowey Creek, Wide Bay district ! !, with iron pyrites in auriferous quartz (R.); Old Chowey reefs, nearly due north of Didcot, Wide Bay district ! !, with specks of gold in its midst (R.); Mount Shamrock Mine, Wide Bay district !, containing visible gold (L.); Burnett district ! !, exact locality not yet made public, in quartz with molybdic ochre, showing fine flakes of gold (L.).

MOLYBDIC OCHRE—Burnett district, in quartz with molybdenite, specks or flakes of fine gold being visible in the ochre, as well as in the sulphide mineral (L.).

NATROLITE—Main Range, below Toowoomba !, in basalt (L.); Degilbo Run, Wide Bay !, in basalt (R.).

OLIVINE—Gatton, in basalt (L.); Albert district, in basalt (R.); Cania Goldfield, in basalt (R.); Cania, Burnett district, in basalt (R.); Albert and Logan districts, in basalt (R.).

OPAL—Bulloo River ! ! (L.); Barcoo River ! ! (L.); Logan River !, (Hinchcliffe); Springsure (Q. M. C.); Blackwater Creek, Bulgroo, Keeroongooloo, Mayne River, Nickavilla, Winton ! !, "in nodules of ferruginous silicious sandstone and silicious ironstone, either in the 'desert sandstone' formation or denuded out of it and resting on the surface of the underlying 'Rolling Downs' formation. The whole of the area over which the 'desert sandstone' extended—the western half of the colony—might therefore be given as the locality in which 'opal mines' are 'undeveloped'" (J.); Mount Toussaint and Mount

Macedon ! !, in geodes in epidote rock (J.); Cape Hillsborough, about 20 miles north-west of Mackay ! !, as a coating in many fragments of the desert sandstone, forming the Cape tableland (M.).

ORTHOCLASE – Stanthorpe ! !, associated with smoky quartz, the felspar being in large crystals (L.); Pinnacle Lease, Herberton ! !, of pink colour as matrix of cassiterite (L.); North Australian Block, Charters Towers !, in fine pink crystals with chlorite and iron pyrites on granite (C.).

PIMELITE—Cobalt lode, Kilkivan !, earthy variety (R.).

PLATINUM—Russell River Terraces !, minute flakes associated with gold and cassiterite in high-level river drifts capped by immense basaltic flaws, probably miocene (J.).

PREHNITE—Biralee, Bowen River ! !, in cavities in epidote rock, "in radiating groups of crystals" (Allport),—[Analysis of "prehnite rock" by Mr. R. Daintree :—Silica 42·033, alumina 21·606, ferric oxide 8·829, lime 23·633, water of constitution and hygroscopic 2·900, copper carbonate 0.825, total 99.826, sp. gr. 2·844.]

PSILOMELANE — Brookfield, Brisbane (Q. M. C.); Beenleigh (Q. M. C.); Between Chinaman's Creek and Duck Creek, 13 miles from Cloncurry ! !, loose blocks in slate country (J.); Gregory River ! ! !, large lode in sandstone country (J.); left bank of Police Creek, 300 yards from Gregory River ! !, very pure ore (J.).

PYRITES—Bee Creek, 60 miles west of Mackay ! !, as crystals in most of the mines, generally enclosed in a quartzose matrix, associated with galena, zinc blende and copper pyrites (M.); Allendale Lode, Chowey Creek, Wide Bay district ! !, associated with mispickel, galena and sphalerite (R.); Eungella, Mackay district ! !, in quartz with small quantities of copper pyrites and galena (L.); Ravenswood !, in chert as hexakisoctahedra (Q. M. C.); Mount Webster, Mount Perry district ! !, with fine grains of magnetite (L.); Union Claim, Rackhampton district ! !, auriferous associated with black schorl (C.); Eungella Lime Plains ! ! !, in quartz with a trifling quantity of chalcopyrite and galena, assays 2¼oz. gold per ton (L.), iron pyrites occurs probably without exception in all the auriferous reefs in Queensland, in most of the metalliferous lodes, disseminated through most of the plutonic and igneous rocks, in many sedimentary rocks, and conspicuously in the carbonaceous shales which form the country rock of the Gympie goldfield (J.).

PYROLUSITE—Near Didcot Creek, Wide Bay district (R.); Leyburn, near Warwick, very pure massive and sometimes crystalline (L.); 8 to 9 miles west of Gympie ! ! (R.); Thanes Creek, Warwick ! !, crystallized, massive and stalactitic (R.); 20 miles from Port Douglas, near Mount Spurgeon ! ! !, the ore is of a high percentage and the lode very large (Towner); Mountain Home !, dendritic markings on quartz in copper lode associated with green carbonate of copper, ferruginous red oxide of copper, asbolane and garnets (J.); between Gregory River and Police Creek ! !, loose pebbles (J.); Mitchell River, below mouth of St. George River ! ! !, large lodes associated with quartz in slate and greywacke country (J.); between Police Creek and Fiery Creek ! ! (J.); Mount Morgan !, with silicious sinter and red and brown hæmatite (J.); Mount Leyshon, near Charters Towers !, in volcanic ash traversed by auriferous ferruginous veins (J.); Argentine Silver Field ! !, with argentiferous lead ores and pyrites in "Colorado" and other mines (J.); Hodgkinson Goldfield !, coating quartzite on Peak river (J.); Flinders River, near Coalbrook !, in films on bedding-planes and joints of "desert sandstone" (J); Magazine Island, Townsville, and west of Arthur's Creek, Burdekin River ! !, as dendritic markings on quartz poryhyry, unusually fine examples (J.); Gladstone Harbour ! ! !, with ferruginous quartz among hard jasperised metamorphic rocks (R.). Gladstone (C.),—[Analyses :—

Available peroxide of manganese ...	74·84	57·00
Protoxide of manganese	8·20	9·30
Oxides of iron ...	8·60	3·80
Alumina	2·80	2·00
Carbonic acid ...	traces	traces
Sulphur	0·22	0·13
Water	3·80	2·70
Silicious insoluble matter	1·10	25·00
Loss	0·44	0·07
	100·00	100·00

no gold or silver—(Messrs. Johnson, Matthey & Co., London).

PYROMORPHITE—Etheridge Goldfield !, in auriferous quartz reef, with galena and pyrites (J.).; Curlew, about 12 miles south of Charters Towers, with cerussite, galena, gold quartz, chrysocolla, malachite, &c. The pyromorphite is in very small perfect crystals, being combinations of the prism with the basal pinacoid (O.P.) (C.).

QUARTZ—Day Dawn P.C. Mine, Charters Towers ! ! !, auriferous, associated with pyrites, galena, sphalerite, &c., occurs in quartz lode, which is associated with diorite (?) and runs through granite country. The ore is taken from a depth of 997ft. on the course of the lode, representing a vertical depth of 732ft. The lode underlies at an angle of about 50° (T. Buckland).

Iron	23·10
Lead	13·70
Zinc	6·50
Copper	·15
Alumina	·30
Sulphur	30·10
Siliceous insoluble matter ...	25·90
Gold, silver, oxygen and loss ...	·25
	100·00

Produce of gold 14oz. 2dwt. per ton of 2240lb.; produce of silver, 9oz. 15dwt. per ton of 2240lb., (assay by Messrs. Johnson, Matthey and Co., London):—

Lead	7·79
Copper	·36
Iron	20·27
Zinc	6·70
Manganese, with a little cobalt ...	·30
Sulphur	27·65
Arsenic	·15
Antimony	·09
Carbonate of lime	1·50
,, ,, magnesia ...	·21
Alumina	1·20
Silicious rock	33·10
Gold and silver	·04
Oxygen and loss	·64
	100·00

Silver 6oz. 11dwt. per ton of 2240lb.; gold 6oz. 10dwt. 12gr. per ton of 2240lb. (assay by Fred. Claudet, Esq., London, assayer to the Bank of England); Black Jack, Charters Towers ! !, with calcite, the latter in opaque rhombohedral crystals (C.); Charters Towers ! !, when associated with galena, sphalerite and calcite and iron pyrites, nearly always auriferous (C.); *Smoky quartz* Stanthorpe district ! !, with tin ore, with orthoclase felspar

(L.); Stanthorpe Tin Field ! !, in reefs with cassiterite and in stream tin wash (J.). All the goldfields in Queensland ! ! !, containing free gold and auriferous pyrites (L.).

REDRUTHITE—Alliance Mine, Morinish, Rockhampton ! !, in auriferous quartz (L.).

RUBY—Gilbert River !, "in creeks flowing from the Conglomerate Ranges" (Samwell).

SAPPHIRE—Stanthorpe ! ! (Q. M. C.); Leichhardt district ! (R.); Gilbert River !, "in creeks flowing from the Conglomerate Ranges" (S.).

SARDONYX—Stanthorpe ! ! (B.).

SCHORL—Irvinebank Tin Mines ! ! (J.); Ravenswood Goldfield ! !, in granite country (J.); Cooktown ! !, with the tin ores of this district, particularly Mount Leswell, Mount Amos, and The Lion's Den, (*vide* cassiterite), (C.); Union Claim, Rockhampton ! !, with auriferous iron pyrites and calcite (C.).

SERPENTINE—Gladstone (R.); near Ipswich, as matrix of chromite (C.); Canoona, a belt of serpentine (D.); Kilkivan and Yarrol, Burnett district, forming rock masses (L.); different parts of the Burnett district, as Sandy Creek and Mount Coora, coated with green carbonate of copper, or containing copper lodes (Gregory and Aplin); Mount Wheeler, 18 miles from Rockhampton, "within a radius of one mile of Mount Wheeler the serpentine is traversed by auriferous quartz reefs, while the extension of the same band of serpentine over a large area beyond this contains no parallel to the auriferous area round the above-mentioned hill" (D.).

SILICIOUS SINTER—Mount Morgan ! ! !, highly auriferous, supposed deposit of a hot spring (J.).

SILVER (NATIVE)—Croydon Goldfield !, Waratah (auriferous) reef (Biccard); Croydon Goldfield !, in "Miners' Right" and "No. 2 S." Queen auriferous reefs (Wallmann); Queen line of reef, Croydon, with free gold in quartz (Morgan); Mount Albion, Tinaroo district, in oxide of iron (L.); Puzzler Reef, 8 miles north-east of Charters Towers, in spangles splashed over quartz (C.); Scrubby Creek, Broad Sound !, in cerussite lode (J.); Nannam Mine, Orient Camp (Ringrove).

SMITHSONITE—Bowen district !, in vesicular quartz, with carbonate of lead and galena.

SPHALERITE—Bee Creek, 60 miles west of Mackay ! !, massive, in many of the mines enclosed in quartz, associated with iron pyrites, copper pyrites and galena (M.); Tornado Claim, Silverfield, Tinaroo district ! !, with chalcopyrite, arsenical pyrites, and galena (J.); Koh-i-noor, Newelltown, Tinaroo district ! !, with arsenical pyrites and galena (J.); Hector Claim, Ravenswood ! !, auriferous, with iron pyrites (C.); Currency Lass and Politician Claims, Ravenswood ! !, auriferous, with iron and copper pyrites and galena (C.); Alexandra Hill Gold Mine, Charters Towers ! !, auriferous, with iron and copper pyrites (C.); Sunburst P. C., Charters Towers ! !, with galena and iron pyrites in quartz, auriferous (L.); Mary Florence, Rockhampton !, auriferous, with iron and copper pyrites in quartz (C.); Kilkivan Amalgamated Gold Mine, Kilkivan ! ! !, in quartz with a little calcspar, associated with galena and iron pyrites, free gold often visible (L.); Gympie !, in quartz with free gold (R.); Rise and Shine Reef, Kilkivan ! !, auriferous (R.); Mount Leyshon, 17 miles south of Charters Towers ! ! !, with galena, assayed 21oz. 4dwts. 4grs. silver per ton (C.); Ravenswood ! !, with galena (Christoe),—The sample assayed 430oz. silver per ton. An experiment was tried to see whether the galena or the zinc-blende carried most silver, and as the sample was remarkably pure and the two minerals in comparatively large crystals, it was possible to sort out sufficient of each (from the coarsely powdered ore) for a separate assay, and the following returns were obtained:—Galena 431oz. silver per ton, sphalerite 429oz. silver per ton (C.); Charters Towers Goldfield !, with pyrites and galena in auriferous reefs (J.); Ravenswood Silver Mines ! ! !, in lodes with galena, cerussite, stibnite, pyrites' &c. (J.); Sellheim Silver Mines ! ! !, in lodes associated with galena and pyrites (J.); Dry River Silver Mines ! !, in lodes, associated with pyrites, marcasite, chalcopyrite, galena, anglesite, cerussite, and malachite (J.); Degilbo ! !, in lodes, associated with gold, galena and arsenical pyrites (R.); Croydon Goldfield !, in auriferous reefs associated with pyrites, galena and graphite (J.); Ravenswood Goldfield ! !, in auriferous reefs associated with pyrites, arsenical pyrites, copper pyrites and galena (J.); Etheridge Goldfield ! !, in auriferous reefs associated with pyrites, arsenical pyrites, copper pyrites and galena (J.); Norton Goldfield ! !, with galena, iron pyrites, quartz and calcite, auriferous and argentiferous (C.).—[Analyses and assays of two complex zinc, iron and lead sulphides from Norton Field :—

	Goody's Reef.	Frampton's Reef.
Iron	30·60	25·10
Lead	8·90	1·10
Zinc	6·00	7·60
Arsenic	1·55	6·80
Copper	0·95	0·65
Sulphur	36·00	25·70
Alumina	0·40	0·20
Silicious insoluble matter	15·20	32·60
Gold, silver, oxygen and loss	0·40	0·25
	100·00	100·00

Sample from Goody's reef: Produce of gold, 2·400oz. per ton of 20cwt.; silver, 14·700oz. per ton of 20cwt., sample from Frampton's claim: produce of gold, 5·500oz. per ton of 20cwt., silver 4·700oz. per ton of 20cwt. (Messrs. Johnson, Matthey and Co., London)].

STANNITE—Eureka Creek ! !, in Ivanhoe Mine, associated with cassiterite (J.); Watsonville, with cassiterite in Stewart's T. Claim (J.).

STAUROLITE—Agnes Vale, Wide Bay district ! !, twin cruciform crystals in argillaceous slate (R.).

STEATITE—Cobalt lode, Kilkivan (R.).

STIBNITE—Neardie, near Gympie ! !, with valentinite in quartz (R.); St. John's Creek, Burnett district ! !, with valentinite (L.); Victoria Claim, Silverfield, Tinaroo district ! !, accompanying galena (C.); Emily Reef, Northcote, Hodgkinson district ! ! !, auriferous, yielding over 2oz. gold per ton, value of gold £3 19s. per oz. (C.); Rishton ! !, lodes (J.); Mount Wright, near Ravenswood ! ! !, White and Phillips' and other lodes (J.); Herberton !, Home Rule and other tin lodes (J.); Fanning River ! !, lodes (J.); Northcote ! ! !, in large lodes, some of which have yielded payable gold (J.); Woodville, Hodgkinson River ! ! !, lodes (J.); five miles north-west of Gympie !, in fossiliferous limestone (R.); Eidsvold Goldfield ! !, in auriferous quartz reef, south of Stockman's Claim (R.); Etheridge Goldfield ! ! (Hodgkinson).

SULPHUR—Curtis Island, Keppel Bay !, cementing grains of sand (L.); Taylor's Range, Brisbane !, in cavities of quartz formed from the decomposition of pyrites (Q. M. C.); Etheridge ! !, on highly decomposing pyrites (L.).

TELLURIUM—Lucky Valley, Duffer Gulley ! in a quartz vein there are found "small, bright, foliated, metallic plates and scales of tellurium, in which gold may be seen imbedded" (Aplin).

TETRAHEDRITE—Pumpkin Gully, Cloncurry !, in cap of a large lode (J.); Copper Mines at Duck Creek, Cloncurry ! !, in rainbow lode (J.); Argylla Copper Mine ! !, in large lode, with native copper, cuprite and malachite (J.); Leichhardt River ! !, Crusade and other lodes (J.); Mount Orange Copper Mine, Nebo district ! !, with chalcopyrite (L.); Bowen district ! !, with calcite, assaying to 400oz silver per ton (L.); between Bowen and Mackay ! ! !, rich in silver (L.); Emu Plains, Broken River, North Kennedy !, occurs in thin strings, as an alteration product of azurite, associated with calcite and malachite, argentiferous (M.); One Mile, Ravenswood ! ! !, in Great Extended Shaft at 700 feet, "the gangue is 5 feet wide, the ore is exceedingly rich, assays giving by ordinary fire process from 500 to 5000 ounces of silver per ton, the rich ore is contained in a vein from 6 to 12 inches thick, and, singular to say, contains the merest trace of lead. The formation (gangue) below this ore is intersected by small galena veins" (Archibald), although generally spoken of as tetrahedrite, with which, or rather with the argentiferous variety, freibergite, analyses sometimes roughly correspond, the "ore" does not appear (judging from what samples I have seen) to be a single mineral, but an intimate mixture of several ores of antimony, copper, iron, zinc, &c. (J.), assay silver 2384oz. 10dwt. per ton (L.).—Analysis by (J.):—

Copper	12·67	
Antimony	11·38	
Silver	7·29	
Iron	10·31	
Zinc	31·54	
Sulphur	24·87	
Silica	3·90	
	101·86	(C.).

Analysis, different sample:—

Copper	16.25	
Antimony	26.30	
Silver	15·35	
Iron	8·49	
Zinc	8·75	
Sulphur	17·02	
Silicious matter	7·31	
	99·47	(Merry).

THOMSONITE—Strathmore Creek and Bowen River ! !, in geodes in epidote rock (J.).

TITANIFEROUS IRON—In creeks in Mount Perry district (R.); watercourses on the flanks of Mount Jukes, 20 miles west of Mackay ! !, as rounded grains and regular octahedrons, associated with grains of magnetite and quartz (M.).

TOPAZ—Never-can-tell claim, Coolgarra, Tinaroo, with cassiterite crystals (C.); Running Creek, Star River (yellow), in tin wash, associated with garnets (J.); Stanthorpe district (white) in tin wash (J.).

TOURMALINE—Cloncurry ! !, with free gold (Q.M.C.); Union Gold Mine, Rockhampton ! !, with calcite as matrix of auriferous pyrites; Great Freehold, Mount Perry district ! !, in masses composed of fine divergent acicular crystals (L.); Mount Leswell, near Cooktown ! ! !, in coarse crystals with cassiterite (L.); Stuart Valley, Burnett district ! !, in fine-grained felsphatic rock; St. John's Creek, Burnett district !, in quartz (Q.M.C.); Cooyar Range, Narrango !, long prismatic crystals in coarse granite (R.); Mount Victoria, Mount Perry district ! !, in radiating crystals (R.); Woodonga, near Kilkivan, in radiating crystals (R.); Lizard Island ! !, in large crystals (J.); Argentine Silver Field ! !, large thick crystals embedded in quartz (J.); Fanning Diggings !, small crystals passing into the aggregated fibrous bundles called schorl (J.).

VALENTINITE—Neardie, near Gympie ! !, and St. John's Creek ! !, with stibnite (L.).

WOLFRAM—Noble Island ! ! !, in quartz (L.); Stanthorpe district ! !, associated with cassiterite (L.); Brisbane district ! !, in quartz (L.); Flagstone Creek, Bowen district ! !, in quartz, forming cap of a galena lode (L.); Bonnie Dundee, Coolgarra, Tinaroo !, with cassiterite and mica in red chlorite (C.); Mackay district !, in quartz (G. Francas); Great Northern P.C., Herberton ! !, with quartz and cassiterite (C.); Chance claim, Watsonville, Tinaroo ! !, in fine large crystals in ferruginous gangue, with quartz and cassiterite, also massive (C.); Eureka Creek, Tinaroo ! !, with cassiterite (C.); Herberton Tin Mines ! !, with cassiterite in lodes (J.); Stanthorpe Tin Field ! !, with cassiterite (J.); Eungella Goldfield ! !, with garnets and iron glance in a large lode in granite country (J.); Annan Tin Mines ! !, with cassiterite and tourmaline in lodes at Mount Amos (J.).

ZEOLITE—(SCOLECITE ?) Charters Towers,—This zeolite, which is of a pale pink, occurs in the joints and cleavage planes of the granite. One sample from the Rainbow Lease is massive and is found on both walls of the lode. The polished surface shows an included vein of pure white calcite. The mineral is found at various depths (C.).

	(I.)	(II.)	(III.)	(IV.)
SiO_2 ...	46·25	49·04	47·0	47·24
Al_2O_3 ...	27·35	26·64		26·64
CaO ...	13·95	12·24		12·95
H_2O (by ignition) ...	13·47	13·30	13·7	14·20
Fe_2O_3 ...	trace	trace		trace

In the above analyses No. 1 is from the Queen Block Extended, No. 2 from the Mary claim, No. 3 from the Rainbow, and No. 4 from the Mexican (C.).

ZIRCON, Narrango Creek (R.) ; Russell River Terraces ! ! (hyacinth), water-worn, associated with gold, quartz (Clarke); Eungella, Broken River (J.) ; Constant Creek, about 18 miles west of Mackay, occurs both as small crystals and grains of a deep yellow or reddish brown colour, all more or less rounded by attrition, in the sandy gravel in the bed of the creek, associated with fragments of quartz and mica (M.)

MINERALS OF NEW ZEALAND.

By Sir JAS. HECTOR, K.C.M.G., F.R.S.

Actinolite !—Milford Sound (Hector); Para-para, (Cox), as radiating fan-shaped crystals in metamorphic schists.

Albite, or Soda Felspar ! ! — Maori Point, West Coast, Wilkes River, Makarora, Dun Mountain, George Sound, in diorites (Hector, Haast, Davis).

Alum ! !—Pomahaha, as a product of pyritous shale (Hector, 1862); Puai Island, Waikuaiti (Hochstetter, 1860); Tokomairiro, as potash alum (Hector, 1862); D'Urville Island, as manganese alum (Hackett, 1866). Analysis per cent (Skey):—

Alumina	10·40
Ferric oxide...	1·11
Lime	·50
Magnesia	5·46
Soda	·41
Sulphuric acid	37·40
Hydrochloric acid	traces
Water	42·72
Insoluble in water	2·00
	100·00

Alunite !—Rotorua, deposited by geysers (Ulrich)

Alunogene ! !—Tuapeka, Manawatu, occurring in some of the brown coals, is colourless, crystalline, and completely soluble in water. Analysis per cent. (Skey):—

Sulphate of alumina	55·60
Sulphate of lime	1·01
Sulphate of magnesia	2·99
Alkaline sulphates	3·00
Water	37·40
	100·00

Andesine !—Colleville Peninsula, Taupo district, Ruapehu, in andesites (Hutton).

Anorthite !—Kakapo Lake, West Coast, in diorite dykes (Hutton).

Anthophyllite !—Karori, Wellington, in a massive laminated form (Davis).

Antigorite !—Dun Mountain, in serpentine schists (Cox).

ANTIMONIAL OCHRE !—Endeavour Inlet, as a coating on antimonite (Cox).

APATITE !—Wangapeka (Lab. and Geol. Reports).

APOPHYLLITE ! !—Turnagain Point, in amygdaloids, Rangitata, as ichthyopthalmite in felsite porphyries (Haast).

ARAGONITE ! !—Collingwood, Dunedin, Thames, in cavities in basaltic rocks and from hot springs (Hector); and several other places, lining fissures and cavities in volcanic rocks of Bank's Peninsula (Haast).

ARSENIC (NATIVE) !—Kopanga Mine, Coromandel, in auriferous quartz lode with calcite (Hector, 1867).

ASBESTOS ! ! !—Milford Sound, Collingwood, Takaka (Hector).

AUGITE ! !—Hororata district, Dunedin, Nelson, Auckland, Collingwood, Bank's Peninsula, Acheron, Chatham; enters into the composition of all basalts, dolerites, anametesites, trachydolerites, diabases and melaphyres; sometimes in crystals ½ inch long, Nelson (Hector).

AZURITE !—Nelson, Great Barrier Island, in gossan of copper lodes in serpentine.

BARYTES !—Waikoriti (Mantell, 1852); Akitea (Hector, 1867); Thames (Skey, 1870); East Cape (McKay, 1874).

BERYL !—Dusky Sound, in hornblendic schists (Cox); Stewart's Island, with tin stone in large crystals (McKay), determined by Skey.

BISMUTH ! — Owen, Collingwood, alloyed with gold (Hector), determined by Skey.

BITUMEN—Cast up on the south and east coast of New Zealand in considerable quantity (Lab. Geol. Reports III.)

BOLE ! !—Lyttelton Tunnel, in dolerite rocks (Haast). Analysis (Skey) :—

Silica	44·78
Alumina	15·66
Iron	16·87
Manganese	·60
Lime	2·02
Magnesia	5·02
Potash	2·69
Water (constitutional) ...	12·36
	100·00

BORNITE !—Kawau, Dunstan, in micaceous quartz (Hector).

BOURNONITE !—Wangapeka, occurs in quartz with galena (Hector).

BRAUNITE ! !—Malvern Hills, vicinity of Wellington, massive (Geol. Survey, 1873).

BRONZITE !—Dun Mountain, in diorite rocks (Hector, Davis).

BROOKITE !—Otepopo, in crystalline dolerite (Hector, 1862).

CALAMINE !—Tararu Creek, as lustrous transparent crystals attached to diallogite, but always external (Skey).

CALCSPAR (CALCITE) ! !—Tokotea Range, Otago, in tertiary rocks of Otago as dogtooth spar; Nelson, in limestone at Moeraki; Canterbury, as Iceland spar (Hector 1862, Haast 1864); Dunedin, Sea-cliff, near Waikouaite, Cape Rodney, Tararu Creek, Thames, smoke-coloured calcite, Cape Rodney (Cox, 1882).

Marble ! !—Collingwood district (Hector, 1863); West Coast Sounds (Hochstetter, 1860); Kakaka, Canterbury (Monro, 1866).

Stalactite and *Stalagmite* ! !—Whangarei, Waipu, Collingwood, Mount Somers, occur in many limestone caves.

Travertine ! !—Oamaru, Mauriceville, Takaka, and many other places, deposited from calcareous waters (Hector, 1862).

CERVANTITE !—widely distributed, occurs incrusting stibnite.

CHABASITE !—Dunedin, in vesicular basalts (Hector); Helenburn and Bank's Peninsula, in trachytic rocks (Haast).

CHALCOPYRITE ! ! !—Kawau, Great Barrier Island, Moke Creek, Paringa River, Canterbury, Collingwood (Geol. Surv.).

CHIASTOLITE !—Collingwood, embedded in clay slate (Hector).

CHLORITE ! !—Fox Glacier, Westland, in chlorite schists (Cox); Tararu Creek, Thames (Skey); West Coast of Otago and Otago Heads, in an amorphous form in vesicular basalts (Hector); Kakapo Lake (Liversidge).

CHROME OCHRE ! !—Nelson, occurs in combination with "chromite" in small quantities (Hackett, 1861).

CHROMITE ! !—D'Urville Island, Dun Mountain, Aniseed Valley, Red Hills, Otago, in a band of serpentine and olivine, also occurs as massive crystals, massive amorphous crystalline, disseminated, and granular (Hector, 1865); Nelson ! !, associated with nephrite (Hector, 1865). Sp. gr. 3·328. Analysis (Skey):—

Silica	12·66
Chromic oxide	47·69
Ferrous oxide	24·08
Alumina	6·29
Lime	3·16
Magnesia	6·12
	100·00

CHRYSOBERYL !—Stewart Island (determined by Skey, 1889).

CHRYSOCOLLA !—Nelson, encrusting gossans of copper ores in the serpentine belt.

CHRYSOTILE, or PERIDOT—Dun Mountain, traversing the dark green serpentine (Cox).

CHLOROPHYLLITE !—Mount Somers, fine earthy mineral filling cavities in rocks (Haast).

COALS ! ! !—Special schedule, abstract of report by Sir J. Hector (Geol. Surv. Dept.

COALS OF NEW ZEALAND.

No.	Description.	Locality.	Analyses by Skey.				
			Fixed Carbon.	Hydro-Carbon.	Water.	Ash.	Evaporative Power.
1	Anthracite ...	Acheron, Canterbury ...	84·12	2·06	1·80	12·12	10·93
2	Bituminous ...	Coalbrookdale	74·83	20·50	1·16	3·51	10·72
3	" ...	"	70·00	22·15	2·52	5·33	9·10
4	" ...	Banbury	69·97	25·71	·99	3·33	9·09
5	Altered brown coal	Malvern Hills	68·54	19·89	4·15	7·42	8·87
6	Bituminous ...	Tyneside	65·59	29·18	·82	4·41	8·52
7	Glance Coal ...	Rakaika Gorge	64·51	21·27	6·76	7·46	8·30
8	Bituminous ...	Wallsend	62·87	31·64	1·66	3·83	8·17
9	" ...	Grey River	62·37	29·44	1·99	6·20	8·01
10	Pitch Coal ...	Kawa-Kawa	61·16	28·00	2·51	8·33	7·95
11	Bituminous ...	Preservation Inlet ...	60·88	20·69	4·33	6·19	7·91
12	Pitch Coal ...	Black Creek, Grey River.	60·20	29·97	8·01	1·82	7·82
13	Bituminous ...	Mokihinui	59·75	32·14	3·27	4·14	7·76
14	" ...	Coalpitheath	58 81	38·98	1·02	1·19	7·64
15	" ...	Mokihinui	57·92	34·94	3·96	3·18	7·50
16	" ...	Brunner Mine	56·62	35·68	1·59	6·11	7·36
17	" ...	"	56·21	37·83	1·50	4·56	7·30
18	" ...	Westport	56·01	37·17	2·60	4·22	7·28
19	" ...	Mokihinui	55·59	38·86	3·16	2·39	7·20
20	" ...	Brunner	54·16	35·85	2·50	7·49	7·04
21	Altered brown coal	Malvern Hills	53·29	32·04	12·65	2·02	6·92
22	Bituminous ...	Otamataura Creek ...	52·89	36·63	2·19	8·29	6·90
23	" ...	Wallsend	53·10	35·47	1·41	10·02	6·90
24	" ...	Near Cape Farewell ...	48·59	43·17	2·18	6·06	6·31
25	Pitch coal ...	Shag Point	43·19	30·15	15·82	10·94	5·61
26	" ...	Kawa-Kawa	50·15	42·63	4·18	3·04	6·50
27	Glance coal ...	Whangarei	50·11	38·68	8·01	3·20	6·50
28	Pitch coal ...	Kamo	50·01	37·69	9·61	2·69	6·50
29	Brown coal ...	Malvern Hills	49·99	35·42	11·79	2·80	6·49
30	" ...	Fernhill	49·95	36·95	12·00	1·10	6·49
31	" ...	Allandale	47·31	36·26	12·41	6·02	6·15
32	" ...	Kaitangata	46·48	33·48	14·66	5·38	6·04
33	" ...	Shag Point	46·21	32·65	16·02	5·12	6·00
34	" ...	Homebush	44·92	36·00	15·83	3·25	5·83
35	" ...	Hokonui	44·28	38·22	16·50	1·00	5·75
36	" ...	Kaitangata	44·11	38·32	15·44	2·13	5·74
37	" ...	Nightcaps	43·62	33·68	18·33	4·37	5·67
38	" ...	Springfield	42·68	33·66	18·65	5·01	5·55
39	" ...	Orepuki	42·64	36·26	14·44	6·66	5·54
40	Pitch coal ...	Walton's Whangaraei ...	38·80	41·20	7·20	12·80	4·96
41	Brown coal ...	Kaitangata	38·29	32·43	17·50	11·78	4·87
42	" ...	Shag Point	35·76	30·92	13·22	20·16	4·64
43	" ...	Allandale	34·72	40·26	18 99	4·86	4·51
44	Pitch coal ...	Grey River	34·72	55·48	6·20	2·60	4·51

Name of Coal.	Approximate Total Output of Coal up to the 31st December, 1888.
	Tons.
Bituminous	2,484,687
Pitch	803,948
Brown	1,797,725
Lignite	146,472
Totals	5,232,832

Total output of coals of New Zealand to 31st December 1888, 4,618,937 tons.

COBALT BLOOM !—Otago, occurs in schists and gneiss (Hector).

COPPER (NATIVE)—Great Barrier Island, Nelson, Lake Wakatipu, Dun Mountain, Perserverance Mountain, &c., in plates associated with copper deposits in serpentine (Skey); as grains disseminated through a granular serpentine, as fine grains in basaltic dykes which cut through trachydolerite breccias (Geol. Survey), (Cox).

Black Copper, or *Tenorite*—D'Urville Island.

Copper Glance !—Nelson, in various parts of the serpentine belts, in a massive form.

Peacock Copper—Maharahara, Champion Mine, occurs associated with native copper (Hector).

Red Copper !—D'Urville Island, Lake Te Anau; 35·60 per cent. copper.

COPPER PYRITES ! ! !—Waipori, Moke Creek, Coromandel, in a compact amorphous form (Hector). Analysis (Skey):—

Copper	15·03
Iron	28·00
Quartz	21·00
Sulphur	35·97
	100·00

COPPERAS !—Kawau, Barrier Islands, crystallised.

COVELLINE !—D'Urville Island (Hector, Cox).

DERMATIN !—Dun Mountain, West Coast Sounds, occurs in their faces with smooth polished surfaces (Davis).

DIALLAGE, or ALUMINOUS AUGITE ! !—Kakapo Lake, in diorites (Hector); Martin's Bay, in gabbro and in reefs traversing mesozoic limestones (Hector).

Green Diallage ! !—Mount Arthur, in serpentine schists (McKay).

DIALLOGITE ! !—Thames (Hector, 1881), associated with calamine; Makara (Skey, 1870).

DILESSITE !—Mount Somers, fine earthy mineral filling up cavities in melaphyres (Haast).

DIOPTASE !—Thames, Nelson, occurs as an encrustation on the copper ores (Skey).

DOLOMITE !—Malvern Hills, interstratified with augitic sandstone (Haast, 1865); Collingwood (Hector, 1872).

DOPPLERITE !—Waiapu, formed as a surface deposit by oxidation of exuded petroleum. Analysis (Skey)

Oils	3·1
Paraffin	9·3
Earthy matters	26·9
Water	11·3
Oxygenated hydro-carbons ...	49·4
	100·0

DUFERENOYSITE !—Great Barrier Island, as a fine crystalline vein associated with galena in large crystals (Hutton).

DUNITE ! !—Dun Mountain, found in masses (Hochstetter), named by Hector, 1863. Analysis (Reuter):—

Silica	42·80
Magnesia	47·38
Protoxide of iron	9·40
Water	·57
	100·15

ELATERITE !—Kawau (Hector, 1865), hardness 2 sp. gr. 1·034; Poverty Bay (Liversidge, 1877).

ELECTRUM ! ! !—Thames, usually found in places where gold occurs.

EMERALD !—Dusky Sound, in quartz with pyrrhotine (collected by Dockerty, determined by Cox and Skey).

EPIDOTE !—West coast of Otago, in granites (Hector); Mount Torlesse, in diorites (Haast); Wairarapa, in massive form (Hector). Analysis (Skey):—

Silica	44·71
Iron	14·66
Alumina	11·47
Lime	22·93
Magnesia	2·13
Water of constitution ...	4·10
	100·00

EPSOMITE, or EPSOM SALTS !—Otago, as an efflorescence (Hector, 1865).

FAYALITE !—Nelson, in schist, contains 2·6% copper (Skey).

FELSPAR (GLASSY) !—Taupo district, in rhyolites, &c. (Hector).

FLUOR SPAR ! ! !—Stewart's Island and West Otago (McKay, 1889); Batton River, associated with sulphate of baryta (Park, 1889); determined by Skey.

FULLER'S EARTH !—Great Barrier Island Hot Springs, in trachyte tuffs (Hutton).

GAHNITE !—Stewart Island, with tin stone (McKay); determined by Skey, 1888.

GALENA !—Kaituna and Kaimauawa Range, associated with quartz, generally argentiferous; Wangapeka, containing an average yield of about 91 ounces of silver per ton; Great Barrier Island (Skey).

GARNET *(Iron Lime)*—West Otago, in gneiss (Hector).

Black Garnet—Dunedin, in vesicular basalts (Hector).

GLAUBER SALTS !—Brancepeth, Whareama, Wellington, sample forwarded by Mr. W. H. Beetham in 1874 (determined by Skey).

GLAUCONITE !—Otago, occurs in schist and green sands as rounded grains in several of the younger secondary beds (Hector).

GOLD (NATIVE) ! ! !—Auckland, Taranaki, Hawke's Bay, Wellington, Nelson, Marlborough, Canterbury, Southland, Westland, occurs plentifully in reefs, alluvial deposits, sea sand, &c., as crystals in the Ben Nevis Range and Mahakipawa.

GRAPHITE ! ! !—Pakawau, occurs chiefly as thin flat veins interstratified with metamorphic schist, was largely worked prior to 1866; Wangapeka and Mount Potts, disseminated throughout the graphtolite or carbon slates (Silurian) and in the glossopteris beds (Permian), (collected by Hector); Waikoura Creek, a boulder of very pure graphite in a stream from Mount Egmont. Analysis of Pakawau sample (Skey):—

Carbon	58·10
Water	2·68
Ash	39·22
	100·00

GREEN EARTH !—Malvern Hills, filling cavities in melaphyres (Haast).

HALLOYSITE ! !—Dunedin (Hector); Water of Leith (Liversidge); Scinde Island (McKay), in decomposing basalts. Analysis (Skey):

Silica	58·22
Sesquioxide of iron	5.82
Alumina	24·34
Lime	2·02
Magnesia	2·53
Water	4·81
Alkalies and loss	2·26
	100·00

HAUERITE ! — Wakatipu district, Collingwood, in crystals (McKay); Hauerite per cent. 10·87 (Skey).

HAUSMANNITE !—Selwyn River, in rolled pieces and coating joints in rocks (Haast, 1865).

HECTORITE !—Dun Mountain, named by Cox, occurs with serpentine rocks (Cox, Tran. N.Z.I. 1882, p. 409). Analysis (Skey):—

Silica	57·89
Ferrous oxide	18·46
Alumina	4·74
Ferric oxide	traces
Manganese	traces
Lime	1·99
Magnesia	13·94
Water	2·98
	100·00

HEMATITE ! — Mount Gilbert, Nelson, Dunstan, as lenticular masses. Analysis (Skey):—

Silica	4·60
Alumina	3·00
Sesquioxide of Iron	90·60
Water of constitution... ...	1·80
	100·00

HEULANDITE ! — Canterbury, in amygdaloidal traps associated with felsite porphyries (Haast).

HESSITE !—Te Aroha, in auriferous quartz (Hector); analysed by Skey.

HORNBLENDE ! !—Widely distributed (Hochstetter, 1863).

HYPERSTHENE ! !—Warp Point, Kaduku River, in diorite rocks and in hypersthenite (Hector).

IDOCRASE, or VESUVIANITE !—Dusky Sound, as dirty-green, fluted prismatic crystals in quartz associated with crystalline rocks (Docherty), (identified by Skey).

IDRIALITE, or INFLAMMABLE CINNABAR !—Dunstan, Serpentine Valley, Waipori, Ohaeawai Springs, occurs as rounded grains in alluvium (Hector). Analysis (Skey) :—

Water	6·89
Hydrocarbon	21·50
Cinnabar	34·10
Sand	37·51
	100·00

ILMENITE !—Taranaki, in iron sands in all parts of New Zealand, especially Taranaki.

IRIDOSMINE !—Takaka, Orepuke, occurs in gold wash as small flat grains (Hochstetter).

IRON PYRITES ! !—Collingwood, Wakatipu district, &c., occurs in octahedral crystals (Lab. and Geol. Reports).

ISERINE ! !—Common on the West Coast, S. I., (Lab. and Geol. Reports).

JADE, NEPHRITE, or AXE-STONE ! !—Milford Sound, Teremakau River, known as "maori greenstone." It occurs as rolled pieces on the beach and as white nephrite (Hector). Analysis (Skey) :—

Silica	51·03
Ferric oxide, with traces of manganese and chronium ...	12·43
Alumina	1·42
Lime	9·00
Magnesia	21·35
Soda	traces
Water (constitutional) ...	·97
	95·20

KAOLIN ! ! !—Manuherikia, Arrow River, Mount Somers, Collingwood, Stewart Island, formed by the decomposition of felsite porphyries (Hector, Cox).

KERMES !—Endeavour Inlet, occurs with stibnite.

KYANITE, or DISTHENE !—Westland, associated with quartz.

LABRADORITE ! ! — Purahanui Range, Mount Charles, Bank's Peninsula, in trachydolerites (Hector, Haast).

LEAD (NATIVE) !—Collingwood, in the wash of a creek in the form of round grains, like shot. It is alloyed with gold (Skey, Tr. N.Z., In. XII., p. 367).

LEPIDOLITE !—Thompson Sound, in marble (Hector).

LEPIDOMELANE !—Milford Sound, in schists and gneiss rock (Hector).

LEUCITE ! – Castle Point, in leucite basalt (McKay). Analyses (Skey) :—

Silica	48·63	48·29	43·06
Lime	25·39	26·59	24·34
Alumina ...	20·70	20·47	11·47
Iron and manganese ...	traces	traces	7·24
Magnesia ...	2·93	·85	9·06
Water ...	2·35	2·53	3·42
Loss		1·27	1·41
	100·00	100·00	100·00

LEUCOPYRITE !—Thames, Reefton, Collingwood, with mispickel (Cox).

LIMONITE ! !—Wangaru, Parapara River, Shotover River, Collingwood, in massive earthy botryoidal, mamillary and concretionary forms (McKay).

MAGNESITE !—Rotorua, crystalline (Cox, 1878); Chatham Islands, massive (Smith).

MAGNETITE ! !—Lake Wakatipu, Mount Cook, disseminated through various rocks in minute crystals and grains (Haast), 72 per cent. iron (Skey).

MALACHITE — Moke Creek, D'Urville Island, occurs as thin encrusting films on some copper ores (Hector, Cox). Analysis (Skey) :—

Copper	58·20
Iron	1·10
Silica	3·33
Sulphur	traces
Carbonic acid and water ...	37·37
	100·00

MANGANITE ! ! — Tory Channel, Kawarau, Clutha, Otago, Waiheke, Waimarama, Wellington, Waipu, "in veins in schists," "as rolled fragments in alluvial drift." Analysis (Skey) :—

Sesquioxide of manganese ...	63·42
Sesquioxide of iron	66·66
Alumina	traces
Silica	7·25
Sulphur	traces
Water (hygroscopic)	10·22
Water (constitutional) ...	12·45
	100 00

MARGARITE !—Milford Sound, in schists and gneiss (Hector).

MEERSCHAUM !—Dun Mountain, in contact with massive white quartz (Davis). Analysis (Skey):—

Silica	53·76
Lime	2·36
Alumina	4·35
Iron oxides	traces
Magnesia	20·36
Water of constitution... ...	19·17
	100·00

MELLITE !—Thames, described as a resinous substance with a splintery fracture (Hutton, 1870); Bligh Sound, from a cave (Hector, 1876).

MENACCANITE !—Brancepeth, Wairarapa, occurs associated with felspar (Skey).

MERCURY !—Waipori, Bay of Islands, Westport, occurs in alluvial wash in the form of small thin globules (Hector); contains 99.54% of mercury.

METEORITE, or METEORIC IRON !—Wairarapa. Hardness 5·6, specific gravity 3·254, weight, 9¼lbs., contents 49 cubic inches, containing 24 % iron, with silica, sulphur, nickel, &c..

MICA ! ! !—West Coast, in all schists; Charleston, in granite as large plates.

(*Biaxial*, or *Potash*) !—West Otago, in schists (Hector).

(*Uniaxal*, or *Biotite*) !—Dusky Inlet, Milford Sound, a black green mica rock with numerous minute crystals of zircon (Hector).

Chrome Mica !—Dead Horse Gully, in flat tabular plates (McKay, Skey). Analyses (Skey 2):—

Specimens from	1 SCHWARTZENSTEIN.	2 DEAD HORSE GULLY.
Silica	47·68	39·25
Alumina	15·15	22·12
Chromic oxide ...	5·90	1·56
Ferric oxide ...	5·72	18·69
Manganous oxide ...	1·05	·41
Magnesic oxide ...	11·58	10·60
Sodic oxide ...	1·17	1·13
Potassic oxide ...	7·27	
Water	2·86	4·06
Lime		2·18
	98·38	100·00

MUSCOVITE, or MICA ! !—Snowy Peak Range, Milford Sound, Charleston, Dusky Bay, Great Barrier Island, as a common constituent of mica schist, gneiss and granite.

MISPICKEL ! —Milford Sound, Waipori, Malvern Hills, Collingwood, Thames, associated with gold (Hector, Hutton, Cox). Analysed by Skey.

MOLYBDENITE !—Dusky Sound, as flakes in a gneiss rock (Docherty, 1880).

NATROLITE !—Dunedin, in vescicular basalts (Hector); Bank's Peninsula, in volcanic rocks (Haast); also in cavities of basalts from Dunedin (Hector); Mount Livingstone, Look-out Point, Whakahara.

OBSIDIAN, or VOLCANIC GLASS ! ! — Mayor Island, Bank's Peninsula, Mount Eden, Taupo Island, associated with rhyolites and on the sides of trachyte dykes (Hochstetter, Hector).

OLIGOCLASE ! !—Mount Misery, Malvern Hills, Snowy-peak Range, in quartz porphyries (Haast, Daintree).

OLIVINE, or CHRYSOLITE ! !—Mandamus district, Hurunui district, in dolerites (Liversidge, Hutton); Banks' Peninsula, Chatham Islands, as grains in basaltic rocks (Haast); Saddle Hill, Milford Sound, in basaltic rocks (Hector, 1862).

OPAL ! !—Mount Somers, Malvern Hills, inferior qualities only.

Common Opal and *Semi-opal* ! !—Malvern Hills, filling small cavities in quartz porphyries (Cox, Haast).

Fire Opal !—Otago Peninsula, in tuffs, collected by Capi. Fram, determined by Skey.

Opal Jasper ! !—Portobello, Otago, in trachytic tufa (Liversidge).

Pitch Opal ! !—Dunstan, Rakaia Gorge, Harper's Hill (Liversidge).

Wood Opal, or *Silicified Wood* ! !—Mount Somers, Canterbury, Coromandel, occurs in tuffs and conglomerates and where silicious rocks are decomposing (Haast, Hochstetter).

Geyserite ! !—Rotorua (Hochstetter).

Hyalite !—Bank's Peninsula, Malvern Hills, found lining cavities in vocanic rocks (Haast): Dunedin, in vesicular grey-trachyte (Liversidge).

Menilite ! !—Bay of Islands.

ORTHOCLASE, or POTASH FELSPAR ! !—Mount Misery, Bank's Peninsula, West Coast, Auckland Islands, Ruapuke, Great Barrier Island, Sugar Loaves, Boulder Bank, Nelson, Hororata district, Dusky Sound, as a constituent of granites, syenites, gneiss, trachytes and rhyolites.

OZOKERITE !—Dunstan, Otago, occurring brown coals (Hector, 1865).

PALAGONITE ! !—Harper's Hill, Two Brothers, Taipo Hill, as angular fragments in palagonite tufas (Haast). Analysis (Skey)

Silica	38·82
Alumina	23·17
Iron oxide	6·30
Lime	3·65
Magnesia	3·27
Alkalies	2·08
Water	22·76
Carbonaceous matter	traces
	99·97

PEARL SPAR !—Thames (Hector, 1878).

PETROLEUM ! !—Sugar Loaves, Taranaki, from deep-seated coals, altered by volcanic dykes. A specific gravity, ·960 to ·964, rich in lubricants (Hector, Geol. Rep., 1866; Poverty Bay and Waiapu, deep wells and surface springs from middle jurrassic strata (Hector, Geol. Rep., 1873). Paraffin oil, sp. gr. ·843 to ·872, yielded 64% to 84% kerosene (Skey).

PICROLITE !—Dun Mountain, coarsely fibrous, of a dark-green colour (Cox).

PICROSMINE !—Dun Mountain, associated with chromite, and is also found as a network of veins in which crystals of bronzite occur (Cox).

PIMELITE !—Malvern Hills, Clent Hills, filling cavities in amygdaloidal rocks (Haast).

PISTACITE !—West Coast, Mount Torlesse, Mount Somers, Wairarapa, in gneiss, granite, and granulite, and in melaphyres (Hector, Haast).

PITCHSTONE !—Mount Somers, Snowy Peak, associated with quartz porphyries (Haast).

PLATINIRIDUM !— Takaka, Orepuke, as grains in gold-wash (Hochstetter).

PLATINUM (NATIVE) !—Orepuke, Stewart Island, Collingwood, Nelson, Takaka, in the form of small flat grains of a steel-grey or white colour, associated with gold and zircons in southern goldfields, but it has never been found in reef (Hector).

PREHNITE !—Moeraki, Otepopo, Canterbury, in trap rocks (Hector, Daintree).

PROUSTITE !—Thames (Hutton).

PSILOMELANE ! !—Waiheke, Wairuakariri, Bay of Islands, Kawau, Wellington, massive, and is associated with manganite, forming a valuable ore. Analysis (Skey)—sample from Bay of Islands:—

Manganese oxides	75·46
Ferric oxide	11·76
Silicious matters	2·74
Water	10·04
	100·00

PUMICE ! ! !—Tongariro, Tokano, Lake Taupo, Kereru, Ruapehu, &c., along the coast and on the banks of rivers, and on the plateaux round Lake Taupo, 2000 feet above the sea level, occurs also as pumice sand (McKay) at Kereru.

PYRITES (AURIFEROUS) ! !—Thames, Otago, as octahedral crystals in quartz reefs.

QUARTZ—*Amethyst* ! ! !—Rakaia Gorge, in an amygdaloidal trap; Canterbury, in the melaphyres (Haast).

Cellular Quartz ! !—Thames.

Ferruginous Quartz ! !—Abundant (Lab. and Geol. Reports, 1865).

Milk Quartz ! !—Everywhere, in the granites, schists and slates.

Rose Quartz ! !—Rakaia Gorge, in trachyte and pitchstone (Haast).

Bloodstone !—Clent Hills, Snowy Peak, Malvern Hills, in small fragments (Haast).

Carnelian ! !—Malvern Hills, Mount Charles, Otago, in volcanic rocks (Hector).

Chalcedony ! !—Canterbury, Clent Hills, Gawler Downs, Tokatoka, Nioeraki, Otepopo, &c., in "geodes" in the "melaphyres" and quartz porphyries (Hector, Haast, Hochstetter).

Chrysoprase !—Moeraki, Otepopo, Dunedin, Canterbury, Coromandel, filling cavities in amygdaloidal rocks (Haast).

Flint ! !—Kaipara, Mount Somers, in chalk marls (Hector); Campbell Island, in chalk (Hector); Amuri Bluff, in limestone (Haast); Bay of Islands, Tapanui (Liversidge), (see Trans. N.Z. Inst.); Whanganui Heads, in diatom earth (Hector).

Jasper ! !—Coromandel, abundant in volcanic and porphyritic rocks (Hector); Snowy Range, as porcelain jasper (Haast); Auckland, in tuffs and conglomerates (Hochstetter).

Agate Jasper ! !—Coromandel, in trachytic tuffs (Hector).

Plasma ! !—Mount Somers and Gawler Downs, filling fissures in tertiary quartzose trachyte (Haast); Moeraki and Otepopo, in volcanic rocks (Hector).

Potato Stone or Geode ! !—Snowy Ranges (Haast).

Pearl Sinter ! !—Rotorua.

Prase !—Gawler Downs, as small deposits in quartzose porphyritic trachytes (Haast, 1865).

Rock Crystal ! ! !—Tamata, Kereru, Napier, Taupo, Canterbury, Milford Sound, in metamorphic schists, and derived from rhyolitic rocks (Lab. and Geol. Reports).

Silicious Sinter ! ! — Orakeikorako, surrounding thermal springs (Hochstetter); Te Tarata, in terraces.

Siderite ! !—Mongonui, in cover of brown coal beds (Hector, 1866).

Tridymite ! !—Lyttleton Harbour, in trachytic rocks (Ulrich).

RETINITE, or AMBRITE ! !—Hyde, Caversham, Tuapeka, Waitahuna, Dunstan, Bay of Islands, occurs as masses of altered kauri gum in brown coals. First mentioned by Hochstetter, also Hector (Geol. and Lab. reports). Mean of three analyses by Richard Maly :—

Carbon	76·65
Hydrogen	10·38
Oxygen	12·78
Ash	·19
	100·00

RHODONITE, or MANGANESE SPAR !—Canterbury, Kawarau, Clutha, Dunstan, Waiheke, as veins in schists and as rolled fragments in alluvial drifts (Haast, 1865). Analysis (Skey.)

Silica	25·20
Sesquioxide of iron	40·10
Protoxide of iron	1·20
Protoxide of manganese ...	18·85
Alumina	7·20
Copper	traces
Lime	3·02
Magnesic oxide	3·00
Water (constitutional) ...	1·43
	100·00

RUBELLANE !—Bank's Peninsula (Haast.)

SAPPHIRE !—Southern Alps and Collingwood, in alluvial gold beds (Haast, Hutton), determined by Skey.

Emery—Stewart Island.

SAUSSURITE !—Mount Torlesse, in gabbro (Haast).

SCHEELITE ! ! !—Lake Wakatipu, Buckle Burn, Rees River, Waipori, Richardson Mountains, Havelock, solid lodes and large rolled fragments and in arsenical pyrites in the form of small grains (Hector 1863, McKay 1880).

SCHILLER SPAR !—West Coast, with iron pyrites (Hector.)

SCHORL !—Bedstead Gully, Mosquito Hill, Resolution Island, in gneiss and in micaceous and hornblendic schists (Hector).

SCHRÖTTERITE ! — Malvern Hills, filling the cavities in amygdaloidal trachytes, having a mammilated crust on its surface (Liversidge).

SELENITE, or GYPSUM ! ! — Widely distributed throughout Canterbury, Auckland, Nelson, New Plymouth, &c., as groups of crystals associated with sulphur, or as nests of crystals in clay or marls. It is very plentiful, and is mentioned several times in the Geol. Sur. and Lab. Reports.

"SELEN-SULPHUR" !—White Island, massive dark yellow varieties of sulphur (Liversidge, Trans. N.Z. Inst., Vol. X).

SERPENTINE, or MARMOLITE—Mineral Belt, Nelson, and Dun Mountain, as common serpentine forming rock masses (Hochstetter); Milford Sound, noble serpentine, occurring with nephrite in thin grains (Hector). Analyses (Skey):—

	(I.)	(II.)	(III.)
Silica ...	40·20	41·20	45·91
Protoxide of iron	12·10	12·10	1·67
Alumina ...	traces	traces	5·63
Manganese ...	traces	traces	traces
Chromium ...	traces	traces	traces
Magnesia ...	33·20	34·02	35·07
Water (constitutional ...	2·70	12·94	12·67
	98·20	100·06	100·95

SILVER ! !—Kawau Island, Lake Wakatipu, Waipori, alloyed with gold and as a component of tetrahedrite; Golden Crown Mine, as rolled fragments.

SMARAGDITE !—Red Hill, Collingwood, in diorite (Hector).

SPHÆROSIDERITE !—Mount Somers, Bank's Peninsula, in volcanic and dyke rocks (Haast).

SPINEL — Manawatu and Waipori, Otago, as rhombic dodecahedrons, nearly opaque (Hector).

STEATITE, or SOAP STONE ! !—Milford Sound, massive; Collingwood, foliated (Hector).

STIBNITE ! !—Otago, Endeavour Inlet, Reefton, Langdons (Hector, 1865); Thames (Hutton, 1867); Endeavour Inlet (Cox, 1879), in schistose rocks.

STILBITE ! !—Karori, Mangawhai, Tokatoka, Dunedin, as radiating pearly crystals forming films in joints of auriferous rocks (Skey), also in trachytic rocks as detached crystals (Haast, Liversidge).

SULPHUR ! ! !—White Island, deposited from fumaroles and geysers and from an enormous spring in the centre of White Island (Hector, 1865); Roturua and Taupo districts, from Hot Springs (Hochstetter); Waipara, efflorescence from carbonaceous standstones (Haast, 1870), efflorescence from pyritous reefs (Davis); Wangapeka. Analyses :—

	Liversidge		Cox	
Sulphur ...	99·614	98·888	99·9	62·5
Foreign matters	·386	1·112	·1	37·5
	100·000	100·000	100·00	100·00

TACHYLITE !—Bank's Peninsula, Oamaru, on the sides of fissures where basaltic dykes have intruded (Haast).

TALC ! !—West Coast, S.I., Jackson's Bay, Collingwood, in quartz, and associated with crystalline rocks (Hector).

TARANAKITE !—Taranaki, very much like wavellite, is a double hydrous phosphate of alumina and potash, part of the alumina being replaced by ferric oxide, discovered and described by Skey as a new mineral. Analysis per cent. (Skey) :—

Phosphoric acid		35·05
Alumina		21·43
Ferrous oxide		4·45
Lime		·55
Potash		4·20
Soda		traces
Chlorine		·46
Sulphuric acid		traces
Insoluble in acid (silica) ...		·80
Water driven off at 212°	15·46	33·06
„ „ red heat	17·60	
		100·00

TETRAHEDRITE !—Collingwood, a variety, *Richmondite*, occurs as as a lode at Richmond Hill. Analysis (Skey) :—

Sulphide of lead	... ...	36·12
„ „ antimony...	...	22·20
„ „ bismuth ...	...	traces
„ „ copper ...	...	19·31
„ „ iron ...	...	13·59
„ „ zinc ...	...	5·87
„ „ silver ...	...	2·39
„ „ manganese	...	·52
		100·00

TIN !—Reefton, in granite (McKay, 1874); Stewart Island, in mica gneiss (McKay, 1889).

TOPAZ !—Chatto Creek, Arrow River, Waipori, in alluvium, mixed with rubies, garnets, &c. (Hector); Stewart Island, with tin stone (McKay), determined by Skey.

TREMOLITE !—Kanieri, Hokitika, Milford Sound, in quartzite (Hector).

VIVIANITE !—Dunedin, Awatere, as prismatic crystals in moa bones (Hector).

WAD ! !—Auckland, as crystals (Hector, 1870); Stewart Island (McKay, 1886).

WAVELLITE !—Taranaki, occurs in thin seams of a deep yellowish brown colour, hard, translucent and infusible, traversing the taranakite in various directions (Skey).

WITHERITE, or BARYTO-CALCITE !—Thames, in gold mines (Skey).

WOLFRAM ! !—Stewart Island, with tin stone (McKay, 1889).

WOLLASTONITE !—Dun Mountain, massive in form. Analyses (Skey) :—

	1	2	3	4
Silica ...	48·01	49·30	50·62	58·80
Lime ...	46·20	45·91	44·88	24·60
Magnesia	traces	·80	traces	1·60
Alumina	1·45	1·41	1·84	12·20 (Alumina and Iron oxide)
Iron oxide	traces	traces	1·64	
Loss ...	2·19	1·19	traces	1·40
Water ...	2·15	1·39	1·02	1·40
	100·00	100·00	100·00	100·00

WULFENITE !—Dun Mountain, as crystals of a flat tabular form.

ZINC BLENDE !—Bedstead Gully, Tararu Creek, Great Barrier Island, associated with gold (Hector, Hutton). Analysis (Skey):—

Sulphide of zinc	77·61
Sulphide of cadmium ...	traces
Sulphide of iron ...	20·14
Silicious matter	2·25
	100·00

ZINCITE !—Collingwood (Skey).

ZIRCON !—Southern Alps, Timbrill's Gully, Doubtful Inlet, associated with platinum and gold and in the wash, and also in "biotite rock" (Hector).

NOTE.

This Report is not yet complete, as it does not include the Census of Victorian or Tasmanian Minerals.

REPORT OF COMMITTEE No. 14.

The State and Progress of Chemical Science in Australasia, with Special Reference to Gold and Silver Appliances used in the Colonies and elsewhere.

MEMBERS OF COMMITTEE:—Professor BLACK, Professor KERNOT, Dr. LEIBIUS, Professor A. LIVERSIDGE, Professor ORME MASSON, Professor RENNIE, Mr. S. H. COX *(Secretary)*.

DURING the past year, although a good deal of new work has been projected in Australasia, there is comparatively little fresh to chronicle regarding the treatment of ores of this class. It is true that new inventions have been brought out, but, with very few exceptions, they have not found favour with owners of mines, because, in the majority of cases at any rate, they offer no real improvements upon old and well-tried processes.

We may call attention at the outset of our report to certain subdivisions which may be made in considering the subject, and classify the ores as follows:—

Gold
1. Free milling gold ores.
2. Refractory gold ores.

Silver
3. Free milling silver ores.
4. Easy smelting silver ores.
5. Refractory silver ores.

It will be understood that there is, perhaps, no hard and fast line to be drawn between these different groups, and thus that Nos. 1 and 2 often occur in the same stone, while No. 1 very generally gives place to No. 2 as depth is attained. The characters of the silver ores, moreover, and the methods of treatment to which they must be subjected, necessarily depend largely upon the surroundings, the nature and quantity of flux attainable, the price of coke, salt, and other substances required in the processes to be adopted, and so forth; and our division must thus be of a somewhat arbitrary nature. We shall endeavour, however, to define our meaning in speaking of these different classes of ore so as to make plain the reasons which have induced us to adopt them.

Gold.

Free milling gold ores include all those ores in which the gold is in a free state, associated generally with quartz as a gangue, but occasionally also with porous ironstone or gossan. In the majority of cases, however, where gold occurs under the latter condition, it is coated by a film of oxide of iron, which prevents proper amalgamation, and is also, in many cases, of a very fine nature; these characters would transfer the ore from this class to that of class No. 2.

The treatment of ores of class No. 1 has, from the earliest times, consisted of crushing and amalgamation, and although many new systems of crushing have been tried from time to time, no machine has yet been introduced which will compete with stamps when a large quantity of ore has to be dealt with. The primitive battery crushing of the early days has, however, given place in the better managed mines to plants in which all the points which promote rapid, efficient, and economical work are considered; and although we still find batteries supplied from some foundries built upon the old systems and employing the old patterns, there is a decided tendency at present to erect thoroughly capable machines, and to study what really are the best methods of treating the ore.

Perhaps the chief point of difference to be noted in batteries is that some employ light stamps, with a high drop, while others use heavy stamps, 8 or 9 cwt., with a drop of 6in., or, in some cases, even less. It will be evident that one advantage of the latter form is that the battery can be worked at a higher speed, since those with a low drop will not take the same time to fall as those in which the drop is higher. Another point in which a great difference presents itself in the efficiency of different machines, is to be found in the method of feeding the stone to the battery. In many cases, even now, the stone, as it is brought from the mine, is roughly spalled by hand, and fed into the mill whenever the feeder has time or inclination to attend to the work; and thus at times we hear the stamps striking direct on the dies, having nothing to crush, while at others there is so much stone in the battery that the stamps have a large part of their fall cut off, and are, moreover, crushing stone on stone instead of, as intended, directly on the dies. The more improved batteries of the present day are supplied with ore crushers (stone breakers), which reduce the stone to about one and three-quarter inch metal, and this is fed into the boxes by means of improved self-feeders, such as the Challenge Ore Feeder, which can be regulated so as to furnish a regular supply of ore to the mill.

There is a good deal of prejudice against ore-feeders at some mines even now, and no doubt, in certain cases, they have not worked satisfactorily; but the fault has been, not in the feeders themselves, but in the neglect to regulate them so as to produce the best results.

A crushing battery that is firmly set on good foundations, consisting of vertical mortar blocks, well rammed with sand, that has substantial mud-sills and cross-sills, and the housing constructed so as to resist the strains put upon it, and that is fed regularly with ore that has been first broken by a stone-breaker, will work rapidly without very great vibration, and should put from two to three tons per head per twenty-four hours through a No. 8 screen.

The boxes or mortars are made of various forms, and with a delivery which is high or low, according to the fineness or coarseness to which the crushing is to be carried, and the arrangement of the screens is also varied by different makers. It is in these boxes that the first amalgamation takes place, and usually a stout copper plate is placed in a recess at the back of the box, on which, when the gold is coarse, a considerable proportion is retained. It is, also, sometimes considered advisable to place free mercury in the boxes, but the practice should be deprecated, as it flours the mercury, and a considerable loss frequently ensues.

Outside the screens plates of copper amalgamated with mercury are placed to catch the gold as it flows over the surface, and in many cases of late these copper plates have been replaced by electro plates, which avoid the constant formation of a green scum when the plates are new. Mercury wells are also used in many batteries, but they are not beneficial, because, if any sulphides are present in the stone, they soon form a coating on the mercury and destroy its utility.

For true free milling ores this treatment is all that is necessary, and although machines have been introduced to replace the stamps there are none which have as yet been tried which can claim to have superseded them. Probably the best of the new machines is the Huntingdon mill, which has achieved a certain measure of success, and for small mines is undoubtedly an economical system of crushing. It has, however, been so frequently erected by men who have not had any experience in the plant, and worked by others who are equally ignorant in the matter, that there have been many failures recorded in these colonies against comparatively few assured successes.

The Globe mill again claims to supersede the stamps, but has not yet, so far as we are aware, succeeded in establishing itself at any mine. Another machine, the Ashcroft Pulveriser, which has been patented, works upon a different system, the grinding being done by heavy balls and pestles, an attempt being made to imitate, as closely as possible, the action of the pestle and mortar. The inventor claims that the motion of a ball, or a hemispherical surface, revolving on its own axis at the same time as it is driven round the pan, is the most economical way of reducing mineral to fine powder.

In the earlier machines this motion was imparted to the balls by cones, against which the centrifugal force so acted as to produce the rotatory motion desired, and it acted well so long as the balls preserved their spherical form, but if any small flat surface became worn, or if fine matter accumulated in the machine, the balls ceased to rotate. In the present arrangement the balls cannot stop, and the true spherical form is preserved.

The result of experiments with the first mill made on the new plan is that the hardest quartz can be rapidly reduced to the finest powder, and the inventor has supplied us with the following figures, derived from actual experiments, as illustrative of the work performed:—

Power required to work a four feet diameter mill	6 horse-power.
Quantity passed through wire screen, with 1600 holes to square inch, per hour ...	25 cwt.
Weight of heaviest piece in mill ...	21 cwt.
Total weight of mill	3 tons.

A plant is now being erected at the Britannia Mine, near Forbes, which will afford an excellent guide as to the actual working results of the machine. There are several incidental advantages which are claimed for this mill. The whole grinding pan can be replaced at the same cost as replacing a false bottom. The wearing parts are all castings. The mill requires no foundations, and can be set to work a few hours after arrival at a mine, and can easily be moved from place to place.

The refractory gold ores, in the majority of cases, carry a certain amount of free gold in them, and are thus generally subjected to the processes to which we have alluded before undergoing further treatment. They are sometimes, however, taken direct from the battery for concentration without the intervention of any method of amalgamation, or, at times, passed through a system of pan amalgamation, which will be alluded to further on, without being concentrated at all.

In concentration there is a wide field for inventors, and to this subject a good deal of attention has been directed. Until comparatively lately concentration was performed on blanket tables, in buddles of various form, or on end blow, percussion, or shaking tables only; but of late the Frue Vanner and Triumph Concentrator have been somewhat extensively introduced, doing their work very completely, but working at a comparatively slow rate, *two* vanners being required for each *five* heads of stamps.

A patent has been taken out by Mr. G. C. Knapp and Mr. T. E. Fuller for a concentrator known as the "Champion," which, while working on a similar principle to the Triumph, has different mechanical arrangements, and the belt is shorter and wider. This concentrator comes under the head of belt machines, and was designed by the inventors to modify and overcome some of the defects experienced in their practice with the Frue Vanner, Triumph Concentrator, and other machines of a like character. Their first object was to gain a larger concentrating surface by widening the belt, and their second to do away with a needless length of belt, and thereby increase the facility with which the tailings could flow away. The superfluous length was ascertained by direct experiments with existing machines. With this object in view, the length of the top surface of the belt, from centre to centre of the two end rollers, was made six feet, and the width the same, thereby decreasing the length of the vanner belt by about one-half, and increasing the width by two feet, giving a large increase in the concentrating power of the machine, and getting rid of the tailings in about half the time of the Frue Vanner. Another special point in the construction of the machine, which the inventors claim in their patent, has relation to the means by which the "grade" is raised or lowered, and is one of which any practical man who has seen it will at once admit the advantage.

The work of a machine of this class can be regulated almost exclusively by the alteration of the grade, without reference to the "uphill travel," and, in most machines, this alteration has been effected by wooden wedges, driven in or out by a hammer according as the grade is to be lessened or increased. As, in that case, the whole of the stationary framework has to be raised, it detracts very considerably from the stability of the machine, and, in the case of the Triumph Concentrator, slackens the driving-belt to a great extent, as the wedges have to be driven under the frame at the head.

In the machine now under consideration the raising and lowering is done by a separate framework, made of angle iron, on which the supports of the shaking frame rest in suitable sockets. The front ends of this frame are pivoted on the main standing frame, which is made of cast iron, and bolted permanently down to the longitudinal mud-sills, and it is raised or lowered on the pivots by two hand wheel-screws situated at the foot of the machine, which work in cast iron bosses bolted to the floor.

This machine has been built by the Mort's Dock Engineering Company Limited, but has not yet been worked, pending the arrival of the belt; but it may be mentioned that Mr. Egleston states, in his "Metallurgy of Silver, Gold and Mercury," Vol. I., p. 481, that at the Silver King Mine, in Arizona, six 6ft. vanners were started in August, 1886, and by January, 1887, they had treated 10,178 tons of tails from the twelve 4ft. vanners on which the first concentrations were made. The average amount treated on each of the 6ft. vanners was twelve and a half tons per day, nearly twice the quantity dealt with by the 4ft. machine. The tails from the large vanners yielded only 2·03oz.

of silver, or $7\frac{1}{2}$ % of the value of the original ore, and was almost entirely composed of argentiferous zinc blende. With any of these concentrating machines the heavy pyritous minerals can be concentrated from the ores, leaving the tailings almost absolutely clean, but since every ore requires special adjustments of the concentrators to achieve the best results, it is only by actual trials, which may take a few days, that the most perfect adjustment can be arrived at. Where vanners are employed it is necessary to crush with as little water as possible, and consequently the tables have to be set on a steep grade. If this be not attended to there is too much water for the vanners to work satisfactorily.

It is the subsequent treatment of the concentrated sulphides that has, perhaps, received the greatest amount of attention of late, as the colonies have but recently awakened to the fact that on this treatment the ultimate success of the gold-mining industry depends. In every case the pyrites has to be roasted in the first instance, with the exception of the so-called cyanide process, in which the finely-divided sulphides are digested with potassic cyanide, which is stated to dissolve the silver and gold, and these are subsequently precipitated by zinc, the cyanide being recovered. We are not aware that this process has been tried on a practical scale in the colonies, but the results of laboratory tests by several observers has disclosed the fact that the results are very various, and while sometimes nearly 90 % of the silver and gold are obtained, in other cases not more than half that proportion is saved. It would appear, therefore, that there are some disturbing agencies which are not yet thoroughly understood, and consequently that the process requires further investigation before it can be considered a practical success. Roasting is the first requisite in all other processes, the object being to oxidise the sulphides and liberate the gold in a free state, and this is done at several of the mines. There are certain difficulties attached to roasting ores, some relating to the question of expense and others to the complete extraction of the gold and silver if it is present.

The simplest form of furnace, and the one which is usually employed here, is the reverberatory, the floor of which is made very long, and the ore being fed through a hopper at the end farthest from the bridge, is gradually raked down until it reaches the hottest part near the flame, and from this point it is scraped through a hole in the floor into cars, which convey it to the cooling chamber. Roasting in this furnace can be done as perfectly as in any other, but the expense of handling, and the hard work it entails on the men, is a decided disadvantage, and a good deal of attention has been directed elsewhere to the construction of furnaces which obviate these difficulties. We may mention Bruckner's revolving cylinder, White's, White-Howell and Howell's improved revolving furnaces, which have been largely used in America; but we believe there is only one mine in Australasia, the Waiorongamai, at Te Aroha, New Zealand, where any of them have been erected. Another furnace, the "Stetefelt," works on the principle that a rapid oxidising and chloridising action can be produced by bringing the finely-divided particles, either with or without salt, in contact with an ascending column of hot air, and this again, although it has been worked successfully in America, has, we believe, been only tried at one place, St. Arnaud, in the colonies, where it was subsequently stopped.

A furnace has been patented in the colonies by Mr. H. D. Meston, which consists of several floors communicating one with the other by slots, which can be opened or closed at pleasure. The ore is transferred from one shelf to a lower one through these slots from time to time, and the ore is stirred by revolving stirrers, the final roasting being performed in a reverberatory furnace. This would appear to possess the principal requirements for perfect and economical roasting. It is at present in operation at the Clyde Smelting Works, near Sydney, where it is stated to perform its work satisfactorily.

So long as the gold is free from silver, or contains only a small proportion of that metal, but little difficulty is experienced in roasting, provided sufficient care is taken not to raise the heat too rapidly, and thus fuse or cake the material; but with silver the greatest care is necessary, because, in order to recover this metal, it is necessary to introduce salt at some time during the roast, preferably near the end, and a volatile chloride of gold is frequently formed, resulting, unless the greatest care is taken, in a loss of that metal. It would appear, however, that care and attention can overcome this difficulty, and the loss is comparatively slight where the process is thoroughly understood. After roasting, there are two distinct processes open, each of which has received a good deal of attention; these are respectively amalgamation and chlorination.

Where amalgamation is employed, the roasted ore is ground in charges in some form of pan, and of these there are numerous adaptations. The objects of these pans are to provide as great a grinding surface as possible, and to have a complete circulation of the pulp. This circulation is generally secured by wings in the side of the pan diverting the flow of the current to the centre, but a pan has been patented in the colonies of late by Mr. G. C. Knapp which has an octagonal form, the mullers having, of course, only a circular rotation, and the circulation of the pulp in this machine is as perfect as it is possible to desire. Another pan, invented by Mr. C. Dubois, is closed at the top, and having a steam jacket below, it is claimed that the mercury is volatilised, and thus permeates every pore of the pulp. We have not seen this pan in operation, but it appears that the heat gained could not be sufficient to volatilise the mercury, except at a prohibitory expense.

In chlorination there is not a single instance in which Plastner's system is being employed, that known locally as the Newbery-Vautin process, with modifications, having entirely taken its place. We think some notice of this class of process is necessary, because there is some misconception as to the origin of the principle.

Dr. Mears seems to have been the first to introduce the system of working chlorination under pressure, and to do this he employed a revolving barrel, into which chlorine, generated from chloride of lime and sulphuric acid, was pumped, and the barrel was subsequently rotated. Mr. Thies evolved chlorine from the same substances, but did it in the barrel itself, not obtaining any adventitious pressure; while Messrs. Newbery and Vautin proposed to secure the pressure by pumping in air, the chlorine being generated as in Mr. Theis' process. The system employed here seems to be identical with that of Mr. Theis.

In all chlorination it is necessary to keep the pulp damp after crushing, the test of suitability being that it can be crushed together in the hand, but commences to fall to pieces when the pressure is released. Under these conditions, the chlorine penetrates the ore more completely than when it is dry, besides which, if allowed to dry it cakes, and has to be reground.

Silver Ores.

The various processes of treating the more simple silver ores has been so thoroughly exhausted in numerous works on the subject that it would be going outside our province to note any details regarding it. For the free milling ores a chloridising roasting is first resorted to, and this is followed by amalgamation in pans. This process is now in operation at Waiorongomai, at Te Aroha, New Zealand, and will probably be introduced at the White Rock Mine in New South Wales. There have not, so far as we are aware, been any improvements introduced into the methods of treatment in these colonies, in which, indeed, the silver mining industry is but new. The principal method of treatment which has found favour here is by smelting, and this is adopted over a wide-spread area. At Broken Hill, Sunny Corner, Mount Costigan, Port Pirie, and other places the ores are smelted, and in some cases lead has been bought and passed through the furnaces with the view to recover the silver. In the majority of cases the water-jacket continuous furnaces are employed for smelting, and although, in some cases, refining has been attempted, the bullion is now generally shipped. At Sunny

Corner the first system adopted has given place to smelting to a regulus in the first place, and from this the silver is subsequently recovered with lead. There are, however, no new adaptations of well-known processes to chronicle. As regards the refractory silver ores at Webb's Mine, New England, an ore is being raised which consists of a mixture of fahlore, galena, zinc blende, and copper pyrites, and this has been subjected to a leaching process, modified from Von Patera's. There are many other localities, notably in Northern Queensland, where very refractory ores are met with, and which are generally shipped for sale.

The leaching process does not appear to have been worked satisfactorily at Webb's—at least, operations were suspended, and a good deal of discussion ensued as to what was the best method to adopt for dealing with the ore. Amalgamation was advocated by some, but this has been overruled, and the process about to be employed is stated to be Russell's modification of the Von Patera process, in which sodium hyposulphite takes the place of the corresponding calcium salt, and sodium sulphide is used as a precipitant. There are many advantages in this change, the principal, perhaps, of which is that the lead can be precipitated as a carbonate, leaving the silver in solution, and although the sodium hyposulphite solution is more expensive than the calcium hyposulphite one, it can be used in a more concentrated form, and the sodium sulphide precipitates a larger proportion of the silver than the corresponding calcium salt. This process is about to be introduced at the Broken Hill Proprietary Mine to treat some of their ores, but the "extra solution," a double cuprous and sodium hyposulphite, which forms one of the features of the Russell process, is to be used weaker than specified in Russell's patent. We believe this process to be admirably adapted for the treatment of many of the more complex ores in the colonies, and may quote Mr. Stetefelt's *resumé* of the advantages of this system over pan amalgamation, set forth in a paper read before the American Institute of Mining Engineers. These are as follows:—

1. In amalgamation the fineness to which the ore has to be crushed is determined by the capacity of the settler to work off coarse sands without loss of quicksilver. It is not practicable to use a coarser screen than No. 30 if the crushing is done by stamps. This is almost equivalent to sifting through a No. 40 revolving screen, if the crushing is done by rolls. In lixiviation, pulverising as coarse as possible is desirable. The limit of coarseness is determined by the roasting process. It depends upon the character of the ore, and, principally, upon the manner in which the silver-bearing minerals are distributed in the gangue.

2. The original cost of the lixiviation plant is much lower than that of pans and settlers. A further saving is effected by a reduction in the size of the engines and boilers.

3. In amalgamation the pans and settlers consume not less than one and a half horse-power per ton of ore. The power for pumping solutions, &c., in the lixiviation process is merely nominal.

4. In large mills the quantity of quicksilver in rotation represents a capital of from £6000 to £8000, while the stock of chemicals required for lixiviation does not cost more than one-tenth of this amount.

5. With Russell's improvements, the percentage of silver extracted by lixiviation is much higher than by amalgamation.

6. Lixiviation by Russell's process requires a less careful chloridising roasting. In many cases the salt may be dispensed with.

7. The value of the lost quicksilver and cost in wear and tear of the pans and settlers amounts to more than that of the chemicals consumed in the lixiviation process.

8. The lixiviation process permits of the extraction of copper and lead as valuable by-products.

9. The sulphides from the lixiviation process can be more easily converted into fine bars, and the gold parted, than this can be done with the bullion obtained in amalgamation.

10. Amalgamation is invariably injurious to the labourer's health.

11. Where gold-bearing silver ores have been roasted with salt, lixiviation extracts, in most cases, more gold than amalgamation.

12. The possibility of lixiviating many so-called "free milling ores" without previous roasting, including tailings resulting from amalgamation of roasted or raw silver ores.

13. The possibility of lixiviating with profit some classes of silver ores after they have been subjected to an oxidising roasting only.

Since the foregoing was written, a patent by A. A. Lockwood and H. Chappel has come under our notice, in which the roasting of auriferous and argentiferous ores is performed in retorts by steam, super-heated steam, or carburetted hydrogen. An experimental plant has been erected in Sydney, but we have not yet had an opportunity of ascertaining the completeness of the operation.

REPORT OF COMMITTEE No. 11.

The Bibliography of the Australasian, Papuan, and Polynesian Races.

MEMBERS OF COMMITTEE :—Hon. Dr. AGNEW, Rev. J. COPELAND, Rev. S. ELLA, Rev. W. WYATT GILL, Sir JAMES HECTOR, Mr. A. W. HOWITT, Mr. J. F. MANN, and Dr. JOHN FRASER, *Secretary.*

ALL the members of this committee have been consulted, but the arrangement of the work to be done and the doing of it have, of necessity, been mainly in the hands of those members of it who reside in Sydney. Thus it was agreed that the Papuan Race should be inserted in our programme; it was also thought desirable, and in this all the members of the committee concurred, that an effort should be made to present to these colonies, and especially to Britain, a full and reliable account of some of the less known features of the social and domestic life of the Australasian, Papuan, and Polynesian Races, based on the same topics of inquiry, and written, as it were, in parallel columns. Even those who are well informed on such subjects may find it pleasant to have thus the means of comparing and contrasting at one glance some of the characteristics of these races; and when we consider the lack of trustworthy information of that kind among scientists in European countries, our committee is of opinion that a voluntary labour such as this, may well be added to the work assigned to us. The following syllabus was accordingly prepared and issued to the members of the committee and to others :—

TOPICS TO BE DISCUSSED IN THE REPORT ON THE AUSTRALASIAN, PAPUAN, AND POLYNESIAN RACES.

N.B.—The characteristic features of the Races and other well-known points are omitted.

BIRTH AND CHILDHOOD.—Observances and superstitious beliefs in connection with the birth of a child—any variation in these when the child is a female—is the woman isolated and regarded as unclean for a time—how long? Infanticide of males, females; when, how, why practised—any cannibalism then? Is child named in any formal way—when, how—whence comes the name? How are deformed and sickly children treated? How does the mother carry the child or children—does the father ever carry it? Suckling, how long continued? Is anything applied to the child's head to regulate its shape? During childhood is the child lovingly cared for, disciplined, taught useful habits by parents? Is female child betrothed when young—by whom?

Maturity.—At what age mature? For females, observances on reaching maturity? For males, rites of initiation into the tribe and the privileges of manhood—circumcision, how done, why (as natives say), with what instrument, by what person—how long is initiation carried on—is it progressive as in the grades of freemasonry? Are there mystic ceremonies—of what kind—a badge or sacred belt, a new name, tattoo, hair cut off, restrictions as to food? Are there special colours used at the ceremony—sacred songs, dances, taught? What privileges does the fully initiated youth possess?

Marriage.—Preliminaries? Does a betrothed child at once pass into the charge of her husband? Is there marriage by force, by capture, by sale, by barter? State restrictions, if any, as to marriage among the classes of the tribe—marriage ceremonies and observances? Is there polygamy? Is it restricted to the chiefs? Do children take their tribal (totem) classification from the father or from the mother—in war do they join their mother's kin? The law of inheritance of land or property? How is a widow treated—orphans? Is there any restriction of converse or intercourse between relatives by blood or marriage—why (as natives say)? What work has the married woman to do—how is she treated by her husband?

The Tribe.—What constitutes a tribe? Is there one chief or several—how does a man become a chief—is the office of chief hereditary—how does it pass—the power and authority and duties of a chief? Is there a tribal council—how constituted—its work? How are infractions of tribal law punished?

Social and Domestic.—Huts—how built—of what material, shape? Cultivation—how—kind of food—abundance of food—work done—by whom? Meals, how cooked, how eaten—when, how many each day—reception of strangers? Ornaments—of hair, ear, nose, arms, legs? Clothing? Are the natives well nourished?

Wizards.—What makes a man a wizard? How is he supposed to obtain his magic powers—how use them, for good, for evil—in bringing rain or driving it away—in causing sickness—in curing the sick—in driving away evil spirits—in causing death—in discovering the cause of death, &c.? Does he receive any pay or reward?

Death.—Beliefs as to causes of natural death—observances by relatives at death—cutting of gashes on head or body—modes and colours of mourning—wrappings of dead or other preparations—funeral—grave—mode of interment—grave mound or other mark—articles put in the grave with deceased—offerings or watchings at fire at grave, mourning, how long continued?

Spirit World.—Where? Beliefs as to the continued existence of spirit, and its first condition after death—changes which the spirit undergoes, when, how—transmigration—the spirit's ultimate destiny and abode—its presence and influence among the living—the entrance and road to the spirit world; beliefs as to the deceased great men of the tribe or race?

MYTHOLOGY.—Beliefs as to a creator or creators—assistants in the work of creation, in administration, in communicating with men—as to inferior deities and their province and attributes?—are these supposed to be heroes or (family) ancestors deified?—do they help or injure men?

PHILOLOGY.—A list of the numerals and pronouns in the language, with suggestions as to their etymology? Paradigm of the conjugation and declension of the verb "to go," and of the verb "to kill," with a pronominal object? A few simple sentences to show the grammatical structure of the language? A list of words for the English—man, woman, head, hair of head, eye, nose, tongue, ear, hand, thumb, foot, bone, blood, fire, water, sun, moon, father, mother, son, daughter, brother, sister, cousin, uncle, aunt; and the verbs give, take, make or do, bear, burn, see, hear.

Our committee wishes to present to the next meeting of this Association a comparative view of the Australasian, Papuan, and Polynesian races, to be written in sections and on the same lines (as above) by those who are well acquainted with these races, and are thus able to give reliable information regarding them.

Reports on these lines may yet be obtained in sections for Australia, Tasmania, New Zealand, the New Hebrides, New Guinea, Fiji, and the chief groups in Polynesia. These reports would, doubtless, show considerable uniformity in the usages of the races, but the divergences would also be considerable, and especially interesting to a mind accustomed to observing these usages, and to ask what was their origin and how they came to vary. Of course such a task is a large one, and can be managed only by instalments. We now present two of these instalments, the one written by the Rev. W. Wyatt Gill, B.A., LL.D., and the other by that indefatigable pioneer missionary, the Rev. James Chalmers, of Port Moresby, New Guinea. Dr. Gill's report applies to Polynesia, and especially to the Hervey Islands, where he so long laboured.

The bibliography of the races has been compiled from two books already published, the "Catalogue of the York Gate Library," formed by Mr. G. Wm. Silver, and the "Catalogue of the Sir George Grey Collection," in the Free Public Library at Auckland, of which the latter has been forwarded to us for this purpose through the courtesy of Sir George Grey himself. Our committee has entered in these lists only such books as throw light on the ethnography of the races or the philology of their languages; concise notices of some of the chief publications in the native languages will be found under each head. These lists do not pretend to be complete, and therefore may require to be supplemented at some future time, when also other portions of our report on the races themselves may appear, if the Science Association should wish our labours to be continued.

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Vocabularies and incidental notices of Australian words, and their meanings, are found in the works of many authors who have written about Australia; *e.g.*—1790, White has a few names of animals; 1763, Hunter, about 390 words; 1793, Tench, between 70 and 80 words; 1798, Collins, about 400 words; 1807-11, Péro, about 20 words; 1811, Patterson, a few words; 1814, Flinders, about 15 words; 1820, Oxley, 37 words; 1825, Field, a few words; 1827, Cunningham, over a dozen words; 1827, King, about 50 words; 1832, Henderson, about a dozen words; 1833, Breton, 70 words; 1833, Sturt, a few words; 1834, D'Urville, about 150 words; 1834, Geo. Bennett, 130 words; Threlkeld's Grammar has a large vocabulary of words; 1839, Ogle, about 170 words; 1839, Mitchell, about 350 words and names; 1844, Mrs. C. Meredith, 25 words; 1845, Hodgkinson, a few names; 1845, Strezlecki, remarks on the language; 1845, Eyre, nearly 100 words; 1845, Rev. D. McKenzie, about 50 words; 1846, Dr. Braim, a few notices from Threlkeld; 1846, Hale (U.S. expedition), about 360 words; 1847, Marjoribanks, a few words; 1848, Mitchell, some names; 1848, Gould ("Birds"), about 230 native names; 1849, Sturt ("Central Australia"), some names; 1850, Threlkeld's Key has comparative tables of words;

1851, Bunce, about 80 words; 1851, Henderson, about 70 words; 1852, Mundy, half a dozen words; 1857, Cooper, 220 words; 1860, Geo. Bennett, 50 names; 1862, Latham, about 150 words; 1863, Rev. J. Graham, upwards of 30 words; 1865, Sam. Bennett, comparison of words; 1866, Bailliere ("Gazetteer of New South Wales"), about 3000 names of rivers, mountains, &c.; 1866, Ridley, first edition; 1875, Ridley, second edition, greatly enlarged, about 1200 words; 1878, R. B. Smyth, about two dozen words; 1880, Fison and Howitt ("Kamilaroi and Kurnai"), words for relationships; Curr.

Information about the aborigines of Australia and their languages may also be obtained from "Notes and Proceedings of the Parliament of New South Wales, 1834-38;" "Report of the Select Committee of the Parliament of New South Wales, 1838-1845;" and from numerous articles in the volumes of the "Journal of the Anthropological Institute of Great Britain," the "Journal of the Royal Geographical Society of London," the "Journal of the Royal Colonial Institute of London," the Journals of the Royal Societies of New South Wales, Victoria, &c.

(2.) East Indian Archipelago.

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2. Crawfurd, John.—"History of the Indian Archipelago; Manners, Arts, Languages, Religious Institutions, and Commerce." 3 vols., 8vo. Edinburgh, 1820.
3. Crawfurd, John.—"Grammar and Dictionary of the Malay Language."
4. Hartwig, Dr. George.—"On the Malayan Race." Vol. iv. 5 vols., 8vo. London, 1881-82.
5. Humboldt.—"Uber die Kawi Sprache."
6. Marsden, William.—"History of Sumatra; its Native Inhabitants, Natural Productions, &c." 3rd edition, 4to. With Plates, Folio. London, 1811.
7. Marsden, William.—Miscellaneous Works on "The Polynesian and East Insular Languages;" on "A Continental Roman Alphabet, Applicable to Oriental Languages, &c." 4to. London, 1834.
8. Muller, F.—"Reise der Fregatte *Novara*." Wien, 1867.
9. Wallace, A. R.—"Physical Geography, Ethnology, &c., of the East Indian Islands." In Stanford's "Compendium of Geography and Travel." 6 vols., 8vo. London, 1879-85.

(3.) Melanesia (General).

1. Anderson, J. W.—"Notes of Travel in Fiji and New Caledonia." London, 1880.

2. Campbell, F. A.—"A Year in the New Hebrides, Loyalty Islands, and New Caledonia." Melbourne, 1874.

3. Codrington, Rev. R. H. (D.D.).—"A Sketch of Motu Grammar." London, 1877.

4. Codrington, Rev. R. H. (D.D.).—"The Melanesian Languages." 8vo. Oxford, 1885.

5. Copeland, Rev. J. (Futuna Island, New Hebrides).—"The Language of Aneityum." 1861.

6. Copeland, Rev. J.—"Sheet of Meteorological Observations Made at Futuna Island during the years———." Dunedin, 1878.

7. Duncan, Prof.—"Types of the Lowest Races." Folio. London, 1874.

8. Gabelentz, H. C. von der.—"Die Melanesischen Sprachen, &c." Leipsic, 1860.

9. Garnier, Jules.—"La Nouvelle Calédonie et Tahiti." 12mo. Paris, 1871.

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14. Inglis, Rev. J. (D.D.).—"In the New Hebrides." 8vo. London, 1887.

15. Macdonald, Rev. D. (Havannah Harbour, New Hebrides). "Oceania: Linguistic and Anthropological." 8vo. Melbourne, 1889.

16. Macdonald, Rev. D.—"Three New Hebrides Languages (Efatese, Eromangan, Santo)." 8vo. Melbourne, 1889.

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22. Rienzi, G. L. Domeny de.—"Océanie." Paris, 1836.

23. Romilly, H. H.—"The Western Pacific and New Guinea." 8vo. 1886.

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25. Tyerman, D., and Bennett, G. (see Polynesia).

26. Wallace, A. R.—"Australasia." In Stanford's "Compendium of Geography and Travel." Chapters xxii., xxiii., and Appendix.

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3. Lawes, Rev. W. G.—"Grammar and Vocabulary of the Language Spoken by the Motu Tribe, New Guinea." With Introduction by Rev. Geo. Pratt. 8vo. Sydney, 1885.

4. Lindt, J. W.—"Picturesque New Guinea; with Chapters on the Manners and Customs of the Papuans." With 50 autotype illustrations. 4to. 1887.

5. Stone, O. C.—"A few Months in New Guinea." With Illustrations and a Vocabulary. 12mo. London, 1880.

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Articles on New Guinea, the New Hebrides, New Caledonia, and the other adjacent groups will be found in the "Encyclopædia

Britannica," "Journal of the Royal Geographical Society of London," and "Proceedings of the Royal Colonial Institute."

Books and pamphlets in the native languages of MELANESIA are:—

New Hebrides, etc.

In the languages of Aneityum, Futuna, Tanna, Eromanga, Aniwa, Efaté, Nguna, Epi, Ambrym:—Primer, Catechism, Hymn Book, Lesson Book, Vocabulary, portions of the Bible (the earliest of these dating from the year 1855). The Aneityumese has the whole Bible (1889) and the "Pilgrim's Progress," also a dictionary of the language. Almanacs were printed in 1855 and 1859.

Of the Northern Groups of Melanesia,

Motu Island

Has the Lord's Prayer, Reading Book, and Hymns in the native language.

Solomon Islands

Have Prayers and Scripture Readings.

New Britain

Has Catechism and Hymns, a Dictionary and Grammar, and St. Mark's Gospel.

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2. GORDON-CUMMING, Miss C. F.—"At Home in Fiji." 2 vols., 12mo. London, 1881.

3. HAZLEWOOD, Rev. D.—"A Fijian and English Dictionary." 8vo. Fewa, 1850.

4. HAZLEWOOD.—"A Fijian and English and an English and Fijian Dictionary, &c., with a Grammar of the Language." 8vo. London.

5. MOORE, Rev. WM.—"Handbook of the Fijian Language." 8vo. Hobart, 1866.

6. PRITCHARD, W. T. (H.M. Consul at Samoa and Fiji).—"Polynesian Reminiscences." 8vo. London, 1866.

7. SCHOLES, S. E.—"Fiji and the Friendly Islands; their Scenery and People." 16mo. London, 1882.

8. TURNER, GEO. (LL.D.).—"Nineteen Years in Polynesia, Fiji, &c." 12mo. London, 1884.

9. WATERHOUSE, Rev. JOSEPH.—"The King and People of Fiji." 12mo. London, 1866.

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The New Testament. Mission Press, Vuva, Fiji, 1853.
The Bible. London, 1864 and 1867.

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2. MEYER (see Melanesia).

3. WALLACE, A. R.—"Australasia," in "Stanford's Compendium." Chap. XXV.

Pamphlets in the native languages are :—

Gilbert Islands—

Spelling Book, 1860; Catechism, Hymn Book, Geography.

Marshall Islands—

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3. Angas, G. French.—"Polynesia; a Description of the Physical Features, Inhabitants, History, and Productions of the Islands of the Pacific." 12mo. London, 1866.

4. Arbousset, Th.—"Tahiti et les Iles Adjacentes." 12mo. Paris, 1867.

5. Bird, J. L.—"Hawaiian Archipelago; Six Months in the Sandwich Islands."

6. Boddam-Whetham, J. W.—"Pearls of the Pacific." 8vo. London, 1876.

7. Brenchley, Julius L.—"Jottings During the Cruise of H.M.S. *Curacoa* Among the South Sea Islands in 1865." With Illustrations and Natural History notices. 2 vols., 8vo. 1873.

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12. Cook.—"The Three Voyages of Captain Jas. Cook;" with an appendix giving an account of the present condition of the South Sea Islands. 2 vols., 4to. 1846.

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16. Ellis, Wm.—"Narrative of a Tour Through Hawaii; with Observations on the Natural History of the Island and its Inhabitants." 8vo. London, 1824.

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Rarotonga.

Catechism, 1847; Arithmetic, 1848; Pilgrim's Progress, 1849; Hymn Book, 1852; Astronomy illustrated; English and Rarotongan Grammar (Buzacott); Bogue's Theological Lectures; Scripture Lessons; Geography and School Reading Book; the Laws of Rarotonga, written by the chiefs, and printed at their special request and cost, 1862—all printed at Rarotonga; Barth's Church History; Commentaries on Several Books of the Bible (William Gill); Ata Ao, "Peep of Day" (Mrs. W. W. Gill)—all printed at London; and many others. The New Testament (translated by John Williams), London, 1838; the Bible (translated by Williams, Pitman, and Buzacott), 1st edition, London, 1851; 2nd edition (edited by William Gill), London, 1855; 3rd edition (edited by Geo. Gill and E. R. W. Kranse), London, 1872; 4th edition (carefully revised and carried through the press by Rev W. Wyatt Gill, LL.D.), London, 1888.

Hawaiian.

Catechism on Bible History, 1832; Hymns and Times, 1834; Geography Book, 1845. Printed at Oahu. Sacred Readings, 1841; Pilgrim's Progress, 1842; Arithmetic Book; Church History; Moral Philosophy; The Story of the Lady of the Twilight; Baxter's Saints' Rest; Evidences of Christianity; Keith on the Prophecies; Wayland's Moral Science; Wayland's Political Economy; General History; Ancient History; the Bible; and many others. Printed at Honolulu.

Maori.

Maori Catechism (the first book printed in New Zealand), 16mo., Kirikiri, 1825; The Pilgrim's Progress; Robinson Crusoe; Poems, Traditions and Chants of the Maoris, edited by Sir Geo. Grey; Proverbial and Popular Sayings of the Ancestors of the New Zealand Race, edited by Sir George Grey; and other books; pamphlets very numerous.

Marquesan.

Geography, Arithmetic, Hymn Book, 1869.

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2. Angas, George French.—"Polynesia; a Popular Description of the Physical Features, Inhabitants, &c." 8vo. London, 1866.

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4. Brown, Wm.—"New Zealand and its Aborigines, and the Means of Civilising Them." 12mo. London, 1845.

5. Buller, Rev. Jas.—"Forty Years in New Zealand; with an Account of Maoridom, &c." 8vo. London, 1878.

6. Campbell, Dr. J. L.—"Poenamo." Sketches of the early days of New Zealand. 8vo. 1881.

7. Fenton, F. D.—"Origin and Migrations of the Maori People." 8vo. Auckland, 1885.

8. Fenton, F. D.—"Observations on the Aboriginal Inhabitants of New Zealand."

9. Grey, Sir Geo.—"Polynesian Mythology and the Traditional History of the New Zealand Race." 12mo. London, 1855.

10. Johnstone, J. C.—"Maoria; Manners and Customs of the Aboriginal Inhabitants of New Zealand." 12mo. 1874.

11. Maunsell, Rev. R.—"Grammar of the New Zealand Language." Third edition, Melbourne, 1882; first and second editions, Auckland, 1842, 1862.

12. Polack, J. S.—"Manners and Customs of the New Zealanders, &c." 2 vols., 8vo. London, 1840.

13. Rutherford.—"The New Zealanders; Account of New Zealand and its Inhabitants." With a History of John Rutherford, a Sailor, Detained among them Several Years (1816-27). 12mo. 1830.

14. Shortland, Edward.—"The Southern Districts of New Zealand, with Notices of the Aborigines." 12mo. London, 1851.

15. Shortland, Edward.—Traditions, Superstitions, Manners and Customs of the New Zealanders." 2nd edition. 12mo. London, 1856.

16. Taylor.—"Te ika a Maui; or, New Zealand and its Inhabitants, their Origin, Manners, Customs, Mythology, Religion, Songs, Proverbs, Fables and Language." 8vo. London, 1870.

17. White, John.—"Te Rou; or, the Maori at Home." 8vo. 1874.

18. White, John.—"The Ancient History of the Maori; His Mythology and Traditions." 8vo. Wellington, 1887.

19. Williams, W.—"Dictionary of the New Zealand Language." 8vo. London, 1852 and 1871.

20. Wood, J. G.—"The Maoris." In "Wood's Natural History of Man." Illustrated. 2 vols., 8vo. London, 1868-70.

II.—REPORT ON THE AUSTRALASIAN, PAPUAN, AND POLYNESIAN RACES.

(1.) New Guinea. Toaripi and Koiari Tribes, by the Rev. James Chalmers.

(*a*) TOARIPI TRIBE.

BIRTH AND CHILDHOOD.

In many of the tribes a feast is prepared by relatives when a woman is known to have conceived, but here (Toaripi, or Motumotu) nothing is done. After conception a woman is not sacred, but lies with her husband until near childbirth. When she feels the pains of childbirth, she goes to the bush close by, and selecting a cocoanut or other large tree, lies down beside it. A friend brings her a chatty of water and a shell. She is left alone, and does everything for herself and the child. The afterbirth she takes home and presents to her mother or other near relative, who keeps it for a day or two, when it is thrown into the sea. If a son is born, great is the joy; if a girl—well, only a little pleased. She cooks her own food, but the husband does not partake of food cooked by her; he remains away from her until the child is well grown, when he enters the house, talks with his wife, and nurses the child. There is no cohabitation until the child is grown and able to crawl about. Only then will the husband have connection with her and eat food cooked by her. A man having connection with his wife before then would injure the child, who would sicken and die.

A woman having another child before one is quite grown is spoken of as an animal, a pig, or something else; she would be terribly ashamed. An Eastern Polynesian woman had two children within a year, and the natives were horribly disgusted, and said she was only a sow.

For the first child, on the fifth day after birth, food is cooked by the husband's and wife's relatives, and the women of the village where the woman who has given birth to the child resides partake of it.

Only illegitimate children are killed. There is no infanticide and no cannibalism.

Children are named by relatives—if a girl, the mother's friends give the name; if a boy, the father's friends. A name will be given for a quarrel, or a journey, or anything particular occurring on it, or sickness. A man is now here named by a relative who at the time of his birth was suffering from a sore chest, and he named the child Harepai (sore chest). They do not actually kill deformed children, but they are so neglected that they soon die. They do not pierce the nose until the child is about five or six years old, having no superstition regarding it. The mother carries the child in her arms, or, when going a distance, in a net bag over her back. The father frequently nurses the child. Yesterday a father returned from a journey, and when safely landed, his wife met him, gave him the child, which he nursed affectionately, whilst the wife carried home the things on the canoe. Such may be seen any day. The child suckles until walking about. Children are lovingly cared for by parents and relatives. Uncles and aunts take as great an interest in the children as the parents do. They are not disciplined, are taught planting, sago-making, and fighting.

There is no betrothal in infancy. When young women, they are betrothed. Parents make all arrangements, but not unless it is agreeable to the young man and woman.

MATURITY.

Fourteen and fifteen years old. There are no observances at that time. Lads, when about seventeen or eighteen, leave off the sporran worn by all boys, enter the Eramo (temple or dubu), and these adopt the string, shave the head, and remain for many months until the hair has grown long and frizzy. Before entering the Eramo the father, or nearest relative, kills a pig and makes a feast, and invites all friends to assemble. A relative takes off the sporran, and fastens on the sihi (string), after which all sit down and eat. When the hair is well grown he leaves the Eramo, and again there is feasting. He is now considered a man, and is marriageable. When in the Eramo he is not supposed to look upon or be seen by a woman. Female friends cook food and leave it outside, making a noise as they leave, and shortly the lad descends, takes it into the Eramo, and eats it. They spend the time in the Eramo making armlets from fibres. The old men, who live mostly in the Eramo, occupy themselves in working (plaiting) belts, which are worn by young men after birth of the first child.

When the first child is born the father cooks a pig and food, and the belt, being purchased with food, is then fastened on, there to remain until rotten, or, on death of a near relation, it is cut off.

When in the Eramo, various kinds of food may not be eaten, especially taro. Sago and bananas may be eaten, and only a very few kinds of fish. The young man's hair is shaven off on entering by a friend, for whom he will do the same.

Not until after they have left the Eramo is the "Roaring Bull" seen. On the occasion of its being worked all women and children and young men keep away. Near to here are two large houses filled with masks, which are all very sacred, and are now kept from vulgar gaze until after a large feast, soon to be held, when they will be used for dancing, and afterwards burned. A short time ago two old men sat in one of the houses, communicating with the spirits and working the "Bull." Large quantities of food were brought them by men. Not until a youth has been in the Eramo can he wear a mask or join in the dances and drum-beatings of the tribe, and only then is he considered a man. Not until he has descended from the Eramo does he know a woman. All singing, dancing, and drum-beating are considered sacred, and never uselessly done.

There is no circumcision practised in the Toaripi Tribe.

MARRIAGE.

When about fourteen years of age, boys and girls go planting in different places, and there is a custom (Hiriho), when the afternoon arrives, the boys get their bows and arrows and rush the girls, who make for the sea, and if one of them is wounded, she is supposed to become the wife of the boy who fired the arrow. Many girls attend school who, a few days ago, were wounded.

As already stated, there is no betrothal in infancy. A young man gives areca nuts to a girl, and she tells her parents, and the young man informs his. The youth's father then gets bananas and areca nuts and carries them to the maiden's parents, and if accepted they are said to be betrothed, and the girl carries firewood at night to the boy's home. They are not married until the young man leaves the Eramo. Should the girl not care for the lad, she informs her parents, and the bananas and areca nuts are returned.

Before marriage, food is collected in large quantities by parents and relations of the young man, and on a fixed day carried to the girl's home. Her parents dress her in feathers, arm-shells, shell necklaces, and best petticoats. The bridegroom remains at his home. The girl, when dressed, sits on a mat in presence of the boy's parents and eats out of a dish cooked specially for her. She then rises, and her father places on her shoulder a bow and a bundle of arrows, and she then accompanies the boy's parents to their home. A large party accompanies them, all carrying food, and preceded by a man carrying a bunch of ripe bananas, which he distributes one at a time to the crowd of children and others who follow. On arrival at the bridegroom's home, she takes off all her finery, which then becomes the property of the husband's parents, and she presents him with the bow and arrows; a dish of food having been prepared, they both eat out of it. The day after, the woman's head is shaven and a large feast is prepared and distributed to each Eramo. She is now a married woman, and does all the work of a married woman.

Relations do not as a rule marry. They are polygamists, but only a few have more than one wife. When two or more wives, they all live in one house. Polygamy is not restricted to chiefs.

The classification is from the father, and in the event of war children would join the father's tribe.

Sons and daughters share alike in land. A woman takes land with her, and dying without issue, the land would return to her own family, brothers or sisters. If there are children, they claim it.

Widows, if they have children, remain with the husband's friends; if no children, they return to their own families. Should a widow again marry, the payment for her is very great, and goes to the first husband's relatives.

Orphans are well cared for by relatives of the father and mother; after death of both parents they are divided.

Women do all the cooking, and a great part of the fishing. Husband and wife plant, fetch wood, make sago, &c.

As a rule the women are well treated; not many beat their wives. A husband beating his wife would have to bear the wrath of all her relatives.

Sometimes a woman, after a quarrel, will leave her husband, and will remain with her relatives until fetched back by him. A woman leaving her husband takes all the children with her.

THE TRIBE.

There is one language, one tradition. There are several chiefs, and no distinction between them. Chieftainship is handed down, and if there are no sons the girls can take it. The chief is supposed to have plenty of pigs, and makes feasts, assisted by his friends. He is not supposed to fight, and does not carry warlike implements—only goes about with a net bag containing areca nuts, betel, pepper, and lime calabash.

They have no councils. Each one does his own sweet will. Breach of custom is punished by the sufferer. Theft or any other crime is so also. As a rule there is very little crime. When food is stolen all denounce it, and it may lead to serious quarrels.

SOCIAL AND DOMESTIC.

Huts are built of wood, on wooden piles about 9 feet above the ground. The house slants towards the back. In the front there is a platform. They plant yams, taro, sweet potatoes, sugar-cane, and always have plenty. There is a very large supply of sago, and at all times it is used. Spoons made from cocoanuts are used for sago and any other soft food, a one-pronged fork is used for other food. They always cook in pots bought from the Motu tribe. They have two meals a day as a rule, sometimes only one.

Husband sleeps in the Eramo, and only occasionally visits his wife, and very seldom sleeps a whole night with her. When they are alone in plantations they will have intercourse.

Father and small children will eat together, and mother, grown-up daughters, daughters-in-law or other female relatives eat apart. Sometimes grown-up sons will eat with the father, but more frequently come in after the meal and have their food.

Strangers are kindly treated and fed regularly as long as they like to remain. Male strangers live in the Eramos, women in houses with other women. They cover themselves from the cold with a cloth, made by the men from the bark of a tree, some made from mulberry tree.

They are greatly given to ornamenting themselves, using various coloured ochres, and marking in various ways. They wear feathers and shell ornaments of various kinds, also collars, garters, and anklets made of netted twine. All men on feast days wear a large carved belt, made from the bark of a tree. They are all well nourished.

WIZARDS (*Karisu Vita*).

There are none here, but plenty at Kerema and Vailala. A spirit enters into a man, and he becomes Karisu Vita. The spirit gives him power. When he desires to kill anyone he gets various kinds of plants, cooks them, and drinks the water. He then goes outside, and near to where the party is asleep whom he wishes to destroy. He goes through some incantations, when pigs' and dogs' bones enter into sleeping one, who soon wakes up ill, and not long after dies. The spirit is said then to carry heart, lungs and liver to some other place, where they are buried.

These Karisu Vita are employed by others, and receive large payment in pigs, shell ornaments and feathers.

When anyone is sick the Karisu Vita is fetched, who prays, and then extracts from the sick one's body pigs' and dogs' bones, and sometimes men's. He is then paid. Should the sick one die, it is because some spirit is having revenge for some misdeed.

The Karisu Vita can cause sickness, and can drive it away. They declare the cause of death, and point out who killed.

The rain-makers, lightning and thunder makers, sun, wind and calm makers reside chiefly at Oiapu, and receive payment from people all round. There is one here, and he often gets payment for wind, rain and sun.

To frighten away general sickness they beat drums, blow conchs, throw fire-sticks, and shout.

DEATH.

Only old people die natural deaths. All others are slain by spirits, it matters not how they die. Relatives assemble and mourn, and cut themselves with shells. The body is dressed in all the ornaments belonging to the deceased. They dig a grave and then place the body in it. In the evening all ornaments are taken off, the body is covered over, and never again uncovered. A house is built over the grave, and relatives sleep there. If a husband dies, the widow throws off her petticoats and goes about as if demented. Her first sign of mourning is to plaster herself all over with river mud and live naked over the grave. Friends bring her food, which she cooks. Three months after death a feast is made, and she goes into black, which is made from burnt cocoanut husk and water. The last mourning is a dress that covers from the neck to the knees, made of native twine, netted. Widows mourn for very long. I have known them continue it for three or four years.

After death the spirit roves about until there is plenty of food got together, when a double canoe is carried to the side of the grave. A number of young men, artistically dressed in their finest, get in, and stand with paddles ready to pull. A large quantity of food is placed on the centre, the widow sits beside it, there is then a loud, long shout, and the young men paddle. They soon get out, and the canoe and food is carried to the river, and in the evening the food and areca nuts are divided amongst the relatives. The spirit has now gone to Lavau, far away to the west.

SPIRIT WORLD.

Motu motu (Toaripi) spirits go to the west, and there all meet. Those there first will be informed of the approach of friends, and they will come to meet them, throw their arms round them, and embrace them. In Lavau they build houses, plant food, and live as man and wife as we do here. It is a good place, with a constant and plenteous supply of food.

MYTHOLOGY.

Hiovaki Semese, one spirit, who lives in the heavens, made the sea and the land. There was nothing until he descended. When he made the sea and land he dwelt at Meveave, and there he planted trees which cause elephantiasis; hence the prevalence of that disease at Meveave. They take offerings to Hiovaki, and seek his favour in fighting. All killed in fighting go to Hiovaki. Hiovaki is the son of Semese by his wife Kauue. He has a younger brother, and they divide work—Miai is his name.

Hiovaki made first men and women from a cocoanut tree which he cut down, and he first taught men how to build houses and Eramos.

I cannot find that they deify heroes or ancestors. Spirits both help and injure men.

PHILOLOGY (see Motu Grammar).

(*b*) KOIARI TRIBE.

BIRTH AND CHILDHOOD.

When a woman is known to have procreated, her husband takes a spear and points it at her breasts, signifying he wants a son, males being more desired than females. When it is certain a woman is in such a state, food is cooked and a feast (udugui) is made by the parents of the husband and wife, and eaten by the woman and all friends and relatives. The woman is not then sacred, but cooks food and sleeps with her husband.

When pains of childbirth first begin, her friends get a supply of dried banana leaves, spread them on the floor, and on these she lies. The house will be full of women, the only males present being her father and husband. The father will call on the spirits of his forefathers to come and help his beloved daughter in her pains. He will take an old cocoanut, break it in two, and over it prays that the child may be quickly born. Food is cooked by the woman's friends, and the women in attendance eat it. The husband, when the pains are great, takes off his sihi (string—only article of clothing worn) and armlets and sits apart. The sihi is made fast to a rafter in the roof, and in pain the woman hangs on to it. An old man, a member of that part of the tribe, is fetched, who looks at the woman, then goes inland and plucks long grass, returns to the house, breaks the grass up small and places it in a dish, pours water over it, repeating a prayer and breathing on it. The grass is then thrown away, and the water poured on the woman's head, who sips what flows over to her mouth. The old man leaves, and soon after the child is born.

When the child is born, food is prepared by friends of both parties. When the navel string drops (dokoru negea), more food is cooked.

The woman stays in the house after the birth of her first child for a month or two. When she goes out for the first time, food is again cooked (hadihoa). From the birth the woman becomes sacred, and is not touched by the husband, nor can he approach any other woman, until the child is grown, crawls about, and picks up food.

The woman does not cook food during the time the child is small, lest the child should suffer; the husband cooks, or friends for him.

Illegitimate children only are destroyed. I know of no infanticide anywhere in New Guinea.

The first-born child, if a son, is named by the father; if a daughter, by friends. Children are named frequently from events.

Deformed children are not destroyed. Fathers frequently nurse children, and are very fond of them.

Children are carried in arms, and, when grown, on the hips. The cradle used is a netted bag, hung up to a rafter, and swung to and fro.

The child is long suckled. I have seen children playing with spears, bows and arrows, sporting in the sea, and spying the mother, rush up to her, insist on her sitting down until they have been suckled. Women suckling frequently suckle a young pig or a pup at the same time. I have seen a child at one breast and a pig at another.

Nothing is applied to the child's head to regulate its shape. When the child is first washed with lukewarm water the head is squeezed to make it round. At Levalupo and Eelema, after birth, the mother and child bathe in the sea.

All children are lovingly cared for. Discipline is unknown, "they grow." Fathers teach sons to fight, hunt, fish, plant, and to make nets, and mothers teach girls to make pottery, cook, &c.

Children are betrothed sometimes in infancy by their parents. The boy's father, seeing a nice girl, or because of friendship, will take a present of food to the girl's parents, signifying he wishes their daughter for his son. If the food is taken it is agreeable, and the betrothal is made. The mother and daughter will constantly visit the boy's home, fetching water, wood and food. The food is cooked in the boy's house by the girl's mother, and eaten by the boy's parents.

MATURITY (*Tubua-kohu*).

When menses are first seen, the girl will be ordered to wash the blood off her legs, and taught how to use her under rami (petticoat). When getting better food is cooked, and friends invited, and an aunt will then take some of the food, pass it round her head, body, and under her legs, praying to the spirits that the girl may grow up strong, beautiful and pure. The girl will be taught to keep pure, to remember that for a virgin a great price is paid. During menstruation she is not allowed to eat pig, fish, or kangaroo. They reach the age of maturity when thirteen or fourteen years old.

At Kabadi and Nara, girls, on reaching maturity, are kept indoors for a long time, well fed, and not allowed to be in the sun. When they are to go out a feast is prepared by her parents, and she mixes with the company, dressed up with all the finery available.

Girls also have tattoo marks made at various times, and when menses appear, the *finale* is made between the legs and back, and then she waits until marriage, when her chest is done.

In Motu and other tribes, lads when about 14 years old, or when hair appears, receive the sihi (string). When the parents think the time has arrived he is sent to his aunt on father's side with food, pig, and arm-shells, and she ties on the sihi. He receives presents from father's and mother's relatives, and visits every part of the village. If there is any girl he likes he may spend the evenings with her, she lying close to him, it may be on his arm, but they must have no intercourse. If he has not been betrothed he can then select the girl he wishes for wife, and will inform his parents of it.

There is no circumcision, and the only place I have seen it was on Rook Island.

MARRIAGE.

Marriage is by payment. After betrothal, the boy's parents and relatives give articles of value to the girl's parents, also give food, fish, wallaby, and pig, when these can be got. Near relatives do not marry.

A young man who has been betrothed will sleep in the girl's house, leaving it before morning light; his parents, knowing where he has been, will ask him if he has been with the girl, and if they had connection. The same is asked of the girl by her parents, and if answered in the affirmative, the girl is that day taken to the husband's house, food is cooked by the friends of both parties, husband and wife eat out of one dish, and she remains in the husband's home. Afterwards, final payment is made, the husband's friends carry to the bride's parents, arm-shells, necklaces, tomahawks, and food. The bride takes home with her to her husband cooking pots, water pots, fish net, hunting net, spear and shield, bow and arrows.

Many betrothed ones, not caring for one another, never come together, and, the girl marrying another, the payment is made to the betrothed. There is generally a good deal of trouble about such lapses.

There is polygamy: it varies in the various tribes—in some many, in others few. It depends upon the wealth of a man the number of wives he has. The more he has the more food he will have, and hence the greater man he becomes.

Children follow their father's tribe, but can hold property in their mother's. In war they follow their father's. Sometimes, when brought up in the mother's, they become members of the same.

Property is divided equally between sons and daughters, and the latter hold land equally with the former. A woman marrying into another tribe takes land with her. Leaving her husband, or dying childless, the land belongs to her father's party. If there are children, on the death of the parents property will be equally divided between sons and daughters. A widow is treated very well; she belongs to her husband's party, and should she marry again, the payment will go to them. When old they are well cared for by their children and friends. Orphans are adopted by the friends of their father and mother.

Relatives do not marry, as they say it is one blood. Cousins of several degrees are called brothers and sisters.

The married woman is fairly well treated. Some husbands are wife-beaters. The Kirarians (inland tribe) often kill their wives. She is supposed to care for the house, fetch and cook food; she assists in planting, but the husband does all the heavy work. She follows to the fight, urges the husband on, and helps in looting.

THE TRIBE.

In former ages there must have been chiefs of some power, but now their power is very nominal. Nowhere is there a real chief with kingly or priestly power to be felt.

A people speaking one language and with like traditions we have called a tribe.

Many become chiefs by force of character, prowess, large family connections, and plenty of food. These often come to the front, and the real hereditary chief sinks into insignificance. Sometimes a sorcerer will hold great influence over a tribe and neighbouring tribes. The oldest member of a family would be called a chief, and would be listened to in restraining from or urging on to fight or kill. In making peace or friendship, it would be done through him. Chiefs such as mentioned declare taboo, order feasts and dances, and have a kind of superintendence over others.

There is no tribal council and no law. There is no one who can pass punishment on another. Only custom is honoured. Breaking a taboo the spirits punish.

SOCIAL AND DOMESTIC.

Nearly everywhere huts are built on piles; at Maiva and some parts of Eelema they are built on the ground. In the Motu district some of the villages are built at sea. The huts vary in kind, from the small humpy to the fine large houses of Kalo. Some are square, with a level ridge pole; others are round at the top, and shaped like a canoe afloat; others like a canoe turned upside down; others like a crocodile with large open mouth. They are built of wood, some of bamboo; some thatched with sago leaf, others with nipa leaf, and others with long grass. The flooring in some parts is large planks made from old canoes; in other tribes strips of palm, and, inland, frequently the sago leaf stem.

In cultivating, the earth is turned over with long, pointed sticks, natives standing in a row, and each native with two sticks. When dry, the women go over the ground, pick out all roots and burn them, breaking up the clods with short pieces of hard wood at the same time. The fencing and hard work generally is done by the men, the women assisting. The women plant, weed, and fetch, the men assisting. Yams, bananas, sweet potatoes, and sugar-cane are the chief kinds of food, and in some districts these grow abundantly.

Food is cooked in pots made from clay by the women, and in some parts earth ovens are sometimes used.

There is only one meal a day, and that in the afternoon.

As a rule, strangers are kindly received, but sometimes rudely, and even cruelly, treated. At Aroma they were badly treated.

Visitors are generally met in a kindly manner, and have food cooked for them. Friends bring dishes of food and place near to visitors.

All the tribes love dress, and use flowers and variegated leaves. In many parts they very artistically paint the face. On the head they wear various kinds of head dresses made from birds' feathers, and greatly delight in the whole plume of the *Paradisea regiana.* They have shell ornaments on the forehead, also necklaces, made from small shells, dogs' teeth, and kangaroos' teeth. On the breast they wear a large pearl-shell crescent. Everywhere they wear tortoise-shell earrings; in some districts they are very large. In the nose they wear ground pieces of shell, and sometimes coral, also pieces of wood when not dressed. On their arms they have large toeas (arm-shells, made from a large conical shell); also armlets, made from vines, pandanus leaves, and reeds. Round the body they have belts of various kinds, some made of native cloth and coloured, others made of the bark of a tree, nicely carved, and inlaid with lime and red ochre. On legs they wear knitted garters and anklets, some very tastefully worked. The most dressy of all the tribes is the Eelema.

The Dahuni natives wear the soft part of the sago leaf, which covers the person, and they look respectable. Mailiu, Aroma, Levalupo, Motu, Eelema, and others wear only a string, and on occasions a narrow piece of native cloth, coloured. Kabadi, Nara, Lolo, Maiva, Kiveri, cover the person with a piece of native cloth, and are ashamed if seen without it.

As a rule, the natives are well nourished, and have plenty to eat; but some seasons, such as this, there is a great scarcity of food in some districts, and hunger is known.

WIZARDS (OR SORCERERS).

Generally descend from father to son. Spirits are supposed to be their familiars. They cause sickness, and remove it. They withhold and give rain. They give fine weather at sea, and cause storms. They kill by their magic, and discover the causes of death. They are much feared, and large presents are given to them, such as large pigs, arm-shells, necklaces, tomahawks, tobacco, and food of various kinds.

DEATH.

Death occurs by some unseen agency. The sorcerer pronounces the tribe that is guilty, and sometimes the individual, and then the dead will be revenged, just as if they had been killed by the hand of an enemy.

Spirits travel by night, and cause sickness and death.

Mourning continues for a long time. The juice from the body is rubbed over the chest and back, and sometimes, mixed with black, it is rubbed over the whole body. Friends and relatives sleep over the grave. At stated times food is cooked, presented to the dead, and eaten by the living. At death they cut themselves with shells and flint, and do so until the blood flows freely.

In Eelema, for some time they besmear themselves with mud as a mark of mourning. Food is cooked, and they then use black.

The dead are wrapped in old mats or native cloth, and laid in a grave covered with a plank. In some districts great mounds of earth cover the graves.

The funeral is attended by friends and relatives, and these also dig the grave. The grave is dug under the house or in the village street.

A chief will be buried with his finery on. Over the grave, if a man, the bow and arrows and spear used by him, also cooking pot and dish, and small bag containing lime calabash and betel nuts, will be placed. If a woman, her petticoat, cooking pots, and dishes, and any other article she used much.

A year is very general for mourning for grown-up people, especially for husband or wife. I have known widows in mourning for three or four years, and widowers for two years. It is indecent to get married within a year or two.

SPIRIT WORLD.

Spirits go west towards the setting sun. On leaving the body they seek some point of land near to, and there await some friendly spirits, who lead them away to a land of plenty. All with a pierced nose pass into that country, hence every native has the nose pierced in childhood. The Motuans say the spirit is dried over a fire, and when light and dry is taken into Tauru. Spirit land is one of plenty, and there they live as they do here. There is death there, and after it the spirits become lights (mamaro) that wander over the sea.

When chiefs or leading men in families are laid in the grave, friends bend down and speak into their ears, and ask that they may be remembered in that other state, and that they always may have plenty of dugong, turtle, fish of all kinds, and kangaroo.

MYTHOLOGY.

The sorcerers and sorceresses have communication with spirits, and it is they who know all about the other state. Spirits can both help and injure men, and are more dreaded than loved.

PHILOLOGY.

See Motu Grammar, by Mr. Lawes, and list of words at end.

(2.) Mangaia (Hervey Islands), by Rev. W. Wyatt Gill.

BIRTH AND CHILDHOOD.

On the island of Mangaia, in the Hervey Group, as soon as a child is born, a leaf* of the *Alocasia indica* (Seeman) was cut off, its sides carefully gathered up, and filled with pure water. Into this extempore baptismal font the child would be placed. First tieing with a bit of "tapa" (native cloth made from the inner bark of the *Broussonetia papyrifera*) the part of the navel-string nearest the infant, the right hand of the operator *longitudinally* divided the cord itself with a bamboo-knife. The dark coagulated blood was then carefully washed out with water, and the name of the child's god declared, it having been previously settled by the parents whether their little one should belong to the mother's tribe or to the father's. Usually the father had the preference; but *occasionally*, when the father's tribe was devoted to furnish sacrifices, the mother would seek to save her child's life by getting it adopted into her own tribe, the name of her own tribal divinity being pronounced over the babe. As a rule, however, a father would stoically pronounce over his child the name of his own

* From 8 to 12 feet in circumference. The *Alocasia indica* is a gigantic aroid, the native name of which is "kape."

god, Utakea, Teipe, or Tangiia, which would almost certainly insure its destruction in after years. It was done as a point of honour; besides, the child might *not* be required for sacrifice, although eligible. The bamboo-knife would be taken to the "marae" of the god specified, and thrown on the ground to rot. If a second god's name were pronounced over the child, the bamboo-knife would go to one "marae" and the name of the babe only be pronounced over the second "marae." The removal of the coagulated blood was believed to be highly conducive to health, all impurities being thus removed out of the system.

An analogy was believed to exist between the pith of a tree and the umbilical cord at birth. Hence the expressions "ara io" *i.e.*, "pathway of the pith," or simply "io"† *i.e.*, "pith," are still used for "God."

On the island of Rarotonga, when a boy was born, a collection of spears, clubs, and slinging stones was made. When the sun was setting, a leaf of that gigantic aroid, *Alocasia indica*, filled with water, was held over these warlike weapons, and the umbilical cord treated as above described. The idea was that the child should grow up to be a famous warrior.

The wife is, as a rule, isolated from her husband ten nights only.

Infanticide was rarely practised in the Hervey Group, excepting at Rarotonga, where it was common.

In six out of of seven islands of the Hervey Group cannibalism ceased only with the introduction of Christianity. It is worthy of note that on the remaining island—Mangaia—this revolting practice ceased *before* the introduction of Christianity, a circumstance unparalleled in Polynesia. It was in this wise: About a century before the Gospel was conveyed to those islands, the famous priest-chief, Mautara, had, by craft and force, crushed out all his foes, and seized the reins of government. There was not a person living on the island but was connected with him or his by worship, blood, or marriage. When this far-seeing man acquired absolute power, he wisely forbade cannibalism, through fear of perpetuating the anarchy which for generations had existed. Still the old habit showed itself again, even in Mautara; and solitary instances of cannibalism are known to have taken place in later times by stealth, not openly and constantly as in the early days of the celebrated priest-chief.

Old cannibal Hervey Islanders have assured me that human flesh is "far superior to pig." My worthy friend and helper, Maretu of Rarotonga, was, in early manhood, a cannibal. This I learnt from his own lips. But the last generation that practised cannibalism has entirely disappeared. Their descendants, in many instances, through shame, deny the well-known facts of the past.

† In Maori "iho" (= io) means the *funis umbilicus.* See "Myths and Songs" by the present writer, page 37.

At Mangaia, and, I believe, the other islands of the Hervey Group, it was customary to prepare the body in this wise: The long spear, inserted at the fundament, ran through the body, appearing again with the neck. As on a spit, the body was slowly singed over a fire, in order that the entire cuticle and all the hair might be removed. The intestines were next taken out, washed in sea-water, wrapped up in singed banana leaves (a singed banana-leaf, like oil-silk, retains liquid), cooked and eaten, this being the invariable perquisite of those who prepared the feast. The body was cooked, as pigs now are, in an oven specially set apart, red-hot basaltic stones, wrapped in leaves, being placed inside to insure its being equally done. The best joint was the thigh. In native phraseology, "nothing would be left but the nails and the bones." It is worthy of notice that only warriors partook of these horrid feasts in the Hervey Group, very rarely, and by stealth, women and children (as in times of famine), or the remains of a broken clan hiding in the forest or in caves. Indeed, when a warrior wished his son to partake of human flesh for the first time, it was needful to deceive the lad by saying "it was only a bit of pork." Of course, when the truth oozed out, the son felt less scruple in following the evil ways of his father and uncles. Taoro, of Rarotonga, cooked his only child (a son) as a return feast for his cannibal friends. There can be no question that, at first, an inward voice protested against this unnatural practice. Yet, after a time, they learned to glory in their shame.

For many generations after the settlement of the islands cannibalism was rarely practised. Native traditions distinctly informs *when* it was first sanctioned by the authority of leading men, and thus grew to be customary. Strange that on Mangaia it should again have ceased. In the opinion of many, in the deadlock which existed about the date of the introduction of Christianity, the natives of Mangaia would have relapsed into cannibalism. The deadlock was this:—Teaô would only consent to beat the drums of peace on condition that his two maternal uncles, the leading victorious warrior chiefs (Teaô being himself amongst the vanquished), were slain, and laid on the altar of Rongo as the price of peace! It was for this that Teaô lost his rank in after days.

Deformed children are very kindly treated indeed, although, perhaps, the deformity was occasioned by the cruel treatment of the parents in a burst of passion.

A single child is universally carried astride on the hip of the mother. "Thy daughters shall be nursed at thy side" (Isaiah, lx. 4.). When there is a second child to be carried, it is placed on the shoulders of the mother, so that it rides triumphantly, holding on to the hair of the parent. This leaves one hip free to carry a basket of food and cooking leaves. It is rare for a father to carry his child.

I have known a lad, three years old, to be still suckled, but in general the period of suckling does not extend beyond two years. Too often infants are not suckled at all, on the plea that the "mother's milk is bad." Such children are "mama paru," *i.e.*, brought up by hand. Bits of "taro" (*Caladium petiolatum*), well chewed, are given to it from time to time. The kernel of an old cocoanut is finely scraped, the rich, oily juice is then expressed from it, and given in small quantities to the infant. The spoon anciently used for the purpose is the leaf of the gardenia. I have often wondered how the stomach of the infants should be able to stand it; but they do, and become fine men and women. Of late, however, the use of the cocoanut has gone out of fashion, much to the detriment of the children. The soft, half-formed kernel itself is much used as the child becomes stronger.

Many natives feed their new-born children on "paka," *i.e.*, the baked leaves of the "taro," dipped in water. The mortality amongst infants thus reared is great, and should they attain to adult age they have a diminutive frame.

A chief's child would have three or four wet nurses, in order to produce the enormous frames for which they were famous.

It is customary for a native woman, when visiting her friend, to suckle her infant.

At Rarotonga, to regulate the shape of the child's head, it was a common practice to apply slabs of soft wood ("buka tea") to the forehead and back of the head to produce the desired shape, *i.e.*, a high head. This practice did not obtain on Mangaia, nor, I think, on any other island of the Hervey Group.

It is still customary in the Hervey Group for mothers to press with the palm of the hand the noses of their infants, so that they may grow squat and round, "not (as I once overheard a woman say) like the *thin*, *starved* nose of the white race."

When children are small they are spoiled by their parents; but when of a useful age all this disappears, and many of them have a very hard life. The curse of native family life is adoption; this makes discipline almost impossible. A cross word will make the youngster run off to its adopted parents, who sympathise where they ought to scold. I have known parents take a present of food to the runaway, and humbly entreat his return; but all in vain! These adopted parents, however, will resolutely set themselves to discharge the duties of real parents in teaching the youngster the arts needful in after life.

The betrothal of the female child often takes place in the families of chiefs, in order to secure a suitable match. In that case the girl is continually receiving presents from the family into which, at adult (say 13 or 14 summers) age, she is to marry. Should the contract not be fulfilled, full payment is exacted for all these gifts; but, as a rule, the contracts are well kept, so many parties being interested in the the affair.

MATURITY.

When circumcised, a lad considers himself to be a man. This rite was not unfrequently delayed, so that the lad might become a finer man. It was performed about the age of 17 or 18.

A Hervey Island girl may be considered mature at the age of 14. It must not be imagined that the ages of children were marked off by years, as with us.

For females, a slight tatooing, the patterns being different from those on males.

She is expected to make her *début* by taking part in the next grand dance. The great requisites of a Polynesian beauty are to be fat and as fair as their dusky skins will permit. To insure this, favourite children in good families, whether boys or girls, were regularly fattened and imprisoned till nightfall, when a little gentle exercise was permitted. If refractory, the guardian would even whip the culprit for not eating more, calling out, "Shall I not be put to shame to see you so slim in the dance?"

These dances invariably took place in the open air, by torch-light. About a year was required for getting up one such entertainment. This long interval was needed, first, for the composing of songs in honour of the fair ones and the rehearsal of the performers; secondly, for the growth of "taro," &c., &c., to provide the grand feast necessary. The point of honour was to be the fairest and fattest of any young people present. I know of no more unpleasant sight than the cracking of the skin as the fattening process proceeds; yet this calls forth the admiration of the friends.

There is no analogy between the initiation of males into the tribe and the grades of freemasonry, it being done once for all. No new name is taken, no special colours used at the ceremony. The advantage that accrues is simply this—he ranks as a man, can marry, take part in tribal dances, songs, recitations, and the various duties of adult native life.

CIRCUMCISION.

An imperfect sort of circumcision has been practised in the Hervey Islands from time immemorial. Captain Cook's account of the ceremonies attending this rite at Tahiti applies to nearly all the branches of the great Polynesian family. In point of fact, the term "circum-cision," as applied to these islanders is a solecism.

The operation is sometimes attended with danger, and is usually performed about the age of sixteen. The lad invariably wears a necklace of fragrant flowers after his recovery, and takes the coveted rank of a man.

Two reasons were assigned for this observance in heathenism. First, in the event of being slain in battle, or being offered in sacrifice, that the nude body should not be reviled as "the carcase of an uncircumcised wretch." It was considered to be sufficiently remarkable to be handed down in tradition that amongst the sixty who fell in the important battle of Māueue, fought about 184 years ago, were two uncircumcised youths.

Secondly and principally, the performance of this rite was, and still is, absolutely indispensable to marriage. No Hervey Island woman would knowingly marry an uncircumcised husband. A few years ago a young man, a church member, complained to me that nothing could induce his wayward spouse to live with him. The near relatives of the woman had again and again taken the truant wife back to her husband, but in vain. I requested a deacon to go and remonstrate with her upon her conduct. The dark-skinned shrew said to the deacon, "What! ask me to go and live with an uncircumcised husband? Never!" A year or two afterwards, severe illness caused her to alter her mind.

The greatest insult that can be offered to a man is to accuse him of being uncircumcised. The contemptuous expressions in the sacred writings, in reference to the uncircumcised Gentiles, seem to the Hervey Islanders to be quite natural.

This epithet, put in the most offensive way, led to war some years prior to the introduction of Christianity to the island of Mangaia, in the Hervey Group. The predecessor of Numangatini, the late king of Mangaia, was on one occasion thus reviled, without reason, by his maternal uncle. The irate sovereign demanded that his two maternal uncles should be slain, and presented in sacrifice to the god Rongo, by way of atonement for the insult. The leading warriors of the day declined to carry out his insane wish. Two bloody battles resulted from the king's persistence.

The first native pastors set their faces like flint against the practice of circumcision. The entire despotic power of the great warrior chief, who embraced Christianity, was brought to bear upon the extinction of this custom, but utterly failed to uproot it. My predecessor wisely persuaded the chiefs to blot circumcision, as a crime, out of their statute-book.

Numbers of white men in the Eastern Pacific Islands, married to native women, have submitted to this degrading custom to please their wives.

The natives of Peurhyus, Manihiki, Rakaauga, Pukapuka, and Niue, also the Ellice and Gilbert Islanders, do not practise circumcision, although the parent stock of all those islanders still observe it. The reason for its disuse, doubtless, was the fact that in all those islands the sharp red quartz, invariably used in circumcising, is not found. Bamboo is unsuitable for the operation; like Zipporah of old, they "take a sharp stone" for a knife.

In the Southern New Hebrides, *i.e.*, Fotuna, Aniwa, Aneityum, Tauna, and one half of Erromanga, circumcision is universally practised. It appears to have been introduced from Tonga by the first settlers on Fotuna and Aniwa, who originally drifted from that Island. These drift natives have, in most of the islands, intermixed with the true Papuans, and propagated their own customs. The Loyalty Islanders, the natives of New Caledonia, and the Northern New Hebrides, who appear to be pure Papuans, are reported not to practise circumcision.

The mythical origin of circumcision at Mangaia runs thus:—The god Rongo invented it in order to steal away the affections of Tākā, the beautiful wife of his twin-brother Tangaroa. In this he was but too successful. Unable to endure this new affront put upon him by his unscrupulous brother, Tangaroa took flight (accompanied by his other wife) to other lands, where he enjoys the supremacy justly due to the eldest-born divinity. Rongo enjoined the observance of circumcision upon his worshippers.

It should be borne in mind that Rongo, tutelar god of Mangaia, is the "Orono" (or rather Rono) of the Sandwich Islands; the "Oro" (or rather Ro'o) of Tahiti and most of the Leeward Islands; "Terongo" (= *the* Rongo) of Atiu; the "Longo" of Samoa. In some mythologies he is the *son* of Tangaroa, in others the *twin-brother*, to indicate equal rank.

The *modus operandi* is as follows: a piece of cocoanut shell (scraped smooth and thin) is introduced beneath the upper part of the prepuce, and a longitudinal slit made. The divided prepuce is then drawn underneath into a slight twist. A soothing application heals the wound in a few days. The operator frequently renews the twist, so that eventually a small lump remains underneath the urethra. I asked a venerable deacon the motive for this singular custom. Respondit ille: Hoc facere eo consilio, cùm ne album illud (piāpiā quam vocant), sub præputio exsistat; tùm autem maxime, quo magis feminæ venereâ voluptate fruantur. I believe that the statement of my aged friend is perfectly correct; indeed, it may serve to explain why Polynesian women are far more lascivious than their Melanesian sisters in the Western Pacific, where this curious practice was originally unknown.

MARRIAGE.

Special messengers, of high social rank, are despatched to make the proposal and convey presents in ratification of the contract; but the betrothed child usually remains in the custody of its parents, now and then paying a visit to the other parties with much ceremony and under proper guardianship.

Marriage never occurs by force or capture. Sometimes a fallen tribe or family would endeavour to resuscitate its fortunes by giving in marriage the flower of the tribe to some disagreeable but powerful old chief.

The pet daughter of a chief often married into an inferior or fallen tribe, the parent intending thereby to swell the ranks of his own warriors by the welcome addition of this inferior or unlucky clan. In times of peace this servile son-in-law is expected to be at the beck and call of his father-in-law. There is, properly speaking, no such thing as sale or barter of wives in the Hervey Group.

Exogamy was the universal rule of the olden time. Should a tribe be split up in war, the defeated portion was treated as an alien tribe. I have known comparatively near relatives to marry with the approbation of the elders of the victorious portion of the tribe, expressly on the ground that the sanctity of the clan law had been wiped out in battle.

Distant cousins sometimes (though rarely) marry; but must be of the same generation, *i.e.*, be descended in the same degree (fourth or fifth, or even more remotely) from the common ancestor. That the male branch should thus invade the female is a far more pardonable offence that the converse, but even then, should misfortune or disease overtake these related couples, the elders of the tribe would declare it to be the anger of the clan-god (kua kai te angai). It is the duty of parents to teach their growing children whom they may lawfully marry, the choice being extremely limited. The correct thing in the native mind undoubtedly is exogamy.

The nuptial ceremony consisted merely in a feast, when bride and bridegroom, seated together on a piece of the finest white native cloth,* ate together in the presence of their friends, and received gifts from them, the good things of the bridegroom's friends going to the bride, and *vice versâ.*

A remarkable ceremony obtained on Mangaia in families of distinction on the marriage of the first-born. Gaily dressed, he walked from his own door-way to the house of the father-in-law over a continuous pathway of living human bodies, members of the wife's clan. On reaching the goal, three elderly females so prostrate themseves as to form a living seat for the bridegroom. A fish is now brought forward, and, with the aid of a bit of sharp bamboo, cut up into dice upon a human body. It is now presented to the bridegroom, who eats it raw. Piles of native cloth and food are then formally presented to the happy man. All parties partake of the feast, and afterwards the road of living bodies is again formed for the distinguished son-in-law to go back, as he came, to his home.

In due time (a few months later on) the husband's friends return the compliment to the bride, only it is understood that (unless of inferior social status) the second exhibition should surpass the first. The native name of this remarkable custom is "maninitori." It is a usage of great antiquity, but no account

* The inner bark of the *Broussonetia papyrifera* beaten out with mallets and pasted together.

is given by tradition of its origin. (See my "Life in the Southern Isles," pp. 59, 60.)

Polygamy has been entirely done away with by Christianity. In the olden time it was very common, and was not restricted to chiefs. As women were rarely slain in war, superfluous females were divided out amongst the victorious warriors. The famous Arekâre, of Mangaia, had ten wives, Parima six, others two apiece. In general, if a man of position married the eldest girl of a slave-family, the younger sisters became his as a matter of course, being only too glad to have a protector. Even amongst those of equal rank a man often had two or three sisters to wife at the same time. Even now, in Christian times, a woman feels herself to be deeply injured if her brother-in-law does not, on the death of his wife, ask her to become a mother to his children.

Children, unless distinctly adopted into another clan, always follow the father. The name of the god pronounced at the severance of the *funis umbilicus* really determines the clan of the infant, as before stated. In war they usually followed the father's kin; but the duty of an adopted son would be to fight alongside of his adopted father. Sometimes serfs, forgetting the claims of blood, followed their lord to battle.

Land is the property of the tribe, and must on no account be alienated. The adopted son possesses land only so long as he goes with the clan, obeys the commands of the elders, and fights (if need be) against his nearest of kin for the tribe into which he has been adopted. A woman, in general, owns not an inch of soil, lest she carry away the right to it into another family. Usually she gives up one child at least to her own tribe, the rest going to the father's. When her husband dies, she lives on with the tribe as *slave* to her children. She weeds, plants, and eats because of them. If they die, she goes back to her tribe as she originally came—empty-handed.

When a chief has only a daughter, and that daughter is married (by the father's arrangement) to a man of inferior (*i.e.*, slave) rank, the husband lives with her on land given to her for their mutual support (or, as the phrase runs, "land given to her *to feed her husband*.") In all points *she* rules the household and lands; but should war break out, *he* may elect to fight by the side of his father-in-law, and if victory incline to their side, he is no longer counted a slave. Should he go with his own clan to fight against his father-in-law's tribe, the wife may or may not go with him. Sometimes the wife, with her children, will stay on with her own clan; so that, if victorious, the children will share the good things of the mother's tribe, whilst the unhappy father, if not slain in battle, becomes a homeless, hunted fugitive. In no case may a woman take into another clan any portion of the ancestral lands of her own tribe. The reason of this is obvious; these lands were originally won and subsequently kept by the bravery of the entire tribe. Rarely did women fight; their part was to stand a little *behind* the husband, to carry baskets of stones and weapons with which to supply the warriors. Heavy *tikoru* clothes were thrown by the wives over these spears to turn their points aside from the mark.

At Rarotonga, &c., the soil was the sole property of the high chiefs (areki) and under-chiefs. These distributed the land in accordance with their own wishes

I do not consider that orphans were in general ill-treated; the uncles, as a matter of course, looked after their welfare. In the native language there is but one word for "father" and "uncle." It was of the last importance to the tribe that their numbers should be kept up; hence the care taken of the children, and their careful education in mimic war.

There are no restrictions as to converse, but as to kissing ("rubbing of noses") plenty. The rule is to "kiss" only *near* relatives on either side. The elders of the tribe settle these knotty points. Many a quarrel have I had to compose, the ground of the dispute being that the lady had no right to permit So-and-so to kiss her. The usual defence is, "it was done openly, and therefore could bear no ill significance." Half the troubles in native life arise from this source; the other half from land-grabbing, or, as the natives phrase it, "land-eating."

Woman is the slave of man in heathen society. She plants, carries home the food, collects the firewood and succulent oven-leaves, cooks her lord's meal, spreads out supper on hibiscus leaves (in lieu of plates, and of the same size), never omitting the sea-water, used as sauce and salt. Torch-fishing is woman's occupation only. Whenever she gets home, often in the small hours of the morning, a special oven for these dainties must be prepared by her for husband and children. The wife is expected not only to feed but to clothe her husband. She strips off the bark of the paper-mulberry (*Broussonetia papyrifera*), steeps it in running water, beats it out with a square iron-wood mallet, pastes the strips together, stains the cloth, or, with the aid of leaves, makes designs on it, glazes the outer side, that her lord may strut about in his new clothes. *His* duty is to defend land and life, to plant and weed, and to fish with hook or net or spear. The wife, in her torchlight fishing, simply grabs sleepy fish, or puts her hand in holes which they haunt (often to her cost), but never uses either canoe, hook, or net.

But as their children (girls) grow up, all the duties of the mother are performed by the daughters. And the strange thing is, that they are perfectly content with their lot. To see a woman emerge from the mud of a taro-patch (up to her waist), in which she has been planting taro-tops (no man at Mangaia plants a taro-patch), and then go to the stream to wash herself, excites pity. But *she* does not think herself to need pity.

At Rarotonga, and some other islands, men plant and bring home the "taro," but the women weave mats and baskets.

After all, despite the horny hands of Mangaian women, their lives are pleasant, so long as Christianity secures immunity from the cruel bloodshed of heathen times. Even in the old time they enjoyed their old dances and semi-dramatic performances. In general, it was the young women and girls who took part in these diversions, the middle-aged prompting or clapping hands or looking after the feast to follow.

The model Rarotongan warrior never (like other natives) allowed his wife to *sleep on his arm*, lest his spirit should become enervated. After slaying a foe, he became "tapu," so that he might, for a certain period, only kiss his wife and children. On no account might he cohabit with his wife until the "tapu" had been removed. During this period of "tapu," all the warriors of the same tribe lived together, receiving immense presents of food. When a sufficient interval had elapsed, in preparation for the removal of the "tapu," they would go unitedly to fish. If, while fishing, a warrior happened to be bitten by an "aa" (conger eel), or get his legs clasped by an octopus, he regarded this as a sure presage of a violent death. If he, that day, caught only a miserable fish, such as the poisonous "no'u," it plainly indicated that in his next battle he would only kill a wretched sort of person, not a chief or a warrior. On the other hand, if he caught a really fine fish, it was evident that he would hereafter conquer and kill some person of distinction, and thus enhance the fame of his tribe!

THE TRIBE.

Descent in the *male* line from a common ancestor (tama tane) constitutes the tribe. Descendants in the female line (tama vaine) *may* be adopted into the tribe, with the consent of the elders, after bathing in a sacred stream in order to wash off the taint of old slave or antagonistic associations. (See my "Historical Sketches of Savage Life," pp. 136-9). In general, slaves married into the victorious clans, were content to follow its fortunes; but there were numerous exceptions to this rule. When dying, *mothers* of rank would commend their children to the chiefs of their own tribe, the slave-fathers having no voice whatever concerning their own offspring. The filial instinct, however, often led these children to endeavour to restore the fallen fortunes of the father's conquered clan. Usually, the question of tribe was decided by the divinity or divinities named at the severance of the *funis umbilicus*. But all the worshippers of Tanè, with its numerous modifications, were supposed to form but one tribe *In every case* there must be oneness of origin (on the maternal if not on the paternal side), even in cases of adoption. When a great favour—life or land—was sought, it was wonderful how close the relationship was made to appear; but when a grudge had to be paid off, the sins (blood-shedding) of that branch of the clan were alone remembered.

Each tribe had its own god or gods,* its own marae or maraes (groves for worship), its own prayers and incantations, and its own songs. Even in the matter of clothing there were special differences. I have seen a man stripped naked for presuming to wear the garments of another tribe. The meek defence was that his grandmother was a member of the said tribe. Thus the will of the individual counted for nothing, or next to nothing, in heathen times.

There is one head chief, many subordinate ones. The office and power of chief is usually passed on to the brother, but when all the brothers were dead, would be transmitted to the eldest born of the eldest male branch of the ruling family ("te kiko mua"). Whenever this individual was deficient in intellect or courage, the tribal oracle was sure to declare that the god had taken up his abode in another (generally speaking, the youngest male) member of the ruling family. This divinely-favoured individual was then duly installed, and the entire tribe compelled to obey, as there could be no appeal from the word of the priest when inspired, for it was the fiat of the gods. On the island of Mangaia "Barima" was not the representative of the eldest branch of the tribe of Tanè, but he was undoubtedly the fittest man, specially selected, it was averred, out of his family by the god Tane-i-te-ata. Primogeniture was the rule, selection by the god the exception. The kingly office *might* descend in the *female* line; and this of necessity, as the males were so generally slain. But the male line would invariably be preferred.

The duties of a tribal chief were (1) to adjust disputes, (2) to confirm or lay aside wills (*vivâ voce* wills, of course), (3) to lead in battle, (4) to preside at all tribal work or feasting, (5) to provide at all points for the well-being of the clan, and (6) not the least important of a chief's duties was to consult or worship the gods, on his own behalf as chief and on behalf of the tribe. On Mangaia every high chief must worship Rongo, god of war and ruler of the invisible world. But there would be also his own private god, who must be duly honoured in the daily concerns of life. The worship of Rongo was reserved for great occasions, the making of war or peace, the selection of human sacrifices for the ratification of all degrees of chieftainship, &c. Summoned by the king, as high-priest of Rongo, all tribal chiefs were bound to attend, with a few followers, on behalf of their respective clans

The state was conceived of as a long dwelling standing east and west; the chiefs of the southern (right) side of the island

* The tribe of Ngariki worshipped Rongo, Ruler of Night, *i.e.*, the invisible world, and Motoro, one of the gods of "Day," or this upper and visible world.

represented one side of it; the chiefs of the northern (left) side of the island represented the other side. The under-chiefs everywhere symbolized the lesser rafters; individuals the separate leaves of thatch covering. Yet, by a subtle process of thought, the state itself—with its great and lesser chiefs, and its numerous members—was but the visible expression of a spirit-dwelling in under-world, in which the major and minor divinities did not merely live, but actually constituted it; the major gods being the pillars and main rafters, the minor gods the lesser rafters, &c., &c. The safety of the state consisted in this—that in the spirit-temple in the nether-world there should be no schism or rent; for should there be one, divisions will immediately arise in the visible state, *i.e.*, in the councils of the great chiefs; the necessary consequences being war and bloodshed.

The order of descent in regal families was usually from father to son; but with great land or warrior chiefs it was different, the brothers of the deceased taking precedence of his sons, for the excellent reason that it was their strong arms that won or preserved the tribal lands. The kings were sacred men, priests of the great tutelar divinities; therefore the representative of the senior branch in each generation was held in the greatest veneration, irrespective of age and sex, as being the visible mouth-piece and shrine of the invisible and immortal gods. But *no female* was competent to offer "prayers" (karakia), however well versed in them.

The elders and wise men of the tribe constituted the tribal council. The paramount chief or king must endorse their advice, else it was not law. It was the duty of the presiding chief to *ask* the opinion of the elders on any point.

Punishment for theft of food was the destruction of everything edible on the land belonging to the family of the thief, or the taking of the culprit's life. In general, the former penalty was for members of the tribe; the latter for outsiders. In some islands all offences were punished with one—the death—penalty. No idea of proportion between an offence and its punishment existed in the native mind. As a rule, a chief might do anything he liked; not so the members of the tribe.

Polynesian chiefs were invariably fine men. Makea Damèla of Rarotonga would have been considered a very tall man but for his extreme corpulence. He seemed to waddle, not to walk. In his infancy he had (as was usual with the children of high chiefs) three or four wet nurses at the same time. His eldest brother weighed 312 lbs., their father nearly 5 cwt.

SOCIAL AND DOMESTIC.

In the Hervey Group the huts were in the form of a rectangle, and made of reeds. The thatch used by the common people was merely the plaited leaflets of the cocoanut palm—very pervious to rain. The idol-temples and the great dwellings of the chiefs were covered with pandanus-leaf thatch—idol-temples first, dwellings of chiefs afterwards. The doors were always sliding. There was a sacred and a common entrance. Squares were prettily worked in black sennit on the front and back sides of the dwelling. The "tirango," or threshold, was made of a single block of timber, tastefully carved. *We* name our *dwellings* because they are are enduring; *they* name the *site*, their huts being so perishable.

Only the large open valleys of Mangaia and Atiu were cultivated in the olden time, but at Rarotonga a considerable portion of that narrow strip of rich soil near the sea was well planted.

The weeding spade of Mangaia was not unlike a club in shape, and was made of iron-wood (*Casuarina equisetifolia*). The length was five feet nine inches. Indeed, it was a most formidable weapon at close quarters, as many an unfortunate has found to his cost.

The staff of life on Mangaia and Atiu is the "taro"* plant; on Aitutaki, the sweet potato; on Rarotonga, bread-fruit and plantains; on Mitiaro, &c., &c., cocoanut. In most of the islands a vast quantity of fish is eaten as soon as it is captured.

On Mauihiki the natives subsist on cocoanut and fish; on the sister island of Rakaauga they have in addition a good supply of "puraka" *i.e.*, a coarse species of *Caladium*. On most of the atolls the inhabitants live contentedly on cocoanut and fish only.

Food is abundant throughout the Hervey Group except when a cyclone has wrought its desolation, or continuous rain has flooded the valleys where "taro" is cultivated.

About two days' work in a week will keep a plantation in good order. On atolls, like Mauihiki, where only the cocoanut palm flourishes, no weeding or planting can be done, as the soil consists of sand and gravel thrown up by the ocean on the ever-growing coral. Hence it is that the natives of these atolls are such excellent fishermen, having little else to do.

The usual time for the one real meal of the day in the Hervey Group is at sunset. The richer natives have a warm meal about ten a.m., but in general they cook enough at sunset to last for the morning's repast.

Throughout Polynesia the mode of cooking is similar. A circular hole, two or three feet in diameter, is dug in the ground, the centre being deeper than any other part. Firewood is split and piled up in the hole. Basaltic stones are now laid on the firewood just before it was lighted. When the fire had burnt out, and the red-hot stones fallen to the bottom amongst the glowing ashes, they are carefully arranged by means of a hooked

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* *Caladium petiolatum.*

green stick, of a sort that will not easily burn. A large bundle of succulent leaves are now thrown upon the hot stones, occasioning a dense cloud of steam to arise. On this the well-scraped "taro," split bread-fruits, sweet potatoes, or plantains are placed. Fish are invariably wrapped up in the leaves of the *Cordyline terminalis*, so that their juices may be retained. The oven is now covered in with a second bundle of fresh-plucked leaves. The dry leaves of yesterday are thrown on the top, and the whole pressed down by heavy stones kept for the purpose. In fine weather this steaming oven was made in the open air, in rainy weather under shelter.

In heathen times it was customary at Mangaia and some other islands to slay all strangers. At Rarotonga, if a stranger landed in sight of one of their kings his life was safe; but even then it was not quite wise to travel any distance in the bush without the chief. But in these days the stranger is fairly well treated, often far better than he deserves. He shares the good things going and remains as long as he likes. It is usual, on meeting another, to share whatever food may be in the hand or in the basket. The influx of visitors is rapidly producing a change in their customs; still, I think an unprejudiced observer must admit that the stranger is better cared for in Christian Polynesia than in Christian Britain. The *generous* man is the ideal *good* man yet.

Ear ornaments were universal. The shell of a species of cocoanut producing small, long nuts—their ends rubbed off on madrepore coral—were filled with fragrant flowers and leaves and worn in the slit lobes of the ears of persons (males) of distinction. The lobes were marvellously distended by this practice.

The arms of warriors—between the elbow and the shoulder—were tatooed black only, so that, on dance nights, the beautiful white (*Ovula ovum*, Linn) shell fastened across with sennit might be the more admired. Happy was the dancer who had a shell for *both* arms.

Just above the ankles finely-plaited hair was wound repeatedly, the amount indicating the rank and wealth of the wearer. So, too, with the wrists and neck. From the plaited hair on the neck was suspended a large pearl shell, or, in lieu of this coveted ornament, a piece of "miro" wood (*Thespesia populnea*), adzed into its shape. This plaited hair was called "manoa;" the breast ornament, "tia."

The ears of children were pierced with fish-bone, then enlarged with a twig of the gardenia, so as to admit a fresh-plucked flower (the scarlet *Hibiscus* or the *Gardenia*).

The women had to be content with necklaces and chaplets of flowers, but a favourite daughter might wear plaited hair round her neck. Of course, in each ear a flower was worn, and on her bosom a woman of rank might wear a "miro" ornament. Men emulated the other sex in regard to wreaths and necklaces, the latter often descending nearly to the knee. It is noteworthy that the septum of the nose was *never* pierced by the Hervey Islanders, as nasal ornaments were never in vogue in that part of the Pacific.

The Hervey Islanders were a clothed race. The inner bark of the paper-mulberry (*Broussonetia papyrifera*) yielded them the material for their "tikoru." Poorer natives were content to use the inner bark of the "aoa," or banyan tree. On Rarotonga, Aitutaki, and Mauke the inner bark of the bread-fruit tree yielded a light and beautiful garment. Even the *Eutada scandens* was utilised by the poor for the manufacture of clothing.

The defect of native garments is their inability to keep out moisture. To remedy this, on Mangaia, the outside was sometimes anointed with scented cocoanut oil. The varieties of native dresses, with their distinctive names, were very numerous.

A native woman, in her own dwelling, wears a single garment. In the cold season she throws a "tiputa" over her shoulders. A man at work in the olden time, *i.e.*, when weeding, canoe-making, or fishing, wore only a girdle (măro). Travelling through the rain he was content with a girdle, but on arriving at his hut he would put on old warm clothing. A good covering of native cloth is (as I know from experience) as warm as a blanket.

An unmarried girl wore her petticoat nearly to the knee; when married, it was brought down just below the knee. In sitting, the Hervey Island females rested upon their heels, *not*, as in these days, tailor fashion. This latter indelicate custom was imported from Tahiti in recent times.

Speaking generally, it may be confidently stated that the natives are a well-nourished race. But in the old fighting days, when so small a portion of the soil was cultivated, it was hardly so. The chiefs and all the ruling race were indeed well nourished, but the "ao," or serfs, had sorry times of it. The frequent famines of those days were terrible. I have known natives who kept themselves alive on candle-nuts alone for months together; but they were wretched objects to look at. It is curious that a starved race becomes black almost, but if plenty returns, their natural, agreeable, coffee-colour is restored. In atolls, to the north-west of the Hervey Group and the Line Islands, the natives subsist chiefly on cocoanut, pandanus drupes, and fish. Should any accident (*e.g.*, if the leaflets are devoured by a plague of *Lopaphus coccophagus*, or a cyclone, or if the crowns are sprinkled by ocean spray) occur to the cocoanut palm, it is frightful to see the wasted forms of the islanders.

But even on the most fertile islands, after a cyclone, the sufferings of the natives are great. Happily, now, there are so many introduced plants, as well as imported food, that the natives do not perish of sheer starvation as in the days of heathenism. I have known entire families to subsist on the crown of a felled cocoanut, with what fish they could catch.

The salutation of the Hervey Islanders was the very reverse of our own. We *bow* to our friends; they toss the head upwards, at the same time elevating the eyebrows.

Their great national amusement was the dance. In this singular performance the joints seem to be loose. I do not believe it possible for any European to move the limbs as a Polynesian loves to do. At a very early age mothers carefully oil the hands, &c., and then knead the tiny limbs, stretching and "cracking" each joint. Respecting the *morality* of their dances, the less said the better; but the "upaupa dance," introduced from Tahiti, is obscene indeed.

WIZARDS.

Priests *ex-officio* dealt with the gods and the invisible world. It was for them alone to approach the deities on behalf of the state, clan, or chiefs, *i.e.*, to chaunt *karakia* (prayers) at the *marae** and present offerings. If Rongo were the divinity to be propitiated, a human sacrifice specially selected must be offered. To all other gods offerings of fish and "taro," &c., with the indispensable bowl of *piper mythisticum*, were presented from time to time. No worshipper dared go empty-handed to his priest to inquire the will of the gods. The value of the gift must be proportioned to his rank and means. The load might be carried by *male* slaves to the outskirts of the *marae*, but the offerer had a place allotted to him within the sacred precincts. The priest, or "god-box," clothed in white† *tikoru*, at a little distance, alone, in the most sacred place, went through the needful prayers.

In a case of sickness the deity would be asked about the fate of his devoted worshipper. At Mangaia the favourable response would be couched in these terms—("The spirit) will go to the sun-rising" (ka aere ki te rā iti), *i.e.*, the sick will recover. For the spirit to descend with the sun-god Rā into the nether, or invisible, world is death. If the sufferer must die, a different metaphor was employed by the priest—"kua rau-ti para"—"The leaf of the *ti* tree (*Cordyline terminalis*) is sere," *i.e.*, will drop off and perish.

The office of priest was hereditary throughout the Hervey Group. When a new priest was installed, he first bathed in the sacred stream of his tribe, put on the white *tikoru*, ate only certain kinds of food, and abstained from many things permitted to others. On the day of installation of the priest of Rongo the temporal chief accompanied him to the *marae*—not too closely following him. Offerings of food having been deposited at the

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* Idol grove.

† Off duty, the priest might wear a *yellow* "tiputa" over his shoulders.

usual spot, cooked "taro" and the invariable bowl of "kava" having been disposed of by the new priest-king, the temporal chief shouted, "Ka uru Rongo"—"Let Rongo enter" (*i.e.*, inspire). The new high-priest, seated on a sacred stone,* then fell into convulsions, and spake in a most unearthly voice (? ventriloquism), the words so uttered being accepted as a divine oracle! Thus did the *temporal* sovereign install the new priest-king (*i.e.*, *spiritual* ruler). A grand feast would follow.

Less of ceremony was observed with priests of divinities of inferior rank, but substantially the same process was carried out. The technical phrase for this was "Va'i i te pia atua ou"—"open up the new god-box."

On the eve of an important battle "the omens were taken" (ka pa te vai) by the warrior chief himself. These omens consisted in the drowning of insects, &c., in water, or a fish hunt on the reef. (See my "Savage Life," page 104).

The native phrase, "Ka pa te vai," means, literally, "enclose the water," because in taking the omens by the drowning of insects, &c., it was customary to arrange the cut stems of a banana in a square on the ground. A single leaf of the *Alocasia indica* (Seeman), holding half a bucket of water, was deposited in the hollow, the water being kept from spilling by the cut banana stems. A number of centipedes, green lizards, and dragon-flies were now dashed into the water. The total of creatures drowned prefigured the number of warriors doomed to perish in to-morrow's battle. There was a special prayer (now lost) for this ceremony.

Sometimes two shells (*Turbo petholatus*), intended to represent the two hostile camps, were deposited by the warrior chief on his own *marae*, with an appropriate prayer, in the dusk of evening. On returning at daylight, it is averred that Mokè found the shell representing his foes turned upside down, a sure omen of their destruction, which accordingly took place.

On most of the eastern Pacific islands were "wise women," who were consulted respecting the minor affairs of daily life. These women were supposed to be inspired by a female divinity. A small present must be made ere consulting the priestess. On Mangaia the goddess Ruatamaine was consulted to discover a thief, and to secure success in fishing. There were numberless Ruaatu, or fishermen gods (of stone) in all the islands, each demanding an offering of a newly-caught fish from its votaries, or, in default of that, a hollow pebble to be strung into a sort of necklace, or the midrib of a cocoanut leaf, and thrown into the darkness, with these words, "Here is thy share, O Ruaatu!"

The native name for sorcerer is "taugata purepure," *i.e.*, "a man who prays." A heathen only prays for the ill-luck or death of his foes. The prayers offered by the priests to the gods

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*Te koatu karakia—the stone for praying.

worshipped on the national or tribal maraes were termed "*karakia*;" those on minor occasions to the lesser gods were named "*pure*."* All these prayers were metrical,† and were handed down from generation to generation with the utmost care. There were "prayers" for every phase of savage life; for success in battle; for a change of wind (to overwhelm an adversary fishing solitarily in his canoe, or that an intended voyage of his own may be propitious); that cocoanuts, yams, &c., &c., may grow; that a thieving or murder expedition may be successful; that his hook or net may catch plenty of fish; that his kite may fly higher than all others; that his "teka" (reed) may outstrip the rest; that strong teeth may take the place of his child's first tooth when extracted, &c., &c. A great secret was the prayer at the excision of the *funis umbilicus*, that the boy might be brave, or that the girl might in after-life be fruitful. Few men of middle age were without a number of these "prayers" or charms. They were usually uttered in too low a key to be heard by a stranger, lest he, too, should thus be armed with a dangerous weapon of offence. If a plantation were to be robbed, the appropriate "prayer" or charm must be uttered near to it, so that it might have its full effect. If a man were to be clubbed in his sleep, the "prayer" must not be used until the hut is in sight. Important charms or "prayers" such as these were to grown-up sons part of the equipment of life. In most cases, one or two would never be divulged until there was a premonition of death in sickness or battle. A man felt that if his last bit of "wisdom" were "reeled off" (to use a native parable), die he must.

Payment to the sorcerer consisted in a couple of pieces of native cloth, or fish and "taro," &c.

The succession was from father to son, or from uncle to nephew. So, too, of sorceresses; it would be from mother to daughter, or from aunt to niece. Sorcerers and sorceresses were often slain by the relatives of their supposed victims.

A singular enchantment was employed to kill off the husband of a pretty woman desired by someone else. The expanded flower of a *Gardenia* was stuck upright—a very difficult performance—in a cup (*i.e.*, half a large cocoanut shell) of water. A "prayer" was then offered for the husband's speedy death, the sorcerer earnestly watching the flower. Should it fall, the incantation was regarded as successful. But if the flower still remained upright, he will live. The sorcerer would in that case try his skill another day, with perhaps better success. Old natives assert that these enchantments, if persevered in, never failed; but that since the prevalence of Christianity they have

* In New Zealand "*karakia*."

† Hence appropriately termed by us *incantations*.

all become impotent. Indeed, the "prayers" themselves are happily lost.

In adzing a canoe, it was the duty of the chief *taunga* (artisan-priest) to chaunt an extempore never-ending song, which the other workmen took up. The song gave precision and unity to the stroke of their stone adzes, added to their cheerfulness, and was believed to be supernaturally efficacious in helping on the work to its completion. As the *taunga* would be sure to be associated with the same set of helpers, the assistants knew pretty well what was being chaunted. This sort of thing was called a "pataratara" — "a talking," of which I retain two written but untranslated specimens. Originally it was an address to the tree-spirit not to be angry at their adzing the noble trunk, with an invocation to the axe-fairy, Ruateātonga, to aid the progress of the work.

Taraaere, the last priest of Tangaroa (who had often offered human sacrifices to the tutelar god of Rarotonga), when nearly ninety years of age, said to me:—

"My father taught me how to retain wisdom (korero). He also told me when to marry. He did not feed me with bananas, plantains, and fish, lest, the food being light and slippery, wisdom should slip away from me. No! he fed me with 'taro,' well beaten with a pestle, and mixed with cooked 'taro'-leaves, the glutinous nature of the 'taro' being favourable to the retention of wisdom."

This was uttered without a smile, in the full belief that this simple diet of his youth and early manhood accounted for the marvellous memory which he possessed to the very end of life. He assured me that it was thus the priests of the olden days were brought up.

DEATH.

No one was believed to die a strictly natural death unless extreme old age was attained. Nineteen out of every twenty were regarded as victims of special divine anger or of the incantations of "the praying people" *(Tangata purepure) i.e.*, the sorcerers. Causes of death were:—

1. Infringement of *tapu* laws of all kinds.

2. An uttered resolve broken; *e.g.*, preparation for battle upon the receipt of false intelligence. The trick may be seen through after a time, still the fight *must* at all risks come off, *if once the war-girdle has been put on.* Not only would shame attend the withdrawing warriors, but the special wrath of the war-god would rest upon them. So that there is nothing for it but fight at all risks. A journey prepared for, but not carried out. Many years ago it was intended that the writer should remove to Rarotonga to take charge of the mission there. Everything was ready, when a brother from England arrived for that station. It so happened

that just afterwards I lost two sons in one week of diptheria. I was astounded to find that the natives of Mangaia, while sympathizing with my loss, attributed the sad blow to my failure to carry out my original purpose.

3. A grave dug for a corpse, but not occupied. At the last moment perhaps the owner of the soil objects to the burial, so the corpse is disposed of elsewhere. In that case, the natives firmly believe that someone else must die in order to occupy the empty grave.

4. Unusual luxuriance of growth of plantations of food. The saying is, "E mou Avaiki tena," *i.e.*, "it is also a crop for spirit-land" (portends a crop for the reaper Death, as *we* perhaps would phrase it).

The bodies of deceased friends were anointed with scented oil, carefully wrapped up in a number of pieces of cloth, and the same day committed to their last resting-place. A few were buried in the earth within the sacred precincts of the appropriate *marae;* but by far the greater number were hidden in caves regarded as the special property of certain families.

If a body were buried in the earth, the face was invariably laid downwards, chin and knees meeting, and the limbs well secured with strongest sinnet cord. A thin covering of earth was laid over the corpse, and large heavy stones piled over the grave. The intention was to render it impossible for the dead to rise up and injure the living! The head of the buried corpse was always turned to the rising sun, in accordance with their ancient solar worship.

It was customary to bury with the dead some article of value—a female would have a cloth-mallet laid by her side; whilst her husband would enjoin his friends to bury with him a favourite stone adze, or a beautiful white shell (*Ovula ovum*, Linn) worn by him in the dance. Such articles were never touched afterwards by the living.

Numbers were buried in caves easily accessible, to enable the relatives to visit the remains of the dearly-loved lost ones from time to time. The corpse was occasionally exposed to the sun, re-anointed with oil, and then wrapped in fresh *tikoru* (white native cloth).

The dead were never disembowelled for the purpose of embalming. The corpse was simply desiccated, and daily anointed with cocoanut oil. A month would suffice for this.

Warriors were in general carefully hidden by their surviving friends, through fear of their being disinterred and burnt in revenge.

The people of the entire district where the deceased lived take up "taro" and prepare a feast in honour of the dead. A grand interchange of presents is usual on these occasions; but, excepting the near relatives of the deceased, no one is really the worse for it, as it is etiquette to see that distant relatives get back similar articles to what they brought.

Whatever is laid upon the corpse is buried with it, and no further notice taken of it; but whatever is placed by the side, *without touching it*, is repaid.

The moment the sick died, the bodies of near relatives were cut with sharks' teeth, so that the blood might stream down the bodies; their faces were blackened, and the hair cut off. At Rarotonga it was usual to knock out some of the front teeth in token of sorrow. Everywhere the moment of death was the signal for the death-wail to commence. The most affecting things are said on such occasions, but always in a set form, commencing thus :—

Aue tou e! Aue! Aue!
Alas for us! Alas! Alas! &c.

The wailers usually lose their voices for several days, and their eyes are frightfully swollen with crying.

As soon as the corpse was committed to its last resting-place, the mourners selected five old cocoanuts, which were successively opened, and the water poured out upon the ground. These nuts were then wrapped up in leaves and native cloth, and thrown towards the grave; or, if the corpse were let down with cords into the deep chasm of "Auraka," the nuts and other food would be successively thrown down upon it. Calling loudly each time the name of the departed, they said, "Here is thy food; eat it." When the fifth nut and the accompanying "raroi," or pudding, were thrown down, the mourners said, "Farewell! we come back no more to thee."

A death in the family is the signal for a change of names amongst the near relatives of the deceased.

Chiefs and priests occasionally received the honour of a "spirit-burial," the corpse being borne to the most renowned *marae* of his tribe on the island, and allowed to remain within the sacred enclosure for some hours, but the same day hidden away in the tribal cave. In such cases the depositing of the body in the *marae* was "the burial," or the committal of the spirit to the care of the god worshipped in life, whilst the letting down of the corpse into the deep chasm was designated "the throwing away of the bones" (*tiringa ivi*), the well-wrapped-up body being regarded as a mere bundle of bones after the exit of the spirit.

In the olden times, relatives of the deceased wore only "pakoko," or native cloth, dyed red in the sap of the candle-nut tree, and then dipped in the black mud of a taro-patch. The very offensive smell of this mourning garment was symbolical of the putrescent state of the dead. Their heads were encircled with chaplets of mountain fern, singed with fire to give it a red appearance.

The *eva*, or dirge, and the mourning dance succeeded. Of this dirge, four varieties are known. They invariably took place by day, occupying from ten to fifteen days, according to the rank of the deceased. Sometimes "a death-talk" was preferred, consisting of sixty songs in honour of the dead, mournfully chanted at night in a large house built for the purpose, and well lighted with torches. Each adult male relative recited a song. A feast was the inevitable *finale*.

Each island of the Hervey Group had some variety of custom in relation to the dead. Perhaps the chiefs of Atiu were the most outrageous in mourning. I knew one to mourn for seven years for an only child (a woman), living all that time in a hut in the vicinity of the grave, and allowing his hair and nails to grow, and his body to remain unwashed. This was the wonder of all the islanders. In general, all mourning ceremonies were over in a year.

SPIRIT WORLD.

Spirit-land proper is underneath, where the sun-god Rā reposes when his daily task is done. It is variously termed Po (Night), Avaiki, Hawai'i, Hawaiki, or home of the ancestors. Still, all warrior spirits, *i.e.*, those who have died a violent death, are said to *ascend* to their happy homes in the ten heavens above. *Popularly*, death in any form is referred to as "going into night," in contrast with day (ao) *i.e.*, life. Above and beneath are numerous countries and a variety of inhabitants—invisible to mortal eye; but these are but a *fac-simile* of what we see around us now.

The Samoan heaven was designated *Pulotu* or *Purotu*, and was supposed to be under the sea. The Mangaian warrior hoped to "leap into the expanse," "to dance the warrior's dance in Tairi" (above), "to inhabit Speck-land (Poêpoê)" in perfect happiness. The Rarotongan warrior looked forward to a place in the house of Tiki, in which are assembled the brave of past ages, who spend their time in eating, drinking, dancing, or sleeping. The Aitutakian brave went to a good land (Iva) under the guardianship of the benevolent Tukairaua, to chew sugar-cane for ever with uncloyed appetite. Tahitians had an elysium named "Miru." Society Islanders looked forward to "Rohutu noanoa," *i.e.*, "sweet-scented Rohutu," full of fruit and flowers.

At Mangaia the spirits of those who ignobly "died on a pillow"* wandered about disconsolately over the rocks near the margin of the ocean, until the day appointed by their leader comes (once a year), when they follow the sun-god Rā over the ocean and descend in his train to under-world. As a rule, these ghosts were well disposed to their own living relatives; but often became vindictive if a pet child was ill-treated by a step-mother

* I te urunga piro, *i.e.*, a natural death.

or other relatives, &c. But the esoteric teaching of the priests ran thus :—Unhappy* ghosts travel over the pointed rocks round the island until they reach the extreme edge of the cliff facing the setting sun, when a large wave approaches to the base, and at the same moment a gigantic "*bua*" tree *(Fagrœa berteriaua)*, covered with fragrant blossoms, springs up from Avaiki to receive these disconsolate human spirits. Even at this last moment, with feet almost touching the fatal tree, a friendly voice may send the spirit-traveller back to life and health. Otherwise, he is mysteriously impelled to climb the particular branch reserved for his own tribe, and conveniently brought nearest to him. Immediately the human soul is safely lodged upon this gigantic "*bua*," the deceitful tree goes down with its living burden to nether-world. Akaanga and his assistants catch the luckless ghost in a net, half drown it in a lake of fresh water, and then usher it into the presence of dread Miru, mistress of the nether-world, where it is made to drink of her intoxicating bowl. The drunken ghost is borne off to the ever-burning oven, cooked, and devoured by Miru, her son,and four peerless daughters. The refuse is thrown to her servants, Akaanga and others. So that, at Mangaia, the end of the coward was annihilation.

At Rarotonga the luckless spirit-traveller who had no present for Tiki was compelled to stay outside the house where the brave of past ages are assembled, in rain and darkness for ever, shivering with cold and hunger. Another view is. that the grand rendezvous of ghosts was on a ridge of rocks facing the setting sun. One tribe skirted the sea margin until it reached the fatal spot. Another (the tribe of Tangiia, on the eastern part of Rarotonga) traversed the mountain range forming the backbone of the island until the same point of departure was attained. Members of the former tribe clambered on an ancient "*bua*" tree (still standing). Should the branch chance to break, the ghost is immediately caught in the net of "Muru." But it sometimes happens that a lively ghost tears the meshes and escapes for awhile, passing on by a resistless inward impulse towards the outer edge of the reef, in the hope of traversing the ocean. But in a straight line from the shore is a round hollow, where Akaanga's net is concealed. In this the very few who escape out of the hands of Muru are caught without fail. The delighted demons (taae) take the captive ghost out of the net, dash his brains out on the sharp coral, and carry him off in triumph to the shades to eat.

For the tribe of Tangiia an iron-wood tree was reserved. The ghosts that trod on the *green* branches of this tree came back to life, whilst those who had the misfortune to crawl on the *dead* branches were at once caught in the net of Muru or Akaanga, brained, cooked and devoured!

* Because they had the misfortune "to die on a pillow," and because they had to leave their old pleasant haunts and homes.

Ghosts of cowards, and those who were impious at Aitutaki, were doomed likewise to furnish a feast to the inexpressibly ugly Miru and her followers.

Evidently, the ancient faith of the Hervey Islanders was substantially the same. Nor did it materially differ from that of the Tahitian and Society Islanders, the variations being such as we might expect when portions of the same great family had been separated from each other for ages.

There is no trace in the Eastern Pacific of the doctrine of transmigration of human souls, although the spirits of the dead are fabled to have assumed, temporarily, and for a specific purpose, the form of an insect, bird, fish, or cloud. But gods, specially the spirits of deified men, were believed permanently to reside in, or to be incarnate in, sharks, sword-fish, &c., eels, the octopus, the yellow and black-spotted lizards, several kinds of birds and insects. The *ignis fatuus*, opportune mists concealing a victim, imagined balls of fire guiding the fleeing or killing party, were all the working of their gods for the destruction, safety, or guidance of mortals.

In sleep, the spirit was supposed to leave the body and travel over the island, to hold converse with the dead, and even to visit spirit-world. Hence the dreams of mortals. Some of the most important events in their national history were determined by dreams.

The place in which the placenta (enua) of an infant is buried is called the "ipukarea," or natal soil; and it was believed that, after death, spirits of adults, as well as children, hover about the neighbourhood.

MYTHOLOGY.

Strictly speaking, the Hervey Islanders had no conception of a creator, as the islands were believed to be dragged up out of the depths of Avaiki, or Nether-World, otherwise called Po, or Night, These islands are merely the gross outward form, or *body*, whilst there still remains behind in the obscurity of Nether-World the ethereal essence or *spirit*.

The primary conception of the Hervey Islanders as to existence is *a point;* then something *pulsating;* next, something greater —*everlasting*.

The universe is to be conceived of as the hollow of a vast cocoanut shell, the interior of which is named Avaiki. At the very bottom of this supposed cocoanut shell is a thick stem, gradually tapering to a point, which represents the very beginning of all things. This point is a spirit named *The-root-of-all-existence.* Above this extreme point is another demon, named *Breathing, or Life*, stouter and stronger than the former one. The thickest part of the stem is *The-long-lived.* These three stationary, sentient spirits constitute the foundation, and insure the permanence and well-being of all the rest of the universe.

In the interior of the supposed cocoanut shell, in the lowest depth of Avaiki, lives a woman, or demon, of flesh and blood, named Vari-ma-te-takere (shortened into Vari) — *The-very-beginning.* At various times Vari plucked off three bits from each side, and moulded them into human shape. These six are the primary gods of the universe. Yet no "marae" or image was ever sacred to them, nor was any offering ever made to them.

The first of the six primary gods is Avatea or Vātea (Noon), half man and half fish, whose eyes are the sun and moon.* Evidently we have in Avatea, or Vātea, the god of light. The second primary god is Tinirau (Innumerable), the lord of all fish. The third is Tango (Support). The fourth is Echo (Tumuteanaoa), regarded as a female dwelling in hollow rocks. The fifth, Raka, or *Trouble*, presides over winds. At the edge of the horizon are a number of wind-holes. To each child is allotted one of these apertures, through which he blows at pleasure. The sixth and last of the primary gods is a female, Tu-metua, or Tu-papa, who dwells with the Great Mother, "Vari," at the very bottom of Avaiki, in the *Silent-land*, the only language of which is that of signs and smiles, to comfort her. Tu† (short for Tu-metua or Tu-papa) was the tutelar goddess of the island of Moorea. To her the fourteenth night in every moon was sacred.

In his dreams, Vātea, the eldest of the primary gods, saw a woman, Papa (Foundation), whom he afterwards succeeded in making his wife. Now, Papa was the daughter of Timātekore (Nothing-more). Tangaroa and Rongo‡ were the twin children of Vātea and Papa. They were the first beings of *perfect* human form in the universe, and possessed no second shape. Three other sons (Tonga-iti, Tangiia, and Tane-papa-kai) were born to Vātea and Papa. These are the principal deities of the Hervey Islanders and (with numerous variations and additions) of Eastern Polynesia. To the children of Vātea and Papa belong the maraes and idols; they received the offerings and listened to the prayers of mankind.

The tutelar god of Mangaia is Rongo, whose wife, Tākā, bare him a daughter named Tavake. The boast of the three original tribes on Mangaia is that they are the descendants of Tavake by her own father Rongo, *i.e.*, that they are of divine origin.

Now, Rongo was likewise the dread deity of Tahiti and the Leeward Islands, under the slightly modified designation of "Orō." The original marae of "Orō" in Eastern Polynesia was

* The moon is the fish-eye, on account of its paleness.

† When Captain Cook, for the second time, visited Tahiti, he found the king to be "Otoo," ancestor of the present Pomare. "Otoo" should be written *Tu*, the *O* being a mere prefix to all proper names. This mythological name was adopted in order to secure for its owner the reverence due to the gods, who are invisible to mortal eye.

‡ In the Society Islands "Orō" (Ro[ng]o) was the *son* of Ta'aroa (Tangaroa), not his twin brother.

Opoa, on the island of Raiatea, whence the worship spread to all the neighbouring islands.

At the shrine of this deity, on the island of Tahiti alone, fifty reeking heads were offered in a single generation. To Rongo, Orō, Rono, or Orono (as he is variously named), no offering was acceptable but a bleeding human sacrifice, specially selected, males being always preferred to females. At Tahiti females were ineligible, being regarded as "noa" (common); whereas males were "tapu" (sacred), and therefore suitable for sacrifice.

Tangaroa was specially honoured at Rarotonga, Aitutaki, Samoa, and the Society Islands. In the Tahitian and Society Groups, Ta'aroa was regarded as the originator of the world, and the parent of gods and men. At Samoa, Tangaloa was regarded as the great creator.

The gods were divided into two orders, "dwellers in day," and "dwellers in the shades, or night." The *former* busied themselves with the affairs of mortals; moving, though unseen, in their midst; and yet often descending to Nether-World, the true home of the major gods. The *latter* frequently ascend to day to take part in the affairs of mankind, but prefer to dwell in spirit-land (night). A few were supposed to remain permanently in the obscurity of Avaiki.

Many of the deities worshipped in the Hervey Group and other islands of the eastern Pacific were canonised priests, kings, and warriors, whose spirits were supposed to enter into various birds, fish, reptiles, insects, &c., &c. Strangely enough, they were regarded as being, in no respect, inferior to the original divinities.

The gods *first* spake to man through the small land birds; but their utterances proved to be too indistinct to guide the actions of mankind. The gods were thus led to communicate with mankind through the medium of a human priesthood. Whenever the priest was consulted, a present of the best food, accompanied by a bowl of intoxicating "piper mythisticum," was indispensable. The offerer, in a stentorian voice, said, "Ka uru Motoro"—Enter (*i.e.*, inspire), Motoro!* At these words the priest would fall into convulsions, the god Motoro having inspired (literally, "entered") him, and the oracle would be delivered. From the oracle thus delivered no appeal whatever lay. The best kinds of food were sacred to the priests and chiefs.

Although unsuited for the delivery of oracles, birds were ever the special messengers of the gods to warn individuals of impending danger, each tribe having its own feathered guardians.

The great Polynesian word (Atua) for "God" means strictly *the pith, core, or life of man*. This is evident from its constant equivalent, "ara io," shortened sometimes into "io," which literally signifies "pathway of the pith," or "pith." What the pith is to the tree the god is to the man, *i.e., its life*.

* Or whatever may be the name of the worshipper's deity.

The greater gods alone had carved images for the convenience of worshippers; the lesser were countless, each individual possessing several.

PHILOLOGY.

A list of numerals and pronouns in the language, with suggestions as to their etymology :—

NUMERALS.

1	Okotai, tai.
2	Rua.
3	Toru.
4	Ā.
5	Rima.
6	Ono.
7	Itu.
8	Varu.
9	Iva.
10	Ngauru.
11	Ngauru ma tai (10 + 1).
12	Ngauru ma rua (10 + 2), &c.
20	Rua ngauru (2 × 10).
21	Rua ngauru ma tai (2 × 10 + 1).
22	Rua ngauru ma rua (2 × 10 + 2), &c.
100	Anere (*i.e.*, from the English "hundred") &c.

In the Hervey Group we have two distinct bases of numeration —four and ten. The former base is used in counting cocoanuts, which were from time immemorial tied up in fours (kaviri).

5	Bunches (kaviri) of cocoanuts	make	one	Takau, *i.e.*	20
10	Takau	,,	,,	Rau	200
10	Rau	,,	,,	Mano	2,000
10	Mano	,,	,,	Kiu	20,000
10	Kiu	,,	,,	Tiui	200,000

All beyond this is uncertain.

PRONOUNS.

1.—*Personal.*

First person	Au ...	Maua ...	Matou
First person, including the second ...		Taua ...	Tatou
Second person	Koe ...	Korua ...	Kotou
Third person	Aia, ia ...	Raua ...	Ratou

Of the dual and plural pronouns of the first person, "taua" and "tatou" include the person or persons spoken to, while "maua" and "matou" exclude them.

2.—*Relative.*

Tei and nona, nana.

"Tei" is used only in the past tense and becomes "te" in the future, and is generally accompanied with "ka."

3.—*Adjective.*

First person singular	Toku, taku
Third person singular	Tona, tana
First person plural	To matou, ta matou, &c.

4.—*Interrogative.*

Koai	Who
Teiea	Where
Eaa	What
Teea	Which

Koai and teiea are declinable.

5.—*Demonstrative.*

Singular	Teia	This
	Teianei ...	This here
	Tena	That (near the person spoken to)
	Tera	That (at a distance)
Plural	Eia	These
	Eianei	These here
	Ena	Those (near the person spoken to)
	Era	That (at a distance)

6.—*Indefinite.*

Etai, tokotai ... ... Some, few

Paradigm of the conjugation and declension of the verb "to go" and of the verb "to kill," with a pronominal object :—

Aere ... ... Go

Indicative Mood.

	Singular.	*Dual.*	*Plural.*
Pres.—	Te aere nei au	Te aere nei maua	Te aere nei matou, &c., &c.
Past—	I aere ana au	I aere ana maua	I aere ana matou, &c., &c.
Fut.—	Ka aere au	Ka aere maua	Ka aere matou, &c., &c.

Imperative.

Ka aere koe, &c.

Subjunctive or Conditional Mood.

Present—Me aere au, &c.
Past—Naringa au i aere.
Future—Kia aere au.

Infinitive.

E aere.

Participle.

Aere anga.

Ta ... ... Strike, kill*

* When a native wishes to say "kill," he uses this phrase, "Ta kia mate"—"Strike, so that (he) may die;" or "Ta ua." Still, "ta" may by abbreviation mean "kill."

Indicative Mood.

Singular.	*Dual.*	*Plural.*
Pres.—Te ta nei au, &c. -	Te ta nei taua, &c. -	Te ta nei tatou, &c.
Past—I ta ana au, &c. -	I ta ana taua, &c. -	I ta ana tatou, &c.
Fut.—Ka ta au, &c. -	Ka ta taua, &c. -	Ka ta tatou, &c.

Imperative.

Ka ta koe.

Subjunctive or Conditional Mood.

Present—Me ta au, &c.
Past—Naringa au i ta, &c.
Future—Kia ta au, &c.

Infinitive.

E ta.

Participle.

Ta anga.

Indicative Mood (Passive Voice).

Singular.	*Dual.*	*Plural.*
Pres.—Te taia nei au, &c. -	Te taia nei taua, &c. -	Te taia nei tatou, &c.
Past—I taia na au, &c. -	I taia na taua, &c. -	I taia na tatou, &c.
Fut.—Ka taia au, &c. -	Ka taia taua, &c. -	Ka taia tatou, &c.

Imperative Mood.

Ka taia koe, &c.

Subjunctive or Conditional Mood.

Present—Me taia au, &c.
Past—Naringa au i taia, &c.
Future—Kia taia au, &c.

A few simple sentences to show the grammatical structure of the language :—

Eaa tena ?	What is that ?
E noo ki raro	Sit down
E tu ki runga	Get up
Aea koe aere ei ?	When will you go ?
Apopo	To-morrow
Kapikiia	Call (him)
Teia, te aere mai nei ...	Here he comes
Koai toou ingoa ?	What is your name ?
E vaine taau ?	Are you married ?
E tamariki taau ?	Have you any children ?
Tokoia ?	How many ?
Kua maki koe ?	Are you ill ?
Ka mate paa koe	You will perhaps die
Kare rava ïa	Not a bit of it
Man	Tangata
Woman	Vaine
Head	Upoko, mimiti (of animals)
Hair of head	Rauru
Eye	Mata
Nose	Putaiu, putangiu

Tongue	... ...	Arero
Ear	... ...	Taringa
Hand	... ...	Rima
Thumb	Mangaia ...	Nui (*i.e.*, big)
	Rarotonga ...	Maikao maata (big finger)
Foot	... ...	Vaevae
Bone	... ...	Ivi
Blood	... ...	Toto
Fire	... ...	A'i
Water	... ...	Vai
Sun	... ...	Rā
Moon	... ...	Mărama
Father	... .	Metua tane
Mother	... ...	Metua vaine
Son	... ...	Tamaroa
Daughter	... ...	Tamaine
Brother (of a woman)	...	Tungane
Sister (of a man)	... ...	Tuaine
Cousin	... ...	Taeake
Uncle	... ...	Metua tane
Aunt	... ...	Metua vaine
Give	... ...	Omai; oronga mai
Take	... ...	Rave atu
Make	... ...	Anga
Bear	... ...	Apai, maranga
Burn	... ...	Ka
See	... ...	Akara
Hear	... ...	Akarongo

REPORT OF COMMITTEE No. 3.

Australasian Biological Station Committee.

Members of Committee:—Mr. A. Dendy, Mr. J. J. Fletcher, Mr. A. H. S. Lucas, Mr. MacGillivray, Professor W. Baldwin Spencer and Dr. W. A. Haswell (*Secretary*).

Owing to the impossibility of holding meetings at other times than during the meeting of the Association, the members of the committee being scattered over all the Australian colonies, it has been impossible for the committee as a body to do much in the course of the year. Measures, however, have been taken, which it is hoped will lead to their being in a position to report an important step before the next meeting of the Association.

It was the general opinion of the members of the committee who were present at the Sydney meeting of the Association that Port Jackson is in many respects the most favourable situation for the establishment of the proposed station. The proximity to a capital in which there are good scientific libraries, the sheltered character of the shores, and the richness of the marine fauna all combine to render it the most convenient situation that could be selected. In addition, the neighbourhood of Sydney, or at least some part of the New South Wales coast, is to be preferred as the site of the proposed station, owing to the fact that there already exists there a nucleus for such an institution.

From 1881 to 1886 there was at Watson's Bay, near the Heads of Port Jackson, a small building entitled the Biological Station, which was constructed on a piece of land granted by the Government. The expense of the construction of the building having been defrayed by private subscriptions and subscriptions from various learned societies, including the Royal Societies of New South Wales and Victoria, supplemented by a Government subsidy. The situation was not very convenient, and the station was little used, except by M. N.de Miklouho Maclay, by whose efforts it was founded. In 1886, at the time of a scare regarding war with Russia, the land was resumed by the Government of the colony for military purposes; a sum of money being granted to the trustees of the station as compensation for the loss of the building. This sum of money is now available as a nucleus of the sum required for endowing a new station, and it is proposed that, as soon as a suitable site can be got, additional subscriptions should be solicited, both from private individuals and from the learned societies in the various colonies, so that the trustees may be enabled to begin the construction of the new station. It is proposed that this should at first be on a small scale, but so constructed that further extension could be readily effected when required. It is hoped that the New South Wales Government, to whom application has been made, will grant a portion of one of the numerous reserves on the shores of the harbour as a site for the proposed new station.

REPORT OF COMMITTEE No. 6.

The Construction and Hygienic Requirements of Places of Amusement in Sydney.

Members of Committee:—Mr. W. E. Roth, Dr. Ashburton Thompson, Professor Warren, D. J. T. Wilson, and Mr. John Sulman (*Secretary*).

The committee has been compelled to confine its enquiries to the City of Sydney, and has been much assisted by a report of the Royal Commission appointed on the 17th June, 1886, to enquire into the construction of theatres, public halls, and other places of public amusement or concourse. With this report the committee is in full accord, and appends a copy thereof.

As far as the committee has been able to ascertain, there is no legislative enactment dealing with the subject; but as the licensing of theatres is annual, a practical control is thereby secured. These licenses are issued by the Colonial Secretary, and in one recent instance, viz., the Theatre Royal, the pressure employed has been sufficient to secure the carrying out of very necessary alterations and improvements, which will tend to the greater safety and healthfulness of this building.

The committee is, however, of opinion that the annexed report should form the basis of specific legislation, and that an existing body, such as the Board of Health, should be entrusted with the administration of the same, and with power to appoint competent inspectors and other necessary officials. There is a precedent for this course in the position accorded to the Board of Health in Melbourne.

REPORT OF COMMITTEE No. 13.

Australasian Geological Record.

MEMBERS OF COMMITTEE:—Professor F. W. HUTTON, Mr. R. L. JACK, Mr. R. M. JOHNSTON, Mr. JAMES STIRLING, Professor R. TATE, and Mr. R. ETHERIDGE (*Secretary*).

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3. BONNEY, T. G.—Note on a Rock Collected by the Rev. W. S. Green from near the summit of Mount Cook. Trans. N.Z. Inst., vol. xxi., p. 334.
4. CRIE, L.—Sur les affinités des flores jurassiques et triassiques de l'Australie et de la Nouvelle Zealande. Comptes Rendus, Tome cvii., 1888, p. 1014.
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PROCEEDINGS OF THE SECTIONS.

PROCEEDINGS OF THE SECTIONS.

Section A.

ASTRONOMY, PHYSICS, MATHEMATICS, AND MECHANICS.

President of the Section: R. Threlfall, M.A., Professor of Physics, University of Sydney.

1.—THE ELASTIC PROPERTIES OF QUARTZ THREADS.

By R. Threlfall, M.A., Professor of Physics, University of Sydney.

[*Abstract.*]

The research of which the following is an abstract was carried out in the Physical Laboratory of the University of Sydney, with the assistance of Messrs. J. F. Adair and J. A. Pollock. The undoubted superiority of quartz fibres for purposes of suspension led the author to undertake the present investigation, in order to supply the requisite data to instrument makers, and to physicists engaged on the designing of instruments. The investigation of most of the elastic properties of quartz threads depends on the accurate estimation of the thickness of the threads used. The microscopic methods of measuring the quantity were made the subjects of special enquiry, and it is shown that in the measurement of fibres of the order of ·01 cm. diameter constant errors may be practically avoided, and accidental errors reduced to 3 or 4 per cent. per measurement. The greater portion of the uncertainty of a single observation can be eliminated by multiplying the observations. A new method of drawing threads suitable for the production of short, thick fibres was devised. The following points were investigated :—

1. The breaking strength of fibres of various thicknesses, investigated in two ways.
2. The simple rigidity of quartz fibres.
3. The temperature co-efficient of the simple rigidity.
4. The temperature co-efficient of the total torsional rigidity of cylindrical fibres (the datum to be used in instru-

ment making), and practically identical with the temperature co-efficient of the "modulus of torsion."

5. The co-efficient of expansion of fused quartz—a datum requisite for the calculation of (3) from (4).
6. The Young's modulus of quartz fibres.
7. Calculation of the bulk resilience from the foregoing.
8. General investigation as to the limiting intensity of torsional strain which may be given to a quartz fibre without making it exhibit torsional fatigue or nachwirkung.

(1.) The breaking strength turned out to verify Boys' estimate of from 50 to 70 tons per square inch. A new method, involving the use of a spiral spring of brass wire was used for producing the stresses.

(2.) The simple rigidity was calculated from vibration experiments made in an exhausted vibration box. The mean value of several experiments on different fibres was—

$$W = 2{\cdot}8815 \times 10^{11}\ C.\ G.\ S.\ \text{at}\ 22^\circ C.$$

(3.) The temperature co-efficient of the simple rigidity is calculated from the next series of experiments by means of a value for the co-efficient of expansion of quartz, which was the average of a large number of unsatisfactory experiments—it is $+0\ 00013$ per degree cent.

(4.) Determined from experiments on three fibres which were heated and vibrated in a special and rather elaborate piece of apparatus. In order to overcome an experimental difficulty, a method of soldering quartz to brass was devised, depending on the coating of the quartz with platinum. This datum gives the co-efficient of increase of torsional rigidity of any cylindrical fibre, and is the number which must determine the amount of temperature correction to be used in any instrument in which quartz fibres are employed. The co-efficient $e = {\cdot}00013307$ between 22° and $98^\circ C.$

(5.) The co-efficient of expansion of fused quartz was got from an experiment on about 14 grammes of fused quartz, by Matheson's method of weighing in water at different temperatures. The results were such as to show that the expansion of sticks of fused quartz is very irregular. The most probable value over the range 30°—100° is $\alpha^1 = {\cdot}0000017$ (co-efficient of linear expansion).

(6.) Young's modulus was got by bending a thread of quartz, supported at each end on a knife edge, by a platinum wire rider. Several experiments agreeing very well gave $M = 5.178 \times 10^{11}$ *C.G.S.* Which in combination with the result (2) gave.

(7.) Bulk modulus or resilience $K = 1{\cdot}435 \times 10^{11}$ *C.G.S.*

(8.) The tests as to torsional fatigue and nachwirkung were made in the usual way, and showed that no fatigue is to be apprehended in any experimental use to which quartz fibres are likely to be put. As to nachwirkung, the usual symptoms were produced when the intensity of twist rose beyond a certain point. From the experiments it is deduced that a good margin for safety will be left if a fibre ·01 cm. in diameter is not twisted at a greater rate than one-third complete turn per centimeter, and in other fibres at a rate simply inversely as the diameter. The claims of quartz fibres for suspension purposes are established beyond criticism by the above researches.

NOTE.—Further experiments have shown that the temperative coefficient of total torsional rigidity is more nearly ·00012 than ·00013; also that the amount of nachwirkunk exhibited appears to depend on the thickness of the threads in a manner probably related to their rate of cooling during manufacture.

2.—CLOUD OBSERVATIONS.

By W. W. CULCHETH, M.Inst.C.E.

3.—SOME REMARKS ON THE TEACHING OF ELEMENTARY MATHEMATICS AND PHYSICS.

By Rev. W. L. BOWDITCH, M.A.

4.—NOTE ON THE EULERIAN EQUATIONS OF HYDRODYNAMICS.

By ALEXANDER MCAULAY, M.A.

[*Abstract.*]

MR. LARMOR (*Proc. Lon. Math. Soc.*, March, 1884) has from general dynamical principles deduced the Lagrangian equations of hydrodynamics by the principle

$$\int(\delta L + \Sigma Q \delta q)\, dt = o \quad \ldots \quad \ldots \quad (1).$$

[L the Lagrangian function of a system, q a co-ordinate, Q the external force corresponding to q; the initial and final positions and times of the motion, invariable.] We may, by considering *any finite* portion of a fluid, deduce the Eulerian equations, and also the fact that the stress is a hydrostatic pressure. Here by a *fluid* is understood a substance, the potential energy due to whose strain is a function of the density only. For the finite portion we have with usual notation

$$L = \iiint \left(\tfrac{1}{2}(u^2 + v^2 + w^2) - V - f(\rho) \right) \rho\, ds \quad \ldots \quad \ldots \quad (2)$$

where $f(\rho)$ is the potential energy per unit mass due to strain and ds is an element of volume. Eq. (1) gives

$$\int dt \left(\delta L + \iiint (\xi X + \eta Y + \zeta Z) \rho\, ds + \iint (\xi p_1 + \eta p_2 + \zeta p_3)\, dS \right) \quad (3)$$

where (ξ, η, ζ) is the virtual displacement, (X, Y, Z) an external bodily force independent of V, and (p_1, p_2, p_3) the stress per unit surface at the boundary. If by means of the displacement the point would move from P to P^1 and if F be the value of any quantity at P before displacement, $F + \delta F$ will be supposed to mean the value at P^1 after displacement. Thus $\delta(\rho\, ds) = o$, $\delta u = \dot{\xi}$. Hence,

$$\delta L = \frac{d}{dt} \iiint (\xi u + \eta v + \zeta w) \rho\, ds + \iint (\xi l + \eta m + \zeta n) \rho^2 f^1\, dS$$

$$- \iiint \left(\xi \left[\dot{u} + \frac{dV}{dx} + \frac{1}{\rho} \frac{d}{dx} (\rho^2 f^1) \right] + \eta [\,] + \zeta [\,] \right) \rho\, ds,$$

where f^1 stands for $df/d\rho$ and where (l, m, n) are the direction cosines of the normal outwards. From equation (3) we obtain the surface equations

$$-\frac{p_1}{l} = -\frac{p_2}{m} = -\frac{p_3}{n} = \rho^2 f^1 = p \quad \ldots \quad (4)$$

(say), shewing that the stress is a hydrostatic pressure of magnitude $\rho^2 f^1$; and the volume equations

$$\dot{u} + \frac{dV}{dx} + \frac{1}{\rho} \frac{dp}{dx} - X = o \quad \ldots \quad \ldots \quad (5),$$

and two similar ones.

Notice that $\rho^2 f^1 = p$ gives $f = -\int p\, dv^1$ where v^1 is the volume of unit mass. This is the ordinary expression for the potential energy of strain per unit mass.

5.—ON THE DESIGNING OF TRANSIT INSTRUMENTS.

By Professor Kernot, M.A., C.E.

The transit instrument is an appliance of cardinal importance to the astronomer. By its means he determines the relative positions of the heavenly bodies, and upon the accuracy of its indications all his calculated results depend. It is therefore of the utmost importance that this instrument should be in every respect as perfect as it can be made.

The transit instrument consists of a telescope attached at right angles to an axis, which latter is provided with a graduated circle, and supported upon two bearings. For its proper performance it is necessary that the axis be placed horizontal and truly east and west, that the line of collimation of the telescope be exactly at right angles to the axis, and that the circle give a definite and known reading when the line of collimation is horizontal. That these conditions may be always complied with, it is desirable that all parts of the instrument be rigid, or, in other words, remain invariable in form. Now, a rigid substance, though often postulated by lecturers on physics, does not exist in nature. All known solid materials are more or less elastic, and change their form to a greater or less extent. Thus the telescope of the transit instrument may be straight when vertical, but when placed in a horizontal position the ends will droop, and this effect will take place, though to a less degree, in positions intermediate to the horizontal and vertical. Similarly, the axis will droop, but its flexure will be the same, provided the material is homogeneous in all positions of the telescope.

Now, did both ends of the telescope and axis bend equally, no harm would be done, as the effect of flexure would simply move the line of collimation to a position parallel to and a minute distance from that which it would occupy were there no flexure. Unfortunately, however, this equality or symmetry of flexure does not appear to exist; hence, errors arise, and the performance of the instrument is impaired.

In all transit instruments known to us, the telescope tube is of circular section, consisting of two slightly conical portions united by a central cube, or sphere, and the axis consists of two other conical parts. Now, this section is suitable for a beam exposed to bending moments equally in the direction of all its diameters, but is totally unsuitable to the case in point, in which the bending moment is all in one plane, that in which gravity acts. What would be thought of an engineer who employed a circular tube as a girder for a bridge? Why, he would be an object of ridicule to the whole profession. The transit telescope, equally with the bridge-girder, is a beam always flexed in the same plane, and, in the interests of both strength and rigidity, should be made so that its cross section has as large a moment of inertia as possible about its central axis. In this respect it differs essentially from the telescope of an equatorial, upon which gravity may act in any plane. The section, then, of a transit telescope should be rectangular instead of circular, and the bulk of the material should be concentrated in the top and bottom, the sides being as thin as practical considerations permit. The best depth of the beam or tube cannot, I think, be determined by the methods of maxima and minima, but will be as great as practical conditions allow, as the flexure of a beam made as described varies inversely as the depth. In side elevation the tube will have the form of a lozenge, the greatest depth being at the centre, whence it diminishes uniformly to each end, when it need be no greater than is necessary to accommodate the optical apparatus.

The axis may remain a double cone as at present, but preferably enlarged in diameter at its centre, whereby flexure will be reduced.

6.—FURTHER INVESTIGATIONS ON THE LAWS OF MOLECULAR FORCE.

By William Sutherland, M.A., B.Sc.

[*Abstract.*]

In this paper the author gave a brief sketch of the methods and results of his researches during the past year on the subject of molecular force. The most important point in the theory of molecular force is the establishment of the characteristic equation for fluids on the model of Clausius's equation of the Virial—$\frac{3}{2} p v = \Sigma \frac{1}{2} m V^2 - \frac{1}{2} \cdot \frac{1}{2} \Sigma \Sigma F r.$, where F is the force between two molecules at distance r apart. According to a law of force $3 A m^2 / r^4$ between two molecules of mass m, $\frac{1}{4} \Sigma \Sigma F r$ the internal virial must vary inversely as the volume. In agreement with this, the equation for the elementary gases and methane is from Amagat's experiments proved down to the critical volume to be $p v = R T \left\{ 1 + \frac{k}{2} \Big/ (v - \frac{k}{2}) \right\} - \frac{l}{v}$, where l / v is $\frac{2}{3} \cdot \frac{1}{4} \Sigma \Sigma F r$ for unit mass of gas. But in the case of compound gases a different form is, from Ramsay and Young's experiments on ethyl oxide and Amagat's on carbonic dioxide, proved to hold down to the critical volume $p v = R T \left(1 + \frac{2 k}{v + k} \right) - \frac{l}{v + k}$ which is indirectly proved to apply to the great majority of compounds, the most prominent exceptions being the alcohols and water, ethylene and bodies such as acetic acid and nitric peroxide, which have been shown to contain double molecules. The most notable point about this equation for compounds is that the form $l / (v + k)$ for the internal virial holds down to volume $v = k$, at which it becomes $l / 2 k$, and below which it becomes $l / 2 v$. Hence, below a certain volume, k, the internal virial for compounds varies inversely as the volume, as the law of the inverse fourth power requires, but above the volume k the form $l / (v + k)$ would seem to be in contradiction to that law, only that the author is able to show that this form is due to the pairing of molecules in compound gases, the virial constant for the free molecules being l,

and that for the pairs being $l/2$, so that when the volume k is reached all the molecules are paired, and then through the whole range of liquid volume the pairs behave as single molecules in the matter of molecular force. These equations apply down to the critical volume; in the case of the elements and methane the critical volume pressure and temperature are given by the conditions $dp/dv = o\ d^2p/dv^2 = o$, whence $v_c = \frac{3k}{2}, T_c = 16l/27Rk$ $p_c = 4l/27k^2$. At the critical volume $R\left\{1 + \frac{k}{2} \Big/ \left(v - \frac{k}{2}\right)\right\}$ becomes $\frac{3R}{2}$ and the form established below the critical volume is $pv = \frac{3RT}{2}\left(1 + b\frac{v_c - v}{v - \beta}\right) - \frac{l}{v}.$ In the case of compounds the condition $d^2p/dv^2 = o$ is not a possible one, and the critical values are given by $dp/dv = o$ and $v_c = \frac{7k}{6}$ whence $T_c = 120l/409Rk, p_c = 36l/409k^2$. By means of Ramsay and Young's data for ethyl oxide, the general form $pv = \frac{25RT}{13}\left(1 + \frac{\sqrt{T}}{B}\frac{v_c - v}{v - \beta}\right) - \frac{l}{2v}$ is established for compounds below the volume k, while between k and $7k/6$ the form is $pv = \frac{25RT}{13}\left(1 + \frac{\sqrt{T}}{B}\frac{v_c - v}{v - \beta}\right) - \frac{l}{v + k}.$ Thus equipped with equations covering the whole of the present experimental range of fluidity, one can proceed to applications too numerous to detail in an abstract; thus it is possible to amend to a more accurate statement Van der Waals' generalisation that, if volume pressure and temperature for any substance be expressed in terms of its critical values, as units, then one and the same law applies to all fluids. The more accurate statement is that above the critical volume the elements and methane follow the same law, while compounds with the previously mentioned exceptions follow another law, the same for all compounds, but different from that for elements. Below the critical volume these statements are not strictly but only approximately true. With these equations there are five main methods of finding values of the virial constant l from available data. The first is from extended enough observations on the compression and expansion of bodies as gases; the second from one measurement of the co-efficient of expansion a and of the compressibility μ at temperature T of the body as a liquid according to the relation $l = \frac{4}{3}\left(v_0 \frac{a}{\mu} + \frac{25}{26} R\right) v\ T$ the third from the latent heat λ according to the relation $J\lambda = \int_{v_1}^{v_3} T \frac{dp}{dT}\, dv$ which, with appropriate reduction and approximation, gives $Ml/v_1 = 66{\cdot}5\ M\lambda - 101\ T_b$ in terms of the megadyne, gramme and centimetre, where M is the molecular weight and T_b the boiling point (counted of course from absolute zero) λ being measured in calories; the fourth from the equations given for T_c and p_c, whence $l = 409\ R^2\ T_c^2/\ 400\ p_c$ The fifth method depends on results already established (*Phil. Mag.*, July, 1887, and April, 1889), that the internal virial is $3\ \pi\ A\ \rho\ \log L/a$, so that, for compound liquids, $l = 4\ \pi\ A\ \log L/a$ where L/a is a ratio which is constant and the same for all compounds; and that the surface tension χ is given by $\chi = \pi\ \rho^2\ Ae\ /\ (2 + \sqrt{2})$ where e is like a a quantity nearly equal to the mean distance apart of the molecules, from these we get $l = c\ \chi\ v^{\frac{5}{3}}/M^{\frac{1}{3}}$ where c is a constant whose value can be found. To get comparable values for different bodies we must measure χ and v always at the same fraction of the critical temperature. These methods enable us to calculate values of l for a large number of bodies; the following are three illustrative samples of the agreement of the different methods:—

Method	Second	Third	Fourth	Fifth	
CS_2	26·5	25·7	27·2	26·9	Values of M^2 in terms
$CHCl_3$	33·0	38·2	36·1	36·8	of megamegadyne,
C_6H_6	40·0	43·1	42·7	43·8	gramme and *cm.*

Agreement such as this in a large number of cases constitutes the verification of the theory so far unfolded. In seeking for the law that connects the virial constant l of a compound with its chemical composition, it proved advantageous to multiply l by M^2, and it was then found that $M^2 l = 6S + {\cdot}66S^2$ where S is called the dynic equivalent of the compound and is defined as the number of CH_2 groups in the normal paraffin which exerts the same molecular force as the compound; S is the sum of the dynic equivalents of the radicals in the compound. The following are the values of the dynic equivalents for several radicals, along with their molecular refractions in terms of that for CH_2 as unity

	CH_2	C	H	$CO''O'$	O'	NH_2	CN
Dynic equivalent	1	·57	·215	1·9	·6	1·23	1·35
Molecular refraction	1	·54	·23	1·4	·35	1·12	1·18

	NO_3	CNS	S'	Cl	Br	I
Dynic equivalent	2·2	2·85	1·6	1·3	1·6	2·3
Molecular refraction	2·2	3·0	1·7	1·3	2·0	3·1

The significance of the parallelism in the values of these two quantities cannot be discussed in this abstract. The law of l has thus been found, and as l is proportional to A, we have the law of Am^2 in $3Am^2/r^4$ the expression for molecular force.

In extending the theory to inorganic bodies with data at present available it is necessary to construct a theory of the capillarity and compressibility of solutions; this is successfully done with the unfolding of some interesting results in the process, and the same parallelism between dynic equivalent and molecular refraction is again established for a large number of elements. Many matters are treated of in the full investigation which cannot be touched on in this abstract.

7.—REMARKS ON THE ARRANGEMENT OF A GALVANOMETER.

By E. F. J. Love, M.A., Fellow of Queen's College, Melbourne, and Assistant Lecturer and Demonstrator in Natural Philosophy to the University.

[*Abstract.*]

The author of this paper described a ballistic galvanometer, the suspension and mounting of which offered some peculiarities. The suspended system of magnets was made as nearly astatic as possible, and the restoring force was supplied by the torsional rigidity of the suspending fibre. For the latter, the author employed dark human hair, of suitable length, mounted in its natural state without cleansing. This substance he found to possess very perfect torsional rigidity, and to be nearly free from "elastische nachwirkung." It was recommended that all delicately-suspended apparatus should be mounted on india-rubber pillars, of height equal to their diameter, as such a mounting almost completely insulates the apparatus from external disturbance, and, at the same time, rapidly takes up and damps vibrations actually set up within the instrument. The paper further contained a comparison of the merits of Gauss's method of observing by means of telescope and scale with those of Sir W. Thomson's lamp and scale method, the conclusion being strongly in favour of the former for absolute measures of angle, and concluded by describing a simple method of constructing circular scales.

8.—AIDS TO CALCULATION.

By J. J. Fenton.

Section B.

CHEMISTRY AND MINERALOGY.

President of the Section: Professor E. H. Rennie, M.A., D.Sc., University of Adelaide.

1.—ON AN APPLICATION OF CHEMICAL CONTROL TO A MANUFACTURING BUSINESS.

By Ed. W. Knox.

As there are still doubts in many minds about the money value of scientific aid in practical work, I have thought that some interest might be taken in a short account of a purely commercial application of chemical science to a manufacturing business—an application, I think, unique in its completeness as far as Australasia is concerned, though in Europe many better examples might easily be found, but few, if any, where the staff of experts is so large or the work done so wide in its scope.

The business I speak of is that of the company known as the Sugar Company, which is largely interested in the manufacture and refining of sugar in five of the colonies of the Australasian group. Having entered the service of this company twenty-five years ago, and having since passed through all its grades, I can speak with some authority of its transactions; but as I have not enjoyed any training in science, I will deal with the subject on which I am to address you merely from the point of view of one concerned with the results alone.

About ten years since we were led by the great attention then being paid to chemical research in connection with the beet-sugar industry to commence such investigations into our mode of work. We did not know clearly what was wanted, nor did the man we engaged, so the first start was not a success; but it showed us we were on the right track, and we accordingly engaged in Scotland a refinery chemist, and a year later two beet-sugar chemists in Germany, and began the systematic check on our working. Of these gentlemen, the former is now our head chemist (Mr. T. U. Walton, B.Sc., F.I.C., F.C.S.), and one of the latter our inspecting chemist (Dr. Gustav Kottmann, Ph.D.); and it is to the patience and industry of these two gentlemen, and to the system they introduced, that much of the success we have achieved is due. The chemical staff then fast increased in numbers, but it was not till I visited Europe in '85 and saw there to what an extent the supervision of industrial work was passing into the hands of those having chemical knowledge that any large portion of the practical work was entrusted to members of our chemical staff. I sought, however, authority for such a change, and during the past two or three years have gradually, as chances offered, transferred to men who were trained chemists or analysts, the management of a large part of our manufacturing operations.

The method adopted now is as follows:—There is a central laboratory in Sydney, where the head chemist is stationed. Here five or six officers, including juniors receiving elementary training, are always at work, and to this centre all the returns from each factory are forwarded weekly. At each sugar-mill and refinery (nine and three respectively) there are employed a chemist or analyst, and one or more juniors or assistants—not counting the officers who may be engaged in overlooking the manufacture—and each of these analysts is responsible for the chemical investigations to be carried out at his station. At the mills these comprise:—

1. Analysis of the sugar-cane as received
2. ,, ,, juice expressed
3. ,, ,, megass or crushed cane after the juice has been removed
4. ,, ,, clarified juice
5. ,, ,, ,, ,, after it has been boiled down
6. ,, ,, massecuite from the pans
7. ,, ,, sugar and molasses
8. ,, ,, coal

and in addition a record is kept of the work done, and each week a statement is prepared which shows the quantity of cane crushed and sugar produced. The work, of course, is so arranged that the more important analyses which determine the amount of sugar lost in the various processes are made frequently, and those of smaller moment as time permits.

At the refineries the sugar is all sampled and analysed according to the various brands on being landed from the ships, and it is stowed so that it can be procured as wanted. Each day's melting is again analysed, and the weekly averages of all sugars and syrup produced. There is also a careful examination made of the bone-black used for filtering, to determine if this has been rightly re-burned, and full analyses of this also are made from time to time. The records of the work are prepared on different lines from those for the mills, but there is a similar check, and occasional investigations have also to be made into other points connected with the refinery work.

At the end of each quarter for the refinery, and of each crushing season at the mills, the weekly returns which have been prepared are summarised and tabulated, and careful comparison made between the results at the various factories, improvements effected or new methods suggested being brought under the notice of the leading officers, as are also the occasional shortcomings relentlessly exposed by the figures recorded. The refinery returns are all under the charge of the head chemist, the mill returns under that of the inspecting chemist; and the whole of them are made out in such a way that the administrative heads of the different departments—who, as a rule, know nothing of chemistry—can grasp the main features very easily, and then at once deal with any matters which call for attention or explanation. All the work in connection with sugar is carried out by the aid of the polariscope, and indeed could hardly be done without this instrument, which has been devised to make a practical application of the property that a solution of sugar has of altering the character of polarised light allowed to shine through it. The degree of change thus experienced by the rays of light is in exact proportion to the quantity of sugar present in the solution, and when measured by suitable prisms the amount of sugar thus becomes known. This apparatus is the outcome of a long series of experiments and discoveries commenced nearly seventy years ago, and it serves well to illustrate the dependence of practical work on purely scientific enquiry conducted for the acquisition of knowledge, and in this instance, I think, without thought of personal gain.

So far I have spoken altogether of the manufacturing work, but I should here state that we have now also taken the chemical staff into our counsel in regard to the cultivation of the cane grown on our own plantations, at present about 14,000 or 15,000 acres. In past years we have not availed ourselves to any extent of the assistance of the chemists in this department, partly because we were working virgin land, and partly because, till a short time ago, nearly the whole of our supply of cane—and still a large proportion—was grown by others and sold to us when cut. However, the partial exhaustion of our lands and the necessity for applying manure, the desirability for improving the present canes and for introducing new varieties, and some little trouble with diseases in the canes, compelled us to seek the aid of our chemical staff in this branch also, and we are now carrying out an elaborate investigation into the composition of the soils of our various estates; and, under the supervision of the chemists, a vast number of trials in the special cane nurseries established by us two or three years ago, and in the fields with manure of various compositions applied in different ways, and with irrigation and many systems of planting. From all these experiments we shall, in the course of time, derive much benefit; but though there can be little doubt that, by careful selection of cane and manures, we can increase considerably the production of sugar per acre, still we can hardly hope that there can, in a short time, be any improvement in the sweetness of the cane at all corresponding with that obtained in Europe in a few years in beet-roots. Sugar-cane is one of those grasses which has been hitherto believed not to produce fertile seed, and as propagation is therefore effected by planting cuttings, no one has attempted to produce by selection of seed—as is done with the beet—that marked increase in saccharine contents which is so much desired; and any advance in this direction, if actually obtained at all by continually planting the sweetest canes, can only be made by slow and painful steps. Fertile seeds have, however, been lately found by scientific observers in the West Indies and in Java, and as their success in raising plants from such seeds will be emulated by hundreds of planters all over the world, it seems possible that we may now be on the threshold of an important change in our methods of propagating cane, and that we may have grounds for hoping that, in the early future, we may bring about a sensible improvement in the sweetness of sugar-cane, which has not, so far as our knowledge extends, been as yet increased, even if it has not, in some countries, been diminished by the use of immature stalks for cuttings and by careless cultivation. To what extent the beet has been improved can be gathered from the fact that, during the last twenty-five years, its sweetness has been practically doubled, and that nearly 20 per cent. of pure sugar in the picked beets is not unusual, this increase being obtained by extreme care in the cultivation and manuring, but principally by the special selection of sweet beets for seeding, thus following the same line as that pursued by Mr. Hallett when raising the celebrated pedigree wheat, which attracted so much notice a good many years ago.

A good deal of attention is also paid by the chemists to the saving of what are usually called waste products. These play an important part in the manufacture of sugar from the cane. The crushed cane, after the obtainable sugar has been extracted, is used for firing the boilers, and thus furnishes a very large proportion of the fuel needed for working the factory; and this, too, serves a second purpose, as the ashes from it contain a good deal of potash and other fertilising substances which are needed for application to the fields from which the cane has been taken. Then, again, at all our factories, the water driven off the juice of the cane while this is being boiled down is caught and used for watering the megass before it goes to the second mill and for other purposes; and at our New South Wales mills, where fresh water cannot be obtained, it is fed into the boilers, which are thus both fed and fired with parts of the cane we buy. There is, however, one waste product for which yet but little use has been made: this is molasses, of which we make about 5000 to 7000 tons a year. Of this quantity we distil nearly half, and sell a small proportion for other purposes; but the balance is put on the fields as manure, or thrown away. As it contains about 40 per cent. cane sugar and from 10 to 20 per cent. glucose or grape sugar, it is a material of the greatest value for feeding stock; but so far we have not found it possible to make arrangements for disposing of it in any quantity. In the refineries, also, we effect some savings from the by-products by recovering sulphate of ammonia from the bones we distil for making the filtering charcoal, and the spent charcoal itself is converted into superphosphate, the three important components of cane manure—ammonia, phosphoric acid, and potash—being, to a certain extent, provided by the waste material of our own business.

It could not be expected that changes in our methods, such as have been here alluded to, and the general adoption of chemical control, could be carried out without some friction. Among even the strongest and most intelligent of our officers there was at first a hardly-concealed scorn for the new-fangled notions and distrust of the chemists' work; but these have now entirely disappeared, and in every direction their reports are, as a rule, accepted without question, and with confidence in their fairness and accuracy; and the help of the chemists is sought in many ways—here by a manager who wants to check waste in some branch of the manufacture, there by an agricultural overseer who wishes an analysis of the water he is using for irrigation, or advice as to the proportion of manure to apply to a field, or, again, by an engineer who asks for an analysis of the coal he uses or of the gases from a boiler flue, in order that he may know if the setting of the boilers and the arrangement of the fire-bars are those most conducive to the economic combustion of coal.

Having thus briefly sketched our system, I may say a few words about the financial results; and first, as to our expenditure, would state that we are now paying to the chemical staff and to those officers charged with the control of part of the manufacturing business who possess a knowledge of chemistry, and have been chosen for those posts in consequence, some £8000 to £9000 a year in the shape of salaries and allowances for board, &c. There may be some doubt how we can be repaid for such expenditure, but any doubts on this point I do not in the remotest degree share. It would be almost impossible, even if it were necessary, for me to state exactly what is the value of the savings we have to set against such an expenditure; but among those in whose hands the general control of our business is placed there is not a second opinion as to the money advantage of the chemical check; and when I say that saving 10lbs. or 12lbs. of sugar from each ton of cane—say 5 per cent. of the weight of the cane—means to us £15,000 to £20,000 a year, and that an improvement in the colour of our refined sugar, which will bring us a few shillings per ton more for it, represents a similar sum, some idea can be gained of the ground on which the chemical staff has to work and of the savings they can effect; and I can add that some of the losses in our manufacturing business have by their aid been reduced by one-third during the past four years, and the extent of this saving can be guessed by the fact that in one year the entire losses of sugar at our mills amounted to 14,000 tons, *i.e.*, the cane we crushed contained 14,000 tons more sugar than we were able to turn into marketable sugar. From the sum of such loss it is easy to see that there are yet great possibilities in the manufacture of sugar from the cane, and in the cultivation of this crop much can still be done by manuring and thorough culture, even if the sweetness of the cane be not increased, as before suggested. We know now that on one plantation in Java the entire crop of cane has contained in one year as much as 8 tons of sugar to the acre, the cane being about twelve months old; and when we bear in mind that the weight of an unusual crop of maize (80 bushels) is two tons, and that a 40-bushel crop of wheat gives a total yield of one ton of grain and two tons of straw, some idea will be gained of the effect of tropical rain and sunshine in forming sugar in the cane when the circumstances are favourable and the cultivation and manuring are carefully done under skilled supervision. It will be seen, moreover, that sugar-cane occupies an exceptional position among other crops in the weight of marketable produce which can be extracted from it.

And to the money benefits obtained by the chemical check we must add two more, both of considerable importance. The first is the great advantage of having in a large service like ours a body of men of various ages trained in the knowledge that their work is useless unless it is carried out with patient thoroughness, accompanied by uncompromising truth-telling. No chemist worth his salt dreams of concealing anything wrong or twisting his conclusions so as to hide defects in the work of himself and others, and it is surely of great value to have an example of this sort always before the younger as well as the older men. To those who fear to confess a mistake the certainty of its exposure acts as a useful tonic, while to all, from the top to the bottom of the staff, the example is wholesome. The second is the mental refreshment and the increased interest in the work due to the constant discussion of recorded facts and opinions, and of the experiments of the chemists. Speaking for myself, I can say that I have frequently found that energy flagging from the pressure of routine and other monotonous work has again been roused by interesting reports of experiments or suggestions as to changes in our methods; and in the case of others, the constant competition between the officers, the chances offered in the interval between the seasons for independent research and the interchange of results, certainly produce healthful and useful interest in the work.

Such is the record of our experiences, but I may, before concluding, answer two questions which are sometimes put to me. These are—"How was such a staff got together," and "What education do you consider best for boys intended for chemical work." To the first I would say that the officers I have mentioned, as well as one Englishman, one Scotchman, and one German, were engaged in Europe and brought to Australia by us. The rest were engaged here and trained by us, with the exception of a few who had instruction in chemistry before entering our service.

The staff now consists of nine Scotchmen, two Germans, three Danes, one Belgian, one Swiss, two Englishmen, fourteen Australians; total, thirty-two.

It will be noticed at once that the proportion of Englishmen —and of the two one was trained by us—is but small, but I can only say about this that such a result is not due to any inclination on my part to employ in preference men born elsewhere. Whether the passing of chemical work of this sort into the hands of men of other nationalities is due to the temper and character of the English, making them averse to the study and application which it demands, or to the opportunities for such study in England being less frequent or availed of to a smaller extent than is the case elsewhere, is a matter about which I cannot pretend to speak with authority; but I think I should call attention to the position which men born in England hold numerically in a staff recruited as ours has been. Nor have I any intention of comparing the work of the men from the various countries; but I can say this, that we have derived much benefit from having officers of different nationalities and dispositions and trained in different ways, and that the Australians, who are all younger than the others, have shown that in quickness and natural ability they are not inferior, though not all possessed of the patient perseverance which is so marked a characteristic of the Scotch, Danes and Germans; and some of them have been, in a measure, hindered in the acquisition of the knowledge of the work by superficial school training.

And this remark brings me to the second question—about the education best calculated to benefit boys intended for scientific work. To this the reply is very simple, viz., that in my opinion no special training should be attempted. Of all the plausible fallacies put forward from time to time about education, the most foolish seems to me that of attempting to teach any boy a trade at school. If he is to leave school between sixteen and seventeen, as most boys do, the years available are none too long for him to master the ordinary school course, and it is simply wasting precious time to give a boy a smattering of chemistry at school because he is destined for a laboratory when he leaves. Let him be grounded thoroughly in mathematics, let him work seriously at history and geography, and from the first drill him in the Latin grammar, and then teach him to read and understand French and German, the Latin grammar being taken up, as he will learn from it the construction of a language much better than if taught syntax from an English grammar, while it will also be of much assistance afterwards when studying French and German, a partial knowledge of which languages is desirable on account of the valuable scientific literature thus made available. With such a training as this, the boy will have a fair chance when he commences his business life; but if some of his school hours are spent in an endeavour to teach him chemistry, he will find, when put in a laboratory, that he has then to make good deficiencies in his education due to his time having been wasted over so-called technical training. I do not go the length of saying that there should not be a chemical laboratory at a school, or that the boys should be brought up in entire ignorance of chemistry or science of any sort, but I do maintain that the laboratory will do more harm than good unless the masters realise that its function can only be to fulfil that part of the definition of education which requires that a man should know something of everything, or to give a possible bias to the thoughts and aims of some boys who have a natural gift for scientific pursuits; and it is surely an axiom that no boy is fit to take up any branch of science, or indeed any work by which he is to earn a living, until he has received a thorough elementary training, and has learned how to acquire knowledge—the only part of an education he can hope to receive at school.

There only remains now for me to add the hope that the facts and opinions I have been permitted to bring before you this morning may be of some use in showing you how, by the employment of trained experts, the results from manufacturing and agricultural work can be improved, and the losses which now occur may be reduced, and those products now called waste utilised, which latter may in other industries, as in the manufacture of gas, be found of sufficient value to cause an enormous reduction in the expenses of manufacture.

2.—ON THE GUM OF THE LEOPARD-TREE

(*Flindersia maculosa.*—F. v. M.)

By J. H. Maiden, F.L.S., F.C.S., Curator of the Technological Museum, Sydney.

Flindersia maculosa (F. v. M., B. Fl., i. 388) is a synonym of *F. strzeleckiana* (F. v. M.), of Mueller's Census, p. 9. It belongs to the natural order *Meliaceæ*.* It is an interior species, and is found in New South Wales and Queensland. Owing to the peculiar, and somewhat ornamental, spotted or blotched appearance of its bark, it is known as "spotted, or leopard tree." It also bears the name of "dogwood."

During the summer months large masses, of a clear amber colour, exude from the stem and branches. It makes good adhesive mucilage, has a pleasant taste, and is eaten by the aboriginals. It is commonly used by bushmen as a remedy in diarrhœa.

Two samples have been received at the Technological Museum, and the following is an account of them. In view of the scarcity of good gum-arabic, it would be a useful addition to our raw products if abundant supplies of it could be obtained. I have not heard of a gum being yielded by any other Australian species of *Flindersia* :—

Sample I.—From between the Lachlan and Darling Rivers, N.S.W. A most valuable gum. It is in pieces as large as pigeons' eggs, and I have seen a piece half as large as an emu-egg, clear and of excellent quality, with only a small portion of bark at the place of attachment to the tree. In parts of the interior it is said to be fairly abundant. In some cases it remains in the liquid state on the trees for some little time before hardening, or else exudes very rapidly, for it is frequently brought to Sydney in pieces as long as an ordinary earthworm, and of the same average diameter.

It dissolves readily and completely in cold water. It hardly appears to affect the transparency and absence of colour of pure water. In this respect it may be ranked very closely to picked Turkey gum-arabic. It possesses the faint cloudiness which an aqueous solution of gum-arabic soon assumes.

Sample II.—From Tarella, near Wilcannia, New South Wales. This is by no means so pleasing-looking as the preceding sample. For the most part it is dull and dirty-looking externally, as if the tree had been exposed to dust during its exudation. It is very brittle, and has a bright fracture. It is of a very pale colour (almost colourless, in fact), but the presence of the accidental impurity above alluded to reduces its value. This contamination is, however, probably rare. This gum appeared to most frequently exude from half-dead trees.

Leopard-tree gum is, to all intents and purposes, a good gum-arabic. Its average composition may be readily seen from the following :—

	Arabin.	Metarabin.	Water.	Ash.	Total.
Sample 1	80·2	nil	16·49	2·76	99·45
Sample 2	80·08	nil	16·4	2·63	99·11

* For a discussion on gums of this natural order, see a paper by the author, *Proc. Linn. Soc. N.S.W.*, 1889.

3.—OBSERVATIONS ON THE GUMS YIELDED BY TWO SPECIES OF *CERATOPETALUM*.

By J. H. Maiden, F.L.S., F.C.S., Curator of the Technological Museum, Sydney.

The genus *Ceratopetalum* belongs to the natural order *Saxifrageæ*, and is endemic in New South Wales. Of its two species, the first is *C. gummiferum* (Smith), generally of bushy size, though in favourable localities it attains the dignity of a small tree. It is the well-known "Christmas-bush" of Sydney, and its reddish persistent calyx is very showy. For this reason it was also called "officer-plant" in the early days of the colony, though an officer's tunic is of a very different colour. The second species is a well-known gully tree, never found out of moist situations, and is tall, with smoothish bark, bright-looking foliage and white flowers which it bears in abundance. This is *C. apetalum* (D. Don), and its local names are "coachwood," "lightwood," and "leatherjacket."

In describing *C. gummiferum*, Dr. J. E. Smith, in "A Specimen of the Botany of New Holland" (1793), gives an excellent figure of the plant, which he calls the "three-leaved red-gum tree." He says :—"This, Mr. White informs us, is one of the trees (for there are several, it seems, besides the *Eucalyptus resinifera*) which produce the red gum. He further remarks that it is the only wood of the country which would swim in water." (The latter statement is, of course, founded on imperfect knowledge.) This is the first and, as far as I know, the only reference to the gum-yielding propensity of this plant; but it impressed Smith sufficiently for him to give the specific name he did. Mr. White's observation, so early recorded, does not seem to have attracted the attention of subsequent observers.

The first parcel of *C. gummiferum* gum I received was in small tears of a beautiful ruby colour, perfectly transparent, and having a bright fracture. It is powerfully astringent to the taste, sticks to the teeth, and obviously contains a large proportion of gummy matter. This sample was removed from the cut ends of a log, from which it exuded in small drops and in thin pieces which dried very quickly. The tree was 6 to 9 inches in diameter. It seems, as far as our experience goes at present, that ring-barking or wounding the tree, or even cutting it down merely, is of little avail to obtain the gum; the tree must be cut into logs or pieces, so that the timber is open *at both ends*, before the gum will exude in any quantity. It remains to be seen whether the gum exudes most freely in the summer.

I have received a cake of the substance obtained by draining the ends of a severed log on to a plate. When first received it was exceedingly tough; but on exposure to the air for two or three months, it fractured without difficulty between the fingers.

The fractures are quite bright. It has no odour. To cold water it imparts a dark, rich orange-brown colour; at the same time, the insoluble portion forms a bulky gelatinous mass.

In bulk, the gum of *C. apetalum* appears in no way different from that of *C. gummiferum.* It, however, smells more or less strongly of coumarin, which is also contained in abundance in the bark. It is obtained either by wounding the tree or by felling it. In cold water it swells up largely, and at the same time possesses a good deal of coherence. It imparts to the water a pale orange-brown colour and an intense odour of coumarin.

Ceratopetalum gums are kinoid or astringent. They are much of the colour and texture of ruby kinos,* but unlike those substances, swell up and only partially dissolve. They may be described either as *kinos* or as *kinoid gums.* All the definitions of kino with which I am acquainted allude to the tannic acid contained in them, and make no allusion to any gummy constituents. All the gum of kinos of *Eucalyptus* known to me is readily soluble in water, and is arabin; but in the case of *Ceratopetalum*, the gum is present in the form of metarabin. Whether that circumstance is sufficient to remove them from the kinos is a matter of opinion; in any case they form a connecting link between the kinos and metarabic gums. If they be looked upon as kinos, I believe the present is the first instance in which such substances have been recorded from the *Saxifrageæ.*

Ceratopetalum gums form a remarkable group, and at present I do not know any other precisely similar gums. *C. apetalum* is worthy of note as an available source of coumarin, and the presence of that substance sharply separates the two gums. The following difference also appears to be constant. The ash of *C. gummiferum* is quite white, while that of *C. apetalum* is dark brown, very bulky, and difficult to ignite. It contains but a small percentage of iron, but manganese is abundant. The composition of the gums may thus be stated :—

	C. Gummiferum.		C. Apetalum.
Tannic acid (estimated as gallo-tannic acid ...	16·76	...	6·35
Phlobaphenes (soluble in alcohol)	19·5	...	12·21
Phlobaphenes (insoluble in alcohol, together with metarabin) ...	41·6	...	52·09
Coumarin	nil	(variable)	2 to 3
Accidental impurity ...	2·5	...	2·0
Moisture	16·7	...	20·47
Ash	1.8	...	3·44
	98·86		99·56

* See papers by the author, *Pharm. Journ.*, [3] xx. 221, 321, and *Proc. Linn. Soc.*, N.S.W. July, 1889.

Remarks on the above Table.

1. *Ceratopetalum* gums yield, on treatment with cold water, a residue which consists almost entirely of phlobaphenes and metarabin. That the greater portion of it consists of phlobaphenes is proved by the facility with which continued boiling with water converts it into an equal weight of tannic acid. In fact, if the gums of this genus were boiled with water to begin with, the percentage of tannic acid returned would be between forty and fifty per cent. in each case. (Actual experiments gave *C. gummiferum*, 49·78; *C. apetalum*, 41·14).

2. The difficulties surrounding the separation of a mixture of phlobaphenes, insoluble in alcohol, and metarabin, are very great, and my attempts in this direction have not been entirely satisfactory. I, therefore, have no recourse but to state the result as I have done. But from my experiments in converting the phlobaphenes into tannic acid, the metarabin into arabin, and by observing the physical appearance in water and in alcohol of the original mixture, and other tentative methods, I estimate the percentage of metarabin to be about eight to ten per cent. in each case.

4.—ON THE COMPOSITION OF LUCERNE (*Medicago sativa*).

By Wm. M. Doherty, Assistant Government Analyst, New South Wales.

Lucerne, purple medick or alfolfa, now very extensively grown in Eastern Australia as a fodder plant, is of great antiquity, and well known in Europe and Asia.

"The Romans brought it, 470 years before the Christian era, from Media, hence the generic name (A. de Candolle). A perennial fodder-herb of great importance, and largely utilised in most countries with a temperate clime. . . . . Lucerne keeps green and fresh in the hottest season of the year, even in dry and comparatively barren ground, and on coast sands, but developes itself for field-culture with the greatest vigour on river-banks, or when subjected to a judicious system of irrigation, particularly in soil rich in lime. . . . One of the most valuable of green fodders, but less suited for hay, as the leaves so readily drop off. . . . It is also an important honey plant for bees."

Analysis of the Fresh Plant.

The analysis was made on good fresh specimens, obtained in the spring of the present year (1889) from the estate of Robert Scobie, Esq., M.L.A., of Maitland, Hunter River district, New South Wales.

Water		78·18
Albuminoids		3·27
Containing nitrogen ...	0·51	
Carbonaceous matter		16·60
Containing fat	0·12	
„ starch	0·30	
„ sugar	0·15	
„ gum	0·24	
„ woody fibre ...	8·77	
Ash		1·95
		100·00

Results Calculated on the Plant Dried at 212° F.

Albuminoids		15·00
(Containing nitrogen, 2·37)		
Carbonaceous matter		76.07
Containing fat ...	0·55	
„ starch ...	1·37	
„ sugar ...	0·69	
„ gum ...	1·12	
„ woody fibre	40·20	
Ash		8·93
		100·00

Percentage of Inorganic Constituents, Calculated on the Dry Plant.

Potash (K_2O)	3·58
Soda (Na_2O)	0·81
Lime (CaO)	1·25
Magnesia (MgO)	0·36
Oxide of iron (Fe_2O_3)	0·08
Phosphoric acid (P_2O_5)	0·85
Carbonic „ (CO_2)	1·04
Sulphuric „ (SO_3)	0·37
Chlorine (Cl)	0·64
Silica (SiO_2)	0·11

Analysis of the Ash.

Potash (K_2O)	40·20
Soda (Na_2O)	9·09
Lime (CaO)	14·08
Magnesia (MgO)	4·09
Oxide of iron (Fe_2O_3)	1·00
Phosphoric Acid (P_2O_5)	9·57
Carbonic Acid (CO_2)	11·77
Sulphuric Acid (SO_3)	4·20
Chlorine (Cl)	7·27
Silica (SiO_2)	1·30

Table of Comparison

(*Calculated dry*).

Fodder.	Albuminoids, *i.e.*, Flesh-forming Substances.	Carbon-aceous Substances, digestible.	Indigestible Woody Fibre.	Ash.
Lucerne	15·00	35·87	40·20	8·93
Cabbage	14·17	67·02	10·76	8·05
Barley Straw ...	5·10	11·82	78·46	5·02
Wheat Straw ...	4·91	27·79	62·45	4·85
Oaten Straw	3·18	44·62	45·92	6·28
Oaten Hay	12·10	46·33	34·21	7·36
Brewers' Grains ...	19·37	50·31	23·79	6·53

The annexed table shows at a glance the relative values of the foods. I have separated the woody fibre from the other carbonaceous matter, to show the amount of substance contained in the food capable of being assimilated and the amount which cannot be used up as a food by the animal. Lucerne, then, taking this and the high percentage of flesh-forming substances it contains into consideration, stands well at the top of the list of the fodders I have enumerated, and well deserves the reputation it possesses. I add the brewers'-grains, because they are used so largely as a cattle food wherever obtainable, and a comparison may prove useful.

5.—NOTE ON THE ESTIMATION OF ALKALIES IN IGNEOUS ROCKS.

By John Dennant, F.G.S., F.C.S.

[*Abstract.*]

In the analysis of igneous rocks there are no more important bases to estimate than the alkalies, as the particular felspar present can thus be frequently determined. It is true that the microscope enables us to distinguish between the orthoclastic and plagioclastic felspars, or even to make further subdivisions with fair precision; but the chemical analysis is, after all, the most convincing test. Not seldom, there are macroscopic felspar crystals developed, of the same structure as the microscopic ones which constitute the ground-mass of the rock.

A special instance of this occurred to me lately with some phonolite rocks from the Western District of Victoria, in the felspathic matrix of which tolerably large tabular crystals of sanidine were observed. About twenty grains weight of the crystals was separated from the rock and analysed. As soda and potash exist in varying proportions in sanidine, it was necessary to be very accurate in estimating them, and I attempted to control the gravimetric determination by a volumetric one. These two methods gave, however, such divergent results that I made special experiments to ascertain which of them was to be relied on for the estimation of small quantities of the alkalies.

The volumetric method used was that of Fr. Mohr, in which the chlorine is determined by a solution of nitrate of silver of known strength, with potassium chromate to indicate the end of this reaction; and the gravimetric, the ordinary one with bichloride of platinum.

Nearly equivalent quantities of chemically pure sodium chloride and potassium chloride were taken, the actual weights being 4·19 grains and 4·32 grains respectively. These being mixed their solution was divided into exactly equal portions, so that each half contained 2·095 grains of the sodium, and 2·16 grains of the potassium chloride, or 4·255 grains of the mixed salts. The actual weight of chlorine required by theory in this mixture of the two salts is 2·296 grains, or 53·96 per cent., and the amount found volumetrically was 2·31475 grains, or 54·4 per cent., the difference being thus—0·44 per cent., which falls within the limits of reasonable error, and is as near as volumetric determinations can be expected to reach. The formula for calculating from the chlorine found the respective weights of the salts present was the usual one, which gives an answer within one per cent. of the truth, when the amount of chlorine is exactly ascertained. I say exactly, because the slightest error in this becomes much magnified by the multiples used for finding the relative weights of sodium chloride and potassium chloride in the mixture of the chlorides. Thus, although the initial error in my experiment was only 0·44 per cent. of chlorine, yet, by applying the formula, I obtained 6·1 per cent. *more* of sodium chloride and six per cent. *less* of potassium chloride than the solution really contained.

The remaining half was treated with platinum bichloride, the resulting precipitate washed with spirits of wine, and the double salt of potassium and platinum left in the dish weighed. Calculated to potassium chloride, its weight represented 2·1576 grains, or 99·88 per cent. of the amount taken, viz., 2·16 grains. The sodium chloride was calculated from the difference.

Other experiments made have given the same results, *i.e.*, the gravimetric estimation accurate and the volumetric inaccurate The amounts of the two chlorides being nearly equal in these test experiments; the volumetric method was applied under the most favourable circumstances. For estimating large quantities of the salts, as in manufactories, &c., the method may possibly be applicable, but in the analysis of igneous rocks it certainly cannot be trusted.

In the sanidine crystals mentioned, the soda proved to be in excess of the potash, a gravimetric determination giving potassium oxide 4·49 per cent., and sodium oxide 6·16 per cent. The results obtained by the volumetric method were—Potassium oxide 3·68 per cent., and sodium oxide 6·77 per cent.; but I have no hesitation in saying that this wide divergence is solely due to the unreliability of the latter test.

The determination by platinum bichloride may be a little tedious, but there is always the great satisfaction of knowing that it gives almost absolutely accurate results.

6.—AUSTRALIAN METEORITES.

By A. Liversidge, M.A., F.R.S., Professor of Chemistry University of Sydney.

[*Abstract*]

The *Thunda meteorite*, found near Windorali in the Diamantina district, Queensland. The mass received by me originally weighed 137 lbs., and the specific gravity is 7·78. In composition it consists essentially of nickeliferous iron, containing a trace of cobalt, together with a little sulphur, phosphorus and carbon. The crystalline structure is extremely well-marked, which is not only shown by the fractured surface, but by the cut and polished sections when etched by acids, bromine, or copper sulphate. This meteorite is also remarkable for the many nodules of sulphide of iron which it contains, from which fissures proceed in such a way as to show that the iron sulphide must have crystallised last; in fact, it looks as if it had been the cause of the fissures.

Barratta Meteorites, Nos. 2 and 3.—The first meteorite found at Barratta, near Deniliquin, in New South Wales, has already been described in the journal of the Royal Society of New South Wales for 1872 and 1880.

These later ones, also in the possession of Mr. Russell, F.R.S., Government Astronomer, Sydney, were found near the site of the first; the second one has a weight of 31 lbs. and a specific gravity of 3·706; the third weighs 48 lbs. and has a specific gravity of 3.429; the first having a specific gravity of 3·429. In structure and appearance all three are very much alike, and they consist essentially of silicates of magnesia (as enstatite), iron, with small quantities of other substances, intermingled with a network of nickeliferous iron.

Gilgoin meteorite, in the possession of Mr. Russell, F.R.S., Government Astronomer, Sydney, found on the station of that name, near Brewarrina, N.S.W. This weighs 67½ lbs. and has a specific gravity of 3·857. It is very much more cracked and fissured and contains rather a larger proportion of nickeliferous iron than the preceding one, but in other respects closely resembles them.

Eli Elwah. This meteorite is also an earthy one, containing nickeliferous iron, with a chondritic or granular structure; it weighs 33½ lbs. and has a specific gravity of 3·537.

Photographs and micro-photographs of sections of the four earthy meteorites were shown, as well as specimens of each.

7.—NOTES ON SOME HOT SPRING WATERS.

By A. Liversidge, M.A., F.R.S., Professor of Chemistry, University of Sydney.

(*a*) *Note upon the Hot Spring Waters, Ferguson Island, D'Entrecasteaux Group.*

The specimens forming the subject of this note were collected by Sir W. MacGregor, K.C.M.G., Governor of British New Guinea, who thought that these waters might prove to be of scientific interest, and therefore forwarded them to me for examination.

Accompanying the specimens was the following description of the hot springs, prepared by Mr. Basil Thomson, together with two photographs of the locality :—

"The evidence of volcanic action on the east end of Ferguson and Goulvain Islands in the D'Entrecasteaux Group were plainly visible from the sea, but a few miles to the westward gave place to a schistose slaty formation, of which the island seems mainly composed. It was, therefore, with no little surprise that, on the evening of our anchoring in Seymour Bay, we noticed a strong smell of sulphur, the fumes being sufficient to discolour the white paint on the vessel during the night. Seymour Bay lies in the narrow strait named by Captain Moresby after himself, and is fringed with mangrove and dense scrub and backed by low hills.

After forcing our way through mangrove and sago swamps for about half a mile, we came on a well-beaten native path, which led to a rapid stream. Some of the party who stopped to prospect for gold found the gravel in the bed of the stream too hot for the hands, although the water of the stream was cold.

Making our way southward, we emerged from dense scrub upon a flat, bare of vegetation, and dotted with little hillocks of pure sulphur, from which vapour was rising.

The vegetation surrounding this flat was identical with that in the non-volcanic country, and terminated suddenly, but on the flat itself a few eucalypts were trying to exist. This is the most easterly point at which this tree was found in British New Guinea.

Passing over this flat, which gave a hollow sound to the feet, showing that the crust was very thin, we climbed a low hill, and looked down upon a small lake shut in by hills, having a margin of dazzling whiteness, made by the crystallisation of salts, which tasted strongly of alum. At the foot of the hill was a spring of boiling water, which discharged into the lagoon.

The low hills surrounding the lake were composed of sulphur and the white salt referred to above. The water of the lake, which was covered with wild fowl, was of a light yellow colour, and tepid, and the margin was surrounded by a thin crust, which gave way when trodden on, and let one of our party through into three feet of black slime.

All round the base of the hills was a succession of holes full of boiling mud. Near the summit of one of the low hills we found a larger hole, which was throwing up liquid mud to the height of several feet with loud reports. (Photograph enclosed.)

Further to the northward we found a similar lake and hot springs, and some of our party, who were obliged by the hostility of the natives to pass the night on the top of one of the sulphur hills, experienced much inconvenience from the fumes. At night the hills give out a bluish light.

Sydney, 8th March, 1889. (Signed) B. H. Thomson."

None of the specimens were in sufficient quantity to permit of a full analysis being made of their mineral constituents, the largest sample being contained in a so-called quart brandy bottle.

The only quantitative determinations which could be conveniently made were the total solids, fixed solids, loss on ignition, and chlorine and sulphuric acid.

The loss on ignition includes any organic matter which may have been present, water of combination, volatile and decomposable salts, together with some sulphur.

There were four samples in all.

Sample No. 1.—Labelled "*Seymour Bay, Ferguson Island, 11th November*, 1888. *Boiling Water from Hot Spring.*"

This sample was contained in a sodawater bottle, and as one-half of it consisted of solid matter, it would be more correctly described as a mud.

The sediment, or solid matter, was of a bluish-grey colour, and was found to contain a few diatom frustules and small crystals of selenite (calcium sulphate), and a good deal of sulphur. At some future time it is intended to make a more complete examination of this sediment, as there is sufficient for a quantitative analysis.

The sulphur was carefully tested for selenium, but none was found to be present; neither did this residue contain either arsenic or phosphorus.

The supernatant liquid was filtered off from the mud after allowing the specimen to stand for two or three days; the filtrate had a strong smell of sulphurous acid, and strongly reddened blue litmus paper, showing the presence of free acid, and, on exposure to the air, soon became milky from the separation of sulphur.

On evaporating the filtrate down to dryness in a platinum dish over a water bath, a pale brownish residue was left, which rapidly absorbed moisture. On ignition, it intumesced strongly, and gave off dense white acid fumes (of sulphur trioxide), the ignited residue being yellow when hot and brown when cold.

The weighings gave—

Loss on ignition ...	... 9·63	parts per 1000
Fixed solids ...	... 4·47	,, ,,
Total solids ...	... 14·10	,, ,,

The chlorine and sulphuric acid were not determined in this sample. The fixed solids left, on ignition, were found to contain both soluble and insoluble silica—sufficient of the former to gelatinise with hydrochloric acid—much iron, mainly present in the original water in the ferrous condition, some magnesia, lime, and a considerable quantity of sodium chloride. Lithium was sought for, but no indication of it was obtained, although the other three samples gave the lithium band most readily.

SAMPLE No. 2.—Labelled "*Hot Springs, Seymour Bay*, 11*th November*, 1888. *Water after Boiling*." Contained in an ordinary pickle bottle.

This also showed a large amount of a powdery yellow sediment, about 10 per cent. perhaps, which consisted mainly of free sulphur.

The water contained a good deal of free sulphuric acid, and on evaporating down to dryness over a water-bath, the residue blackened from the action of the free sulphuric acid upon the organic matter present, and on ignition copious fumes of sulphur trioxide were evolved. Much gelatinous silica was left, together with iron, lime, magnesia, and soda. This residue showed a well-marked lithium band.

The iron was present in the original water mainly in the ferrous state.

Loss on ignition	...	1·274 parts per 1000
Fixed solids ...	...	3·630 ,, ,,
Total solids ...	..	4·904 ,, ,,
Chlorine ...	...	1·240 ,, ,,

SAMPLE No. 3.—Labelled "*Seymour Bay*, 11*th November*, 1888. *Boiling Water from Small Spring.*" Contained in a sodawater bottle.

This, like No. 2, contained a yellow powdery sediment of sulphur and other matters. It possessed a strong acid reaction, and gave off a smell of sulphurous acid, together with that of sulphuretted hydrogen.

On evaporating down to dryness, a light-coloured residue was left, brown in the centre, and on ignition this blackened considerably but only gave off a small quantity of sulphur trioxide fumes. The salts present were the same as in No. 2, and the lithium band was equally well marked.

Loss on ignition	...	·630 parts per 1000
Fixed solids ...	...	2·470 ,, ,, ,,
Total solids ...	...	3·100 ,, ,, ,,
Chlorine ...	...	·730 ,, ,, ,,

SAMPLE No. 4.—Labelled "*Seymour Bay*, 11*th November*, 1888. *Water from Lagoon, Hot Springs, Saline Lake, margin surrounded by sulphur.*" Contained in a wine bottle.

The sediment from this was but small in amount, and of a dark-brown colour. There was also a little black flocculent matter The water possessed a strong acid reaction, and smelt of sulphuretted hydrogen.

On evaporating down to dryness, a large quantity of iron was found to be present, mostly in the ferrous condition, much gelatinous silica, some lime, magnesia and soda, together with lithium.

On ignition, the residue became intensely black, gave off slight fumes with an acid reaction and decripitated (from sodium chloride crystals), and left a dark ferruginous-looking residue.

Loss on ignition	...	2·110 parts per 1000
Fixed solids ...	...	5·470 ,, ,, ,,
Total solids ...	...	7·580 ,, ,, ,,
Chlorine ...	...	1·390 ,, ,, ,,

These waters present the usual characters of hot spring waters occurring under similar conditions, and require no special comment except as to the presence of lithium, and I regret that none of the samples were sufficient to allow the amount of this element to be estimated; but, perhaps, on some future occasion it may be possible to bring away a larger supply of the water, or in default of that, the residue left by the careful evaporation (on the spot) of a fair quantity of the water.

Lithium was formerly regarded as a very rare element, but the spectroscope shows that, although it only occurs in small quantities, it is one of the most widely-distributed elements, and is found in many minerals, rocks, soils, and in the ashes of numerous plants.

It may prove to be present in these waters in sufficient quantity to render them useful at some future time, for either medicinal or other purposes.

(b). *Note on Water from a Hot Spring, Savo Island, Solomon Group.*

THIS specimen, received from Mr. Chas. M. Woodford, in February, 1889, was contained in an ordinary fruit bottle.

On opening the bottle, a strong smell of sulphuretted hydrogen was emitted, and the gas continued to escape for two or three days, the sides of the measuring flask were marked by small bubbles of the gas as it slowly escaped, and the previously clear water became milky from the deposition of sulphur.

The bottle contained rather a large amount of black sediment, which, under the microscope, was seen to consist of black opaque granular masses, fragments of quartz and other transparent minerals, together with a few diatom frustules; the black particles were soluble in hydrochloric acid and gave off sulphuretted hydrogen, and the solution reacted for iron; hence they were proved to consist of iron sulphide, probably of quite recent origin, just as is seen in the New Zealand hot springs. (Liversidge, New Zealand Hot Springs, Jour. Roy. Soc. of N.S.W. 1887).

With litmus paper the reaction of the water was slightly acid, as might be expected.

The clear water, on decantation, after long standing, so as to be free from sediment, was found to contain ·764 grammes of total solids per litre (53·48 grains per gallon) in solution, and after ignition ·422 grammes (29·54 grains per gallon of fixed solids per litre).

The residue left on evaporation was whitish, with a silky lustre, and emitted an odour of sulphur compounds, as is usual in such water residues; and on ignition gave off much steam from water of combination. It rapidly blackened, and the carbonaceous matter present burnt off but slowly.

The amount of water at my disposal rendered it impossible to make a quantitative analysis of the salts in solution, but the qualitative analysis showed the presence of hydrochloric, sulphuric, and sulphydric acids, together with silica, the metals iron, aluminium, calcium, magnesium, and sodium, and ferrous sulphide, as already mentioned.

As far as can be ascertained from the above necessarily imperfect examination, there is nothing unusual in the character of the water; the spectroscope did not show the presence of any of the rarer alkaline metals, such as lithium. A much larger quantity of the water would be required to make a satisfactory examination for them, but there was quite sufficient of the water to show that they are not present in any quantity.

The following notes are appended, as it may be of interest to some of the members to have the accounts of other Pacific hot spring waters for comparison. *

Samples of Water from the Islands of Simbo and Santa Anna.
Collected by Dr. H. B. Guppy, Surgeon H.M.S. "*Lark.*"

Bottle 49.—Containing water from the fresh-water lake of Wailava, in the island of Santa Anna, collected in April, 1882. I have seen no reference to this lake in any of the works which bear on these islands. The island of Santa Anna has the characters of a raised atoll, with the large central depression occupied at its lowest part by the waters of the lakes of Wailava and Waipiapia. Wailava is about half-a-mile across in length, and has a depth of 15 fathoms, as ascertained by Lieut. Oldham. On carefully examining this lake, I found that its waters are at about the sea level, though they are not affected by the rise and fall of the tides. On one side it is only separated from the sea by a low swampy tract about one-third of a mile across, and not elevated more than 20 feet above the sea. The surface of this tract is strewn with coral fragments, and the more swampy portion abounds with *Auriculæ.* It is evident that this lake has been only cut off from the sea by recent elevation. On making a rough examination, I found the density about that of fresh water, with *chlorides* abundant, *lime* two or three grains per gallon, *ammonia* unmistakeable, *taste* flat and fresh. The water rapidly decolourises a solution of permanganate of potash.

Bottles 142 *and* 143.—Containing water from the boiling spring in the island of Simbo, collected in May, 1882. The island of Simbo is formed of trachytic rocks, and contains in the southern part an extinct crater, a solfatara, and numerous fumaroles, which pierce the rocks, occurring from the sea up to the highest summit, about 1100 feet above the sea. This water was collected from

* Journal of the Roy. Soc. of N.S.W. for 1887, vol. xi p. 223.

the boiling spring on the shores of a lagoon (very probably an old crater) on the south-west side of the island. The spring is placed amongst decomposed trachytic rocks, a foot or two above the sea level. Its temperature is 212°, and large quantities of H_2S are exhaled. Iron oxide stains the rocks around, which are encrusted with sulphur and chloride of sodium in some places. Numerous fumaroles pierce the slopes overlooking the springs: sulphur, alum, milk-white opal, &c., form deposits around their orifices. As this spring is close to the edge of the lagoon of salt water, with the tidal movements of which its waters rise and fall, I am of opinion, from a cursory examination of the water, that its compositiom may be regarded as sea water, plus the substances discharged by a fumarole.

Bottle 150.—Water condensed from one of the fumaroles in the solfatara on the south-west point of Simbo, in May, 1882. A little sulphur, which unavoidably fell in, forms a sediment at the bottom of the bottle. For two hours the thermometer retained in the orifice of the fumarole varied only between 208° and 210° F. Watery vapour, sulphuretted hydrogen, and sulphurous acid were evolved, flaky crystals of sulphur encrusting the sides of the aperture. A strip of paper, soaked in a solution of acetate of lead, was immediately blackened, and the black metallic silver sulphide was formed in the interior of a piece of glass-tubing, moistened with silver nitrate, whilst the presence of sulphurous acid appeared to be indicated by the suffocating smell of burning sulphur, by the presence of sulphur deposits, and by the reddening of litmus paper. No turbidity was produced in lime-water, nor was the presence of hydrochloric acid gas shown on exposing a solution of silver nitrate.

The interior of the solfatara was whitened by the decomposing influence of the vapours evolved. The elevation of the fumarole in question was rather under 300 feet above the sea.

Bottle 151.—Water condensed May, 1882, from one of the fumaroles on the summit of the South Hill, in the island of Simbo, elevated about 1100 feet above the sea. The temperature of the fumarole varied during two hours between 175° and 180° F. Employing the same rough field tests, I ascertained that watery vapour was the principal substance discharged. No effect was produced on acetate of lead, silver nitrate, or lime-water, and litmus paper was very slightly reddened after a prolonged exposure. No deposits were formed around the orifices of the fumaroles on this hill summit. The trachytic rock was much decomposed, and a little of the decomposed rock unavoidably fell in, and forms a sediment at the bottom of the bottle.

For an additional example of water from hot springs at Suva, Fiji, see "At Home in Fiji," by F. M. Gordon Cumming.

8.—ON THE PURIFICATION OF CERTAIN SUBSTANCES.

By R. Threlfall, Professor of Physics, University of Sydney.

9.—NOTES ON THE SPECTRA OF ZINC AND CADMIUM.

By J. B. Kirkland, F.C.S., Assistant Lecturer and Demonstrator of Chemistry, University of Melbourne.

The author, in the course of a spectroscopic examination of some zinc sulphide, obtained under peculiar conditions, was led to make a series of comparative quantitative spectroscopic experiments with samples of zinc obtained from different sources, in order to determine whether, under such circumstances, any difference in the sensitiveness of the spectral lines of zinc could be detected.

Experiments were first made on a series of solutions of definite strengths, containing from 20 to ·001 per cent of the metal as chloride, the apparatus employed consisting of a one prism spectroscope by Browning, and a spark apparatus of simple construction, the spark being produced by a 4-inch induction coil, excited by six large bichromate cells.

The following results were obtained :—With the stronger solutions the spectrum consisted of four brilliant continuous lines, one in the red, *w.l.*, 6362·5, and three in the greenish-blue, *w.l.*, 4809·7, 4721·4., 4679·5.* As the solutions become more dilute, the lines gradually shorten to the negative electrode, until the solution contains ·005 per cent. of zinc. With this degree of dilution the red line is not visible. Finally, with ·001 per cent., the others appear as dots on the edge of the spectrum.

On repeating the above experiments, and introducing a condenser (300 square inches of surface) into the secondary circuit, a pair of very bright lines in the green, *w.l.*, 4923·8, 4911·2, appeared, besides those already noted. These differ in character from the others, being blurred at the edges, and resemble air-lines seen in this region of the spectrum; moreover, they are not nearly so sensitive, for solutions containing one per cent. of the metal give them only faintly, and ·1 per cent. almost imperceptibly. The other samples of zinc experimented on gave exactly similar results. The metal itself was then submitted to the action of the induction spark. The spectrum was essentially the same as that produced by a strong solution of zinc, not a trace of the green lines being visible, even on increasing the

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* Wave lengths are given in ten-millionths of a *mm.* after Thalen.

primary battery; but on including the secondary condenser, they were at once apparent.* From the blurred nature, want of delicacy, and general resemblance to air-lines, it seemed probable the two lines under notice might be due to the oxide of the metal. This conclusion was strengthened by careful consideration of the spectra and physical properties of the natural group of elements, *Be*, *Mg*, *Zn*, *Cd*, *Hg*.

For example, if the spectra of this group be examined, considerable homology is observable between them, the refrangibility of the principal lines of each element increasing inversely as its atomic weight. It is worthy to note, in this connection, the absence in the spectra of *Be* and *Mg* of lines corresponding to *w.l.* 4923·8, 4911·2 in *Zn*, and 5378·8, 5337·5 in *Cd*. A possible reason for this is to be found when the melting and boiling points of the elements of this group are considered. Similarly with their oxides; but with this great difference, that, whilst the metals melt and vaporise at comparatively low temperatures, the oxides, for the most part at least, are non-volatile.

Now, whether the lines in *Zn* and *Cd* are due to the oxide or to the metal, it seems probable, from what has already been noted in the case of *Zn*, that if the spectra of *Be* and *Mg* were examined at sufficiently high temperatures, by the use of a more powerful induction apparatus and extra condensers, lines corresponding to those of *Zn* and *Cd* would be found.

The fact that *Cd* is the most volatile element of this group, except *Hg*, led me to examine its spectrum, in order to find whether the lines *w.l.* 5378·8, 5337·5 would be influenced by the temperature of the spark, as in the case of *Zn*; it seemed probable they might be visible at a lower temperature. On subjecting that element to the action of the spark the lines *w.l.* 6438, 5085, 4799, 4676·8 were the only ones visible; 5378·8, 5337·5 required the condenser. Another trial was made without the condenser, increasing the strength of the primary battery. At this temperature they were seen as a nebulous band.

It has been stated elsewhere† that *insoluble and non-volatile substances do not yield spark spectra*, and as this statement rather upsets the present considerations, zinc oxide, specially purified, was submitted to the action of the spark. It gave lines identical with those of metallic zinc, both at low and high temperatures. In order to settle the question as to the lines *w.l.* 4923·8, 4911·2 in the zinc spectrum being due to the oxide, there appeared only one course open. The spectrum must be observed in an atmosphere free from oxygen and its compounds, pure dry hydrogen being thought most suitable for the purpose.

* In a photograph of the arc spectrum of zinc, by J. R. Cafron, F.R.A.S., where the arc was produced by 40 Groves' cells, no trace of the lines, *w.l.* 4923·8, 4911·2, is shown. This will give some idea of the extraordinary influence of a condenser in raising the temperature of the spark.

† Professor W. N. Hartley in a paper on "Spectrum Photography," *Phil. Trans.*, 1884.

A glass tube, containing a rod of pure zinc, so arranged as to allow the passage of the spark, was filled with pure, dry hydrogen gas, and then hermetically sealed.

On passing the ordinary induction spark, the lines *w.l.* 6362·5, 4809·7, 4721·4, 4679·5 were the only ones seen. With the condenser in circuit the line spectrum of hydrogen was beautifully shown, together with the zinc spectrum, which was now seen to consist, principally, of the lines *w.l.* 6362·5, 6102·8, 6022·7, 5893·6, 4809·7, 4721·4, 4679·5, the lines 4923·8, 4911·2 not appearing. After sparking some time they *gradually* made their appearance, and finally were seen as strongly as in air.

Unfortunately, a minute crack was discovered in the side of the tube, and whether the gradual appearance of these lines occurred simultaneously with the crack, it is impossible to say. Up to the present the author has not succeeded in definitely settling the question, but experiments are in progress, and if successful, will be communicated at another time.

10.—NOTE ON THE PRECIPITATION OF ZINC SULPHIDE.

By J. B. Kirkland, F.C.S., Assistant Lecturer and Demonstrator of Chemistry, University of Melbourne.

The author, being engaged in an analysis of a peculiar looking zinc blende, was much perplexed at the following circumstance. The ore under examination had been dissolved in the usual manner, *i.e.*, in aqua regia, excess of acid being removed by evaporation; the residue was dissolved in 100 *c.c.* of 40 per cent. hydrochloric acid, and the whole diluted to 800 *c.c.* with water.

The above solution was next submitted to a rapid current of sulphuretted hydrogen for about two hours in the cold, until no further precipitation occurred. The precipitate consisted mainly of arsenic, copper, and lead sulphides; these, after being filtered off, were well washed with sulphuretted hydrogen solution. The filtrate in the first instance came through perfectly clear, but on continued washing, an opalescence or milkiness appeared, resembling sulphur. That this should be sulphur seemed unlikely, considering the excess of precipitant used in the first instance. On treating the opalescent solution to a further action of the gas, a white crystalline gritty powder was thrown down in considerable quantity. Could this be zinc sulphide? This seemed highly improbable, for it is generally understood that zinc is not precipitated from solutions strongly acidified with mineral acids.

Upon making a qualitative analysis of the white powder, the result indicated that it consisted chiefly of zinc and sulphur in combination. However, it is well known how one substance may influence the precipitation of another, under certain circumstances; it struck the author there might be something present in the original mineral, precipitable by sulphuretted hydrogen from an acid solution, capable of carrying down large quantities of zinc sulphides. In order to settle this question, recourse had to be made to the balance, a weighed portion of the sulphide was converted into oxide by ignition in a porcelain crucible, in order to get the ratio between them. This method of procedure proved a failure; for, upon stronger ignition over a blast lamp, a brown sub-metallic film condensed on the cool part of the crucible cover, showing the sulphide to be impure. This sublimate proved upon examination, to be cadmium oxide; a second deposit was obtained in a similar manner on prolonged heating, and on testing found to be lead oxide.*

When no further sublimation could be detected, a weighed quantity of the residual oxide was converted into sulphate by dissolving it in dilute sulphuric acid, afterwards removing the excess of acid by evaporation, finally heating to a temperature near redness, so as to render the salt anhydrous. The weight being taken after cooling, the ratio between the oxide and sulphate was found to correspond almost exactly with zinc.†

Experiments with the view to find out the exact conditions necessary for the precipitation of zinc from acid solutions by hydrogen sulphide were made. The result of these proved, firstly, that zinc is precipitated from solutions as long as the acid does not exceed one per cent; secondly, if the temperature of the solution be raised, the quantity of acid required to prevent precipitation is less.

It would appear the conditions vary according to the ratio of zinc salt to the free acid in a given volume of solution, the duration of the experiment having also considerable influence.

11.—ON THE COLOURING MATTER OF DROSERA WHITTAKERI.

By E. H. Rennie, M.A., D.Sc., Professor of Chemistry in the University of Adelaide.

The species of *Drosera* above named is found growing plentifully in the hills in the neighbourhood of Adelaide. The bulb, which is found attached to each plant at a depth of from three to four inches, contains colouring matter which can be extracted by boiling alcohol. On evaporating off the spirit a residue remains,

* These facts are mentioned here as they may be found useful in the detection of traces of cadmium and lead.

† Examined spectroscopically, it contained nothing but zinc, except traces of cadmium and lead.

practically insoluble in water, which, on drying, can be, to a large extent, sublimed, yielding a crystalline sublimate. By fractional crystallisation from alcohol and glacial acetic acid, two distinct substances at least can be isolated, one having the formula $C_{11}H_8O_5$, melting point about 192°-193°, and the other the formula $C_{11}H_8O_4$, melting point about 165°. Both substances are reduced by boiling solutions of stannous chloride, the former yielding a crystalline yellow substance of formula $C_{11}H_{10}O_5$. The examination of these colouring matters, so far as it has been carried out, tends to show that they are respectively trihydroxy- and dihydroxy-, derivatives of a methylnaphthaquinone, but so far material has been wanting for completing the investigation.

The bulbs also contain a white crystalline substance, which is, apparently, a mixture of fats of very high molecular weight.

12.—ON THE OCCURRENCE OF ÆSCULIN IN BURSARIA SPINOSA.

By Professor Rennie, M.A., D.Sc., and E. F. Turner.

Our attention has been recently drawn to the fluorescent solution which is produced when the leaves of the above-mentioned plant are steeped in water, especially if the latter contains a little free alkali. A preliminary spectroscopic investigation, kindly carried out by Professor Bragg, having indicated the presence of æsculin, we extracted a quantity of the leaves by the ordinary method, and obtained, after repeated crystallisation, a white substance having all the characteristics of æsculin. It contained two molecules of water of crystallisation, melted at 204°-205°, and gave, in fact, all the reactions tried for æsculin. The plant, *Bursaria spinosa*, is very common in South Australia, especially on the steep banks overlooking the lake at Mount Gambier; hence it has been suggested that the blue colour of the lake is due to the fluorescence produced by leaves finding their way into the water. This, however, is mere speculation.

13.—ON THE REMOVAL OF GOLD FROM SUSPENSION AND SOLUTION BY FUNGOID GROWTHS.

By A. Liversidge, M.A., F.R.S., Professor of Chemistry in the University of Sydney.

Some examples of gold removed from solution and suspension by fungoid growths, were first exhibited by the author at a meeting of the Royal Society of New South Wales, in September, 1889.

Since then several additional experiments have been made under known conditions, and with a gold solution of known strength.

On the occasion referred to the fungoid growths exhibited had formed in bottles of distilled water, containing very finely divided gold in suspension, which had been prepared at different times to show a class of students that, under ordinary circumstances, gold reduced from a weak solution of the chloride by means of phosphorus dissolved in ether, usually takes several years to completely precipitate and yield a clear solution.

On examining the bottles, some of which had been settling since 1881, it was found that those containing a colourless liquid were also characterised by the presence of fungoid growths, usually at the bottom of the bottles; those without fungoid growths still possessed either the ruby red or the purple colour characteristic of gold reduced by phosphorus in ether; *i.e.*, the gold still remained in suspension.

In the case of a bottle put up on 28th November, 1884, a purple blue growth had formed, and the solution was practically colourless; the bottle had not been opened since 1884, and had been kept in the dark for six years. On removing the stopper the odour of ether was still present.

Under the microscope, with a low power, the growth had the appearance of a mass of matted purple-blue filaments; when dried over a spirit lamp the filaments retained their form, but lost their purple colour and acquired the metallic lustre and colour of gold.

When the growth was rubbed in a mortar it also immediately acquired the colour and lustre of gold.

Although none of the solutions free from fungoid growths were colourless, many of those with fungoid growths still possessed tints of ruby or purple, even after standing for five or six years, *e.g.*, a solution in a bottle put up on 1st December, 1884, was in September, 1889, still of a deep purple-red colour, with a large purple-red muffin-like mould at the bottom of the bottle some $3\frac{1}{2}$ in. across and $\frac{1}{4}$ in. thick; but by 29th May, 1890, the whole of the colour had disappeared from the liquid. The disappearance of the tint between September, 1889, and 29th May, 1890, may have been hastened by the exposure of the bottle to daylight. *

In the case of a quart bottle put up on 30th April, 1885, the solution was, in October, 1889, perfectly colourless, and the fungoid growths were of a different character, some being white and others blue-black; the white ones were floating oval bodies, about $\frac{1}{8}$ in. in length, with a blue-black nucleus.

(Specimens of these growths, together with micro-photographs and drawings of the same, enlarged 1000 diameters, were exhibited).

* This observation is now added to the paper as originally read.

The gold in the foregoing experiments was, of course, merely in suspension, having been reduced by the phosphorus in ether prior to the formation of the growth. The growth seems to have been, in most instances, merely instrumental in removing the gold from suspension, although such growths will reduce or precipitate the gold as well as remove it from suspension.

The growths seem to have formed much more readily in those cases where phosphorus in ether or alcohol was used, and this may have been due to the oxidation of the phosphorus to phosphoric acid, the presence of which is, of course, favourable to such growths, and the ether and alcohol may have, in part, served as food for the moulds, since there was no growth, or but very little, when other solvents for the phosphorus, such as carbon disulphide, chloroform, turpentine and benzene were used.

On 11th October, 1889, ten confirmatory experiments under known conditions were started. Several pint bottles of distilled water were put up, and a definite quantity of the ordinary crystallised gold chloride was added to each. The gold chloride solution was made by dissolving a fifteen-grain tube of the $AuCl_3, NaCl, 2H_2O$ salt in 500 *c.c.* of water, and 5 *c.c.* of this solution were added to each pint (20 fluid ozs.) of distilled water, and a small quantity of the reducing solution, or agent, added at the same time. The bottle was then filled up to the stopper with distilled water, and not re-opened until the time arrived for examining the growth, if any, which had formed. These bottles were not placed in the dark, as in the first experiments.

Roughly speaking, each bottle contained ·01 gramme of the crystallised gold salt.

In addition to chemical reducing agents various organic ones were made use of, and as I was not in a position to obtain named fungi I made use of certain fungoid growths, which can always be obtained in a chemical laboratory, so that the experiments can be easily repeated, and the growths used can, if necessary, be identified and named.

Amongst those used, which are all likely to be more or less pure growths, were the moulds which form spontaneously in solutions of the following :—

1. Potassium acetate
2. Citric acid
3. Oxalic acid
4. Magnesium sulphate
5. Potassium tartrate.

The mould (*Penicillium ?*) from cheese and banana skins was also used. Bread and other organic bodies were also employed. All of these were found to remove the gold, more or less, completely from both solution and suspension, and to become stained with the ordinary blue-purple colour characteristic of gold absorbed or taken up by organic matter.

All the bottles put up prior to October, 1889, had been kept in a cool, dark room, without a window, and the door of which was seldom opened, hence the change may, in these cases, have gone on more slowly.

Although the fungoid growth had been observed in some of the bottles prior to October, 1889, no special attention was paid to the matter until that date, hence in the table which follows no remarks are appended before that date.

The amount of gold chloride in bottles from one to eight is unknown, but from number nine to the end of the series it is ·01 gramme (roughly) of the crystallised double gold and sodium chloride.

Since the note was communicated to the Australasian Association, and pending the printing of the paper, I have been able to add observations upon the solutions up to the 28th May, 1890.

The following table shows the changes which took place in the solutions of gold chloride on the addition of various reducing substances; the first date indicates when the solution was put up and the other dates when the observations were made.

REAGENT AND RESULTS.

DATE. No. 1.

1-12-84. *Phosphorus in Ether.*

1-1-90.—Blue-purple colour. Heavy blue-black growth.
22-5-90.—Blue-purple solution. Heavy blue-black growth, one mass of which $2\frac{1}{8}$ in. long and 1 in. wide.
28-5-90.—No further change.

No. 2.

1-12-84. *Phosphorus in Ether.*

1-1-90.—Perfectly colourless solution. Blue-black growth. Photographs and sketches were made of this.
22-5-90.—Colourless solution. Blue-black voluminous growth, with some light-coloured growth.
28-5-90.—No further change.

No. 3.

30-4-85. *Phosphorus in Ether.*

1-1-90.—Quart bottle. Solution colourless. Both white and blue-black fungoid growths had formed. The white were fluffy, about $\frac{1}{8}$ in. through, quite different from the other growths, and possessing a blue-black nucleus or centre.

No. 4.

30-4-85. *Phosphorus in Ether.*

1-1-90.—Colourless solution. Blue-black growth.

22-5-90.—Very pale-slate coloured solution. Blue-black growth, and a downy white growth streaked in places with blue-black.

28-5-90.—Solution colourless. Blue-black flocculent voluminous growth, also amœba-like growth of very pale-blue tint.

No. 5.

23-11-85. *Phosphorus in Ether.*

1-1-90.—Deep blue solution. Voluminous blue-black growth.

22-5-90.—Purple solution. Large black growth.

28-5-90.—Purple solution. Voluminous blue-black growth.

No. 6.

23-5-88. *Phosphorus in Ether.*

1-1-90.—Water tinted with dark blue. Precipitate blue-black, rather denser and not so much fungoid growth as in the others.

No. 7.

23-5-80. *Phosphorus in Ether.*

1-1-90.—Greenish solution. Blue-black growth.

22-5-90.—Nearly colourless solution, but of a light purple-slate colour.

28-5-90.—Pale-blue solution. Blue-black growth, in loose pieces about $\frac{1}{8}$ in. through.

No. 8.

15-8-89. *Phosphorus in Ether.*

Liquid of a red-purple colour. Only a slight amount of mould, also of a purple-red colour.

28-5-90.—No further change.

No. 9.

11-10-89. *Phosphorus in Ether.*

14-10-89.—Nearly colourless. Slight bluish-green precipitate.

1-1-90.—Red solution. Voluminous purple-red growth.

22-5-90.—Red solution. Voluminous purple-red growth, and a few minute portions of whitish growth.

28-5-90.—Red solution. Floating voluminous purple-red growth and a compact adherent growth at bottom of bottle.

No. 10.

21-11-89. *Phosphorus in Ether.*

1-1-90.—Deep purple-red solution No growth and little sediment.

22-5-90.—Solution almost colourless, but pale-slate colour. A considerable quantity of almost black sediment.

28-5-90.—Solution practically colourless. Dense blue-black growth at bottom of bottle.

No. 11.

15-8-89. *Phosphorus in Ether.*

1-1-90.—Dark purple-red solution. Dark purple-red growth.

22-5-90.—No apparent alteration.

28-5-90.—Fairly deep-purple solution. Bluish-black voluminous growth.

No. 12.

Potassium Acetate Mould.

11-10-89.—Gold reduced immediately, and the solution became of a pale-blue colour in ninety minutes.

14-10-89.—Dense blue-purple precipitate. Clear colourless solution. Mould stained blue-purple.

1-1-90.—Dense thin adherent dark-purple deposit in addition to mould.

22-5-90.—Deposit very deep-black.

28-5-90.—Deposit very deep-black. Solution very pale-slate colour.

No. 13.

11-10-89. *Phosphorus in Benzene* (C_6H_6).

14-10-89.—Purple-blue colour. No precipitate. No growth.

1-1-90.—Purple-blue solution. No growth, and no deposit.

22-5-90.—Slight deposit of a dark-purple colour.

28-5-90.—Solution of a fairly deep-purple colour, apparently turbid. No further deposit, and no mould or growth.

No. 14.

Citric Acid Mould.

11-10-89.—Pale-blue colour in ninety minutes.

14-10-89.—Red-purple solution. No precipitate, and no growth.

1-1-90.—Pale-blue solution. Indigo-blue fungoid growth.

22-5-90.—Mould almost black, one piece $\frac{9}{16}$ in. x $\frac{3}{16}$ in.

28-5-90.—Solution colourless. Deep blue-black deposit, and free lump of similar-coloured growth.

No. 15.

Phosphorus in Alcohol.

11-10-89.—Dirty brown colour at once.

14-10-89.—Blue-purple solution. No precipitate or growth.

1-1-90.—Pale purple-blue solution. Small quantities of bluish growth.

22-5-90.—Considerable quantity of blue-black growth.
28-5-90.—Pale tint of blue left in liquid. Thick blue-black deposit evenly covering all the bottom of the bottle.

No. 16.

11-10-89. *Reduced by Ferrous Sulphate Solution.*

14-10-89.—Clear solution. Flocculent dirty bluish-green precipitate of gold.
1-1-90.—Pale-green solution. Dirty green precipitate. No growth.
22-5-90.—Pale yellowish-green solution. Dirty green precipitate. No growth.
28-5-90.—Bottle coated with very thin film of gold. Bluish-black precipitate in powdery form, not coherent nor adherent to bottle. No growth. Solution colourless.

No. 17.

11-10-89. *Bread Crumbs.*

14-10-89.—Bread stained purple outside. Blue-purple solution. Neither growth nor precipitate.
1-1-90.—Pale-blue solution. Bread stained blue-black. Slight fungoid growth on bread of a pale purple-blue colour.
22-5-90.—No further change.
28-5-90.—No further change.

No. 18.

11-10-89. *Potassium Tartrate Mould.*

14-10-89.—Purple red solution. No precipitate. Mould stained purple.
1-1-90.—Thick, dark-bluish growth. Pale-blue solution.
22-5-90.—Thick, dark-bluish growth. Purple slate-coloured solution.
28-5-90.—Solution colourless. Mould very voluminous, readily floating about, of a deep-bluish colour. Growth $\frac{3}{4}$ in. across. Also a blue-black deposit.

No. 19.

11-10-89. *Magnesium Sulphate Mould.*

14-10-89.—Colourless solution. All gold precipitated. Mould stained dirty green.
1-1-90.—Slight dirty green precipitate. Mould dark green, but had not increased.
22-5-90.—No apparent alteration.
28-5-90.—Colourless solution. Slight blue-black precipitate. Mould blue-black also.

No. 20.

11-10-89. *Green Cheese Mould.*

14-10-89.—Purple-red solution. Cheese mould stained purple. No growth nor precipitate.
1-1-90.—Purple-blue solution and growth.
22-5-90.—Purple-blue solution and growth.
28-5-90.—Dark purple-blue solution. Blue-black growth on pieces of the cheese mould.

No. 21.

11-10-89. *Phosphorus in Turpentine.*

14-10-89.—Red-purple solution. No precipitate. No growth. Turpentine floating on top.
1-1-90.—Red (ruby) solution. Some whitish growth.
22-5-90.—Ruby solution. Some dark ruby-coloured mould in addition to the whitish growth.
28-5-90.—Solution red. Growth dark-red, mixed with some white.

No. 22.

11-10-89. *Phosphorus in Carbon Disulphide.*

14-10-89.—Pale purple solution, the carbon disulphide of a dirty colour.
1-1-90.—Slate-purple solution. Adherent film of light slate-coloured deposit. No growth.
22-5-90.—No apparent alteration.
28-5-90.—Dark (slate) purple solution. No growth, and no precipitate at bottom.

No. 23.

Oxalic Acid Mould.

11-10-89.—Deep-purple in ninety minutes.
14-10-89.—Red-purple solution. No precipitate, and mould had disappeared.
1-1-90.—Purple colour. No mould and no precipitate.
22-5-90.—Slight growth at bottom.
28-5-90.—Red-purple colour. No growth and no precipitate.

No. 24.

11-10-89. *Phosphorus in Chloroform.*

14-10-89.—Almost colourless solution. Chloroform at bottom, of a pale purple-blue colour. No precipitate. No growth.
1-1-90.—Red-purple solution. No growth. A little black deposit.
22-5-90.—Pink-purple solution. A whitish growth. A little black precipitate.
28-5-90.—Pale ruby-red colour. Turbid (metallic) looking. Small quantity of purple-red growth in small heavy pieces. Also small pieces of a waxy-looking material, probably separated phosphorus.

No. 25.

Banana Skin Scrapings (Mouldy).

11-10-89.—Pale-purple in ninety minutes.

14-10-89.—Dark-purple solution. Skin stained. Slight precipitate.

1-1-90.—Dark purple-red solution. Growth on skin almost black.

22-5-90.—Dark-blue purple solution. Growth on skin black. Dark growth at bottom of solution.

28-5-90.—Dark-blue purple solution. Growth on skin purple-black. Also purple-black loose precipitate.

The details of the experiments are given since they show the first appearance of the mould and the time taken for the change in colour according to the removal of the gold.

It is noticeable that no growth was produced where chloroform, turpentine or carbon disulphide was used as the solvent for phosphorus, but alcohol favoured such growth. The development of the mould may be in part due to the presence of the alcohol radical (C_2H_5) ethyl existing in both ether and alcohol; the presence of phosphoric acid, we know, is as essential to penicillium as it is to man.

It is remarkable that the oxalic acid mould did not increase but disappeared (confirmatory experiments are required on this and other points). The organic substances, like bread, &c., behaved as might have been expected.

It was found by Roulin that the salts of iron and zinc promoted the growth of moulds; and Hamlet (Australasian Association for the Advancement of Science, Sydney, 1888, p. 326) found zinc in the mould of mouldy bread, and it may be that many other metallic substances, including gold, are favourable to the growth of moulds.

There is no doubt that gold in natural waters could be removed by any moulds with which it might come in contact; but then any other organic matter, living or dead, does the same. Hence at this stage of the experiments I do not wish to draw any inferences as to the possible part which fungoid growths may have had in the separation and accumulation of gold in natural deposits, alluvial or otherwise.

14.—NOTES ON AN EXAMINATION OF SOME SAND FROM WESTERN AUSTRALIA.

By A. H. Jackson, B.Sc., F.C.S.

15.—NOTES ON THE NEW SILVER FIELDS AT MOUNT ZEEHAN, TASMANIA.

By A. J. Taylor.

Section C.

GEOLOGY AND MINERALOGY.

President of the Section: F. W. Hutton, M.A., F.G.S., C.M.Z.S., Professor of Geology, Canterbury College, University of New Zealand.

1.—NOTES ON THE METAMORPHIC ROCKS OF OMEO.

By A. W. Howitt, F.G.S.

In the memoir which I presented to this association† at its last meeting, I noted the results of my investigations up to that date into the origin, formation and structure of the crystalline schists of the Omeo district. Since then, I have continued my work by an examination of a considerable number of thin slices prepared from samples which I had collected in typical localities. I now propose to submit to the association the further results of this enquiry, in anticipation of a more complete discussion of the data at a future time in the publications of the Department of Mines of this colony.

I now select for illustration three localities, which will afford some light on the obscure questions involved in the consideration of the mode of formation of these schists, and their relation to the sedimentary rocks with which they are associated.

One locality is on the western margin of the metamorphic area at the Upper Dargo River, another on the eastern margin, between Mount Leinster and the Limestone River, and the third at the base of Mount Livingstone. In each of these places I have carefully examined natural sections which cross the strike of the schists, and have then studied thin slices prepared across the foliations of the collected samples. It will not be necessary for the purpose of this paper to do more than to detail the general results of this study, with special reference to certain typical examples, leaving fuller details for the future, when the quantitative analysis of certain of the rocks will have enabled me, possibly, to speak with greater certainty as to the particular beds in the sections, which may be referred to the group of metamorphosed sediments, rather than to the metamorphosed plutonic rocks.

† "Notes on the Metamorphic Rocks of the Omeo district." Vol. i., p. 206, *Report of Australasian A.A. Science*, 1888.

I take for the first example the section on the western boundary, at the Upper Dargo River. The valley of the river at that place is almost coincident with what has been regarded as the line of passage of the normal Lower Silurian‡ rocks of the district into the metamorphic schists. The observations which I had made elsewhere caused me to feel very strong doubts as to there being any passage from the sedimentary formations to the crystalline schists of Omeo, and it seemed to me that this locality might afford some valuable evidence on the question.

The sedimentary rocks at the Upper Dargo are an alternating series of highly-inclined greenish-coloured slates and sandstones, having a north-westerly strike, and being traversed by more or less auriferous quartz lodes. On the eastern side of the river these beds are found to be much corrugated, and to be minutely wrinkled with a silky lustre. Strings and small lenticular patches of quartz are also present in and across the corrugations. Herein one may recognise an early stage of metamorphism.

In ascending the steep spur on the eastern side of the valley the rocks are all mica schists of increasingly marked character, becoming harsher, and with veins of glassy-looking quartz. The dip of the beds appears to be the north of east, at from 60 deg.—70 deg.

At about 400 feet above the river there occurs a mass of diorite in the schists. It is composed principally of rather light-coloured, not very pleochroic amphibol, with a small amount of ideomophic plagioclase and quartz. From about this point the schists more resemble gneisses with a harsher texture, and are marked by the abundance in them of black mica (biotite). From here upwards it is not possible to say with any safety what is the position of the beds, but so far as I could make observations, the dip is probably in accord with that of the lower beds.

In order to show the character of the beds from 400 feet up to 1250 feet, namely, to the summit of the spur above the level of the river, the following may be noted.

As I have said, biotite increases greatly in the schists, until at about 600 feet much contorted foliations of black mica are very marked. Under the microscope the rock is a finely foliated contorted schist, composed of biotite, a little muscovite, grains of quartz, and here and there broken crystals of green tourmaline. I observed here also a white schist with schorl, which traverses the other schists. On examination, it proved to have been originally a dyke composed of orthoclase, quartz, and schorl, similar probably to felspathic dykes, which are common in the

‡ The rock is a very fine-grained mica schist. The mica is in minute colourless flakes, which are arranged either longditudinally in the narrow foliatures or in smaller plumose groups or rosettes. In places there are narrow foliatures, or lenticular aggregates of quartz grains. In other places similar veins of quartz, in which are scattered plates of mica. The whole rock has been molecularly rearranged, assuming it to represent the argillaceous slates near at hand, in some of which minute mica flakes are very numerous.

Omeo district. This rock has, however, been in so far metamorphised that it has become foliated to some extent. The alternating foliatures with the felspars are of quartz, with also a colourless, very fibrous mineral, which appears to be fibrolite. The schorl is in rather narrow prisms.

Mica schists of the character described extend up to nearly 1000 feet above the river, where the schists are composed of foliatures of black mica, felspar and quartz. In places the foliatures contain small masses of felspar and quartz, forming "eyes." The foliatures vary from very narrow to a width of several inches of each mineral aggregate. This rock is a pressure schist, representing a former massive plutonic rock, composed of orthoclase (microperthite), biotite and quartz. At the summit of the spur, 1250 feet, which is nearly also at the summit of the Great Dividing Range, there is a well-marked example of one of the diorite-gneisses of this district. This place is well within the metamorphic area. This gneiss shows in the clearest manner the violent movements to which it has been subject after its consolidation, as well as an original gneissic structure due to the parallelism of some of its constituents. This gneiss is therefore interesting as being an example of both forms of gneiss. That, namely, which is frequent in the margins of the plutonic masses, as, for instance, at Swift's Creek and which has been produced during consolidation. Secondly, that which has been produced in massive rocks after consolidation, by the effects of pressure metamorphism.

The biotite mica is dark coloured, and is in crystals which have been bent, twisted, and in places opened out. It forms in great part the separations between the other minerals, thus producing a gneissic structure. Its position in the rock shows that it was formed after the porphyritic felspars which it surrounds. The felspars are triclinic, the angles have been somewhat rounded, and the crystals are more or less fractured or crushed. The broken fragments have in places been pushed aside, and the interstices cemented with quartz. The quartz is in considerable amount, and has been much granulated by movements in the rock.

This gneiss is evidently somewhat later in age than the generality of the gneisses in which it occurs, and has been therefore less metamorphised than they. As a contrast, I may note the structure of one of the latter. The main mass of the rock is formed of foliations composed of fragments of felspar and quartz, with plates of biotite. The partings are formed of narrow foliations of a pale-coloured mica in minute scales and fibres, which appears to have resulted from the alteration of the finer detritus. In this mass, and surrounded by the foliations of smaller material are what have once been porphyritic crystals of triclinic felspars in the original quartz diorite; these gneisses are good examples of the pressure schists of the district.

In this section there are several points to note. First, the normal lower Palæozoic sediments pass into the corrugated fine grained mica schists at the foot of the hills, and the mica schists up to about 400 feet are characterised by having a preponderance of muscovite mica. From that place, which is marked by a mass of diorite, the schists have a different character, being much harsher in texture, and having a preponderance of biotite mica. Towards the summit of the spur, where the schists are most marked, they are clearly recognisable as metamorphosed plutonic rocks of the quartz diorite class, which are now in the form of diorite-gneisses.

Further careful work will have to be done before these schists can be satisfactorily classed, but for the present I think that these mica schists, in which muscovite predominates, may be referred to the metamorphosed sediments, while the mica schists with a preponderance of biotite and the gneisses belong to the group of metamorphosed plutonic rocks.

On the north-east side of the Omeo district the furthest outlier of the crystalline schists is found, between Mount Leinster and the Limestone River. I propose to take a section from the Limestone River to Marengo Creek, as my second example of the supposed passage of the sediments into the crystalline schists.

The section commences at the Limestone River, where there is a series of highly-inclined sediments, including a band of crystalline limestone (marble). The age of these sediments is, so far as may be judged from the imperfect fossils, of Upper Silurian age. The section follows a generally south-westerly course across a high range, which forms the divide between the Limestone River and the Marengo Creek. If produced further, its course would be not far from Mount Leinster, to which I shall again refer further on.

In order to illustrate the section, I shall shortly describe representative samples, giving the approximate distance in chains in a direct line from the Limestone River.

At a distance of about ten chains the sedimentary rocks are much hardened and broken up by small joints. The beds dip south 40 deg. west at 50 deg. The rock is fine-grained, and under the microscope can be seen to be formed principally of innumerable minute fibres, of what is probably one of the chlorite minerals. Numerous minute veins of quartz granules traverse it, and the rock itself has also a large amount of the same granular quartz distributed through it. This quartz is secondary, and not to be confounded with the elastic quartz in the rock.

At about sixty chains these altered sediments are in contact with a mass of porphyrite, which extends for nearly fifty chains along the course of the section. The sedimentary rocks in contact with the porphyrite are hard and flinty, and with the dip and strike obliterated. Slices of the rock show it to resemble that described, but to be less fine-grained, and with more secondary quartz diffused through it, as well as in narrow reticulated veins. The induration of these sediments is due to silicious infiltrations, which may have been connected with the intrusion of the porphyrites. On the further side of these the sediments are much contorted in places, but are somewhat less indurated and more schistose. At about one hundred and twenty chains the probable strike is to the north-eastward, with a dip of 80 deg. to the south-east. Narrow strings of quartz appear in and across the foliations. Under the microscope, the rock is seen to resemble in mass those already described, but, in addition, to be traversed by numerous winding, although on the whole parallel, partings lined with flakes of a pale yellowish mica, indicating the commencement of a foliated structure produced by pressure. In parts of the rock, where there are some larger elastic grains of quartz, these foliations wind round them, forming "eyes" in the same way as I have described in the pressure gneisses near Omeo.

At about 160 chains the rocks are distinctly more schistose, with little traces left of bedding. Under the microscope, it is an irregularly foliated rock, composed of flakes and small crystals of colourless mica, with a lesser amount of biotite in larger, but irregularly formed plates and crystals. At this point I observe a decided change in the character of the schists.

Those adjoining are very silicious, and are composed of quartz grains full of minute fluid cavities and microliths. The grains of quartz which form the greater part of the rock have not the appearance of elastic quartz, and are separated in places by small foliations of minute flakes of biotite. Further on, at about 230 chains, the schists are also extremely quartzose. They are formed of foliations of quartz grains, between which are narrow foliations of detrital materials, some part of which is felspar, with a little mica, and a comparatively large percentage of epidote. The narrow detrital foliations swell out in places, round small masses, which can be regarded as altered felspars. Immediately adjoining these rocks are gneisses, composed of foliations of orthoclase and plagioclase, which are rounded, in places fractured, but not stretched or distorted. As is usual in such cases, they are all more or less surrounded by margins and endings of detritus, that is, of rubbings of felspar and quartz. Flakes of biotite line the most marked planes of separation. Besides the lesser quartz grains, there are also foliations of quartz, which in places bend round the inclined felspars, or larger quartz grains. In places the quartz has undulatory extinction. Some samples of these rocks show typical examples of such crystalline schists.

Finally, where the track crosses the first branch of Marengo Creek, there are massive quartz diorites composed of biotite mica, triclinic felspar (oligoclase) and quartz. These diorites extend over a large area, and from them might be produced just such gneisses as I have described. They extend over a large area of many miles in diameter, within which rises Mount Leinster, one of the later plutonic intrusions of the district. The sequence of rocks is as far as the intrusive area is concerned—(1), quartz diorite; (2), syenite porphyries and orthophyrs, and thus resembles the Frenchman's Hill area, near Omeo, which I have already described in a former paper.

In the section just described, I find the sequence of rocks to be on the whole very analagous to that at the Dargo River. There is a passage from the nomal Lower Palæozoic formation into metamorphic schists; then a sequence of schists characterised by the gneisses resulting from the metamorphism by pressure of the massive quartz diorites, which in this case exist over a wide tract adjoining the former. In this case still further minute investigations are necessary, but for the present I think that the point of demarcation may be placed a little to the eastward of the quartzose schists, which I regard as being on the margin of the intrusive rocks.

Part of the metamorphism of the sediments must be no doubt attributed to the large intrusive mass of porphyrite.

The third example is near Mount Livingstone. It is centrally situated as regards the whole metamorphic area. It is interesting, because there the schists are surrounded by plutonic rocks still in a more or less completely massive condition as quartz-diorites, and granites. There is in this locality a tract of gneisses undoubtedly produced by the metamorphism of plutonic rocks. At some distance, and to the north east of the Frenchman's Hill, there is a tract of mica schists, produced by the metamorphism of the Lower Palæozoic sediments. Thus the two groups, which I have endeavoured to distinguish from each other at the Upper Dargo and at Marengo Creek, are found here each one by itself.

The schists at Mount Livingstone can be studied in Green Wattle Creek. They are distinctly bedded, more or less nearly vertical on a north westerly strike. The texture of the beds varies from rather fine-grained to comparatively coarse-grained, with numerous "eyes" of felspar, or of felspar and quartz. The character of the beds also varies from the appearance of a mica schist to gneiss. Details will be best illustrated by describing some of the samples collected.

The first to be mentioned is a micaceous schist at the lower end of the gorge-like valley down which Green Wattle Creek flows for several miles. In a hand sample the rock greatly resembles some of the light-coloured mica schists which have resulted from the metamorphism of the sediments, as, for instance, those near the foot of the spur at the Upper Dargo River, of which I have spoken already. A thin slice, however, prepared across the foliations, shows that the rock is formed of alternate foliations of mica, which is almost wholly muscovite, quartz, and small fragments of more or less altered felspars. The felspars are orthoclase and plagioclase, and the alteration is to mica.

The quartz foliations are, as in other cases, bent and drawn out. At some little distance up the stream the schists are much harder, less micaceous, and more felspathic and quartzose. The rock is composed of biotite, quartz, and felspar, with usually subordinate muscovite. The felspars, as usual, form "eyes" in the foliatures and the larger indurduals are either arranged in the line of foliation or more or less across it, just as if slightly turned over in the process of rubbing between two planes. The portions which have been abraded surround the felspars, and are accumulated at the ends, where they tail off into a point where the two micacious or quartzose foliatures come together again round the felspar crystal. In samples from this place I again observed that the crystals of felspar are broken and abraded, and not stretched or distorted. The quartz, however, is evidently both stretched and bent, indicating a considerable degree of plasticity.

In order to obtain some further information as to the structure of these "eyes," I examined slices prepared from a felspar inclusion from this place. It was about an inch in length by three-quarters of an inch in the widest part. The felspar proved to be orthoclase, in which the extinction was slightly undulating in places. At the end it was joined by a mass of fragments of felspar and quartz, gradually narrowing off to where the enveloping foliations of biotite came together from both sides. At one side, where the micaceous foliation touched the felspar, crystals of quartz have been formed, some of them having well formed lateral planes. Some of these are at the contact of the mica and felspar, others in the felspar itself, with a few plates of biotite placed perpendicularly to the foliation. Here and there in the orthoclase are quartz crystals, from which cracks radiate, and round which the extinction is disturbed. It is evident that these quartz crystals and biotite flakes are of secondary origin, that is to say, whatever has been the origin of the foliated structure of the rock, they are not older than it. There is, therefore, evidence here of the formation of biotite mica and the crystallisation of quartz in the pre-existing crystal of felspar, and also that the quartz has been more plastic than the silicates of alumina and alkali forming the felspar.

Schists of this character extend for about a mile in a south-westerly direction, where the rocks become more massive, and of a character which may be best described as that of a quartz-diorite approaching gneiss. When looked at in the block there is apparent a certain parallelism of the mineral, which is not always to be seen in small samples.

I found, on examining a rather fine-grained example of such a rock, that it was composed of biotite, in rather ragged-edged and wasted crystals, numerous triclinic felspars having the appearance of oligoclase and quartz.

Among the felspars, some were good instances of that form of structure where the interior is well crystallised with a margin of greater or less width, less ideomorphic, and apparently of somewhat different constitution, for the interior was mostly more converted into mica than the exterior. The quartz, which was fairly abundant, had the usual character of that found in such rocks. In this sample there was no appearance of crushing, or of the linear arrangement of the minerals.

Among these more massive rocks there is a narrow band, having the appearance of a quartzose schist, but, on examination, I found it to be a prepared and very quartzose rock belonging to the quartz-diorite group.

Beyond this point the rocks are more or less massive quartz diorites, with here and there schistose bands, and this formation extends westward to the upper Dargo River, of which I have already spoken.

Speaking generally, I may now say that the schists of Green Wattle Creek are gneisses, more or less micaceous, felspathic, or quartzose. They are composed of the mechanically rearranged constituents of massive plutonic rocks, as diorites and granites, such as are to be found in the neighbourhood. They are not the metamorphosed representatives of sedimentary beds, as are the mica schists to the north-eastward of the Frenchman's Hill.

The examination shows that in the metamorphism of the gneisses the original minerals have differently resisted the forces acting upon them. The felspars have been crushed, broken and rounded off, but hardly, or at all, distorted or stretched. The quartz, on the contrary, has not only been crushed and broken, but it has become so plastic as to be found in long drawn out and eventually bent portions. The detrital material has been regenerated mostly as biotite, and apparently there is most biotite in the most disturbed portions. It has also produced muscovite, and more rarely intergrowths of quartz and orthoclase in the graphic manner, as micropegmatite. The felspars can be recog nised as being original crystals which existed in a rock apparently analogous to these massive plutonic rocks, which occur in the same locality.

The quartz of the foliatures is of two kinds—original quartz grains which have been crushed, and, in a much greater amount, quartz which has been produced in the form it now has during the metamorphic action.

It seems to me to be now clear that the crystallised schists of the Omeo district are, as I indicated before, of two kinds. Mica schists which have been formed by the metamorphism of Lower Palæozoic sediments, and gneisses which have been formed by the metamorphism of quarts diorites and granites. Where the sedimentary rocks and the plutonic rocks have both been involved in the same process, the mica schists of the one and the micaceous gneisses of the other appear as a passage from the sediments to the igneous rocks. In Green Wattle Creek and at Wilson's Creek the two classes of schists are seen separated. At Dargo River and at Marengo where the two sets are in contact metamorphism has taken place, thus masking the true character.

It may be accepted as a preliminary distinction that where felspars occur in the schists, and more especially where they are surrounded by detritus and form "eyes" in the foliations, the original rock was plutonic; but when the rocks have no felspar, but are composed of merely mica and quartz, the original rock was a sediment. Yet these distinctions are not hard and fast, for the complete comminution of a plutonic rock might give rise to a regenerated schist composed of biotite, mica and quartz. One of the most suggestive observations which I have now made is that the quartz of these schists has been far more plastic than the felspars. Why silica should be so rather than a silicate of alumina and alkali, which is less refractory to high temperature, I do not at present see. But this is certain, that the quartz has been drawn out and bent, while the felspar has been broken. It may be that the action has not been merely that the constituent minerals of the rock have become free to re-arrange themselves by reason of the enormous pressure to which they have been subjected. It has seemed to me that solutions must be taken into account. Yet the rock itself has not gone into solution for the felspars remain intact excepting in so far that mechanical action has broken them.

So little, however, is yet known of the behaviour of mineral substances under great pressure that it is but wise to refrain from endeavouring to explain those phenomena which present themselves as exceptional.

My results so far seem to me to support the views enunciated by Professor Lehmann as to dynamo-metamorphism, at p. 33 of his great work on the *Crystalline Schists of Saxony*. (Alt krystallinischen Schiefergesteine. Bonn, 1884).

Put shortly, they are these:—Rocks which by reason of great earth-stress, not only assume new forms of structure, but also are compelled to adapt themselves to a less space and eliminate constituent substances. Most energetic re-combinations of substance accompany the deep-seated crushing of rock, and any open fissures become filled with secretions. This can, however, only take place under such superincumbent weight as will suffice to prevent an actual disruption of the rock, and such phenomena are usually only apparent in the heart of mountain chains. Such secretions can only exude when the pressure in the rocks exceeds the limit of plasticity, and there is a want of compensating counter pressure which causes the disruption of the whole system of beds. Lehmann believes that it is at such a time that the granite magmas enter the fissures and mix with the secretions of the metamorphosed rocks.

Many observations which I have made in the Omeo district support generally these views.

In conclusion, I may say that the examination of the samples of rock from the margin of the metamorphic rocks at Dargo and at Marengo lead me to conclude that the limit of the metamorphosed sediments is reached in the former locality when the schists become filled with foliations of biotite, and show traces of felspars; and at Marengo where the quartzose pressure-gneisses commence.

2.—CHALK AND FLINTS FROM THE SOLOMON ISLANDS.

By A. Liversidge, M.A., F.R.S., Professor of Chemistry in the University of Sydney.

The following notes are upon some specimens collected by Mr. Charles M. Woodford in the Solomon Islands, and sent by him to me for examination and description.

The specimens consisted of the following:—

1. Water from a hot spring, Savo Island. (See separate note for description.)

2. Rock from "Stoneheap," in the crater of Savo Island.—This is a greyish coloured crystalline trachytic rock, containing small but fairly well formed felspar crystals.

3. Rock from "Stoneheap," in the crater of Savo Island.—This is apparently a solfatara deposit, white and friable, and closely resembling the deposit from New Zealand and other solfataras.

4. Rolled Pebbles, from Belisima River, Guadalciva Island.—These are evidently fragments of one of the older crystalline rocks, and resemble gabbro in appearance. They are of importance, since they indicate the presence of the older rocks in these islands, and if time permits, a fuller examination will be made of them.

5. A hard compact limestone with a minutely crystalline structure, from Isabel Island.

6. Two specimens from Florida or Gela Island.—These somewhat resemble chalk in appearance, but the amount of carbonate of lime present is not great; they are soft, granular, and grey in colour, with a minutely crystalline structure.

After being acted upon by strong hydrochloric acid, the larger fragments retained their original form, and the residue was found to consist of sharp quartz particles and rock *debris*, hence this rock is probably largely made up of volcanic ash and other materials, cemented together by calcium carbonate.

Analyses of somewhat similar specimens from Vati and Mallicolo, New Hebrides, are given in the *Jour. Roy. Soc. of N.S.W.*

for 1883.* Hence it was considered unnecessary to further examine these specimens from Florida Island.

7. Chalk from Ulawa Island, together with flints set free from the same.—Both the chalk and the flints closely resemble those of the south coast of England; the chalk also closely resembles that from New Ireland, (See "On the Occurrence of Chalk in the New Britain Group," by A. Liversidge, *Jour. Roy. Soc. of N.S.W.*, 1877); except that in the particular specimens of the Ulawa chalk examined by me, foraminifera are not so abundant as in the New Ireland chalk, nor are there very many sponge spicules.

The specimens are all rolled, and could not by mere inspection be distinguished from those found at the base of the English chalk cliffs.

I did not consider it necessary to make a complete analysis, but the amount of calcium carbonate and soluble matter was determined and found to be 93·66 per cent., hence in composition the rock is essentially a chalk; the insoluble residue, 6·33 per cent. is gelatinous, of a pale brownish colour, and is composed of particles of silica and the usual rock *debris*. The differences, between a chalk and a limestone are, apart from geological age mainly physical.

8. Flints set free from the above chalk, Ulawa Island.—Some of the flints are not distinguishable in appearance from English chalk flints, but others are rather more chalcedonic.

In all, there were ten specimens of flint, and the specific gravities of four were determined.

1. A brown chalcedonic flint, more or less translucent and with a well marked conchoidal fracture, had a sp. gr of 2·21 to 2·22.
2. A dark smoky flint with whitish spots and markings, and outer skin or crust, so common on chalk flints, well marked conchoidal fracture. The whitish coating varies from $\frac{1}{16}$ in. to $\frac{1}{8}$ in. thickness. The sp. gr. of two pieces were found to be 2·39 and 2·36.
3. A pale brown chalcedonic flint with white films running through it, fissured; well marked conchoidal fracture, but breaks into small pieces on account of the numerous fissures. The sp. gr. was found in different pieces to be 2·23, 2·24, and 2·23.
4. A greyish-coloured flint, with a platy or laminated structure. The fissures between the larger plates little chalk. The sp. grs. of three pieces were found to be 2·15, and a porous specimen 2·23.

* "On the Composition of Some Coral Limestone from the South Sea Islands," by A. Liversidge.—*Jour. Roy. Soc. of N.S.W.*, 1880.

Sections were made of these flints, but no recognisable organic structure was met with in the pieces examined.

The following notes on the occurrence of flints in the Solomon Islands are from Dr. Guppy's letters :—

"These flints are commonly found in the island of Ugi, embedded one or two inches below the surface soil, and are exposed in numbers when the soil is disturbed for purposes of cultivation. I have seen similar flints from the opposite coast of St. Christoval, where they occur under similar circumstances. In Ugi they are found on the low land which fringes the coast, which varies in elevation from five to twelve or fifteen feet above the high-water level; fragments of decayed coral and portions of shells are frequently intermingled in the soil where flints are found. In addition to common flint, which composes the majority of these masses, fragments of chalcedony, carnelian, and a jasper also occur. If I remember aright, all the specimens which I send are fragments of nodules. Their resemblance in some instances to flint implements of the palæolithic age is worthy of notice; one flake is coloured white, and reminds one of the similarly shaped flakes of the Post Tertiary gravels. The prevailing rock of the island of Ugi is an earthy foraminiferous limestone.

I made a careful examination of the natural sections of this rock, which were displayed in the deep gorges worn by the streams, but I never came upon embedded flints. I am informed by resident traders that flints are abundant on the beach of the island of Ulawa, together with fragments of a white rock like chalk. I was unable to visit the island of Ulana.

I may state that in my short experience I have met with islands of very varied geological character. The large islands, such as St. Christoval and Florida, appear to be formed of an axis of primitive eruptive and metamorphic rocks, flanked by more recent volcanic formations, and fringed near the coast by elevated coral-limestone, reaching to a height in some instances of several hundred feet above the sea. In Florida I traced the coral-limestone, often indistinguishable from the compact rock of the existing coral reef, to a height of 900 feet above the sea.

Then comes the volcanic type of island, *e.g.*, Simbo, which is entirely of trachytic rocks, and still retains an old funnel-shaped crater, a solfatara, numerous fumaroles, even on the highest summit, and boiling springs.

Then we have the raised atoll, such as Santa Anna, which, elevated some 500 feet above the sea, offers interesting confirmation of Mr. Darwin's theory of coral islands.

In one instance I succeeded in finding, *in situ* beneath the crust of coral rocks, the crystalline eruptive rocks of the original island before it underwent subsidence and became clothed with coral.

The island of Ugi presents yet another variety of geological structure, a low-lying island; it is composed of bedded foraminiferous limestone, once incrusted with coral-rock, which is now to a great extent removed by denudation; flints occur in the surface soil, though I have not yet found them *in situ*. I intend, however, to continue my observations on this island." —*Jour Roy. Soc. N.S. W.*, 1883.

3.—THE PLUTONIC AND METAMORPHIC ROCKS OF BATHURST, NEW SOUTH WALES.

By W. J. Clunies Ross, B.Sc., F.G.S.

At the last meeting of the association I contributed a short paper on "Metamorphism and the Rocks of the Bathurst District." I should hardly have brought forward another paper on a similar subject but that Mr. Stirling informed me that it was proposed to make the study of the metamorphic rocks of Australia a special feature at the present meeting, while at the same time he courteously invited me to contribute something on that branch of geology.

During the past year I have had the opportunity of studying some of our rocks in more detail than I had previously done, and I therefore propose to give a short account of some of them, both as to their description and mode of occurrence, and to exhibit specimens and sections in illustration of my remarks. On reading Mr. Howitt's interesting paper on the metamorphic rocks of Gippsland, which was published in the last volume of Proceedings, I was struck with the similarity of the geology of that area to that of the Bathurst district, although there appear also to be considerable differences. I am not personally acquainted with the Gippsland rocks, with the exception of a few small specimens lent me by Rev. J. M. Curran, F.G.S., but shall be glad to learn from those familiar with them whether they at all resemble our Bathurst rocks. I do not propose to deal with the geology of the Bathurst district, but to confine myself to recording my own observations on the two groups of plutonic and metamorphic rocks. I use the term plutonic advisedly, to indicate the holocrystalline intrusive rocks of the granitic type, as being tolerably well understood, and not committing one to any particular theory as to their origin.

Before proceeding to deal with the rocks themselves, I may say, for the benefit of those not acquainted with our district, that Bathurst is built on granite, which extends for a considerable distance round the town and that outside the granitic area we come to a series of metamorphic rocks. The granite is covered in places by basalt, and also by drifts, but these do not concern us now.

The rock on which the town is built is very much decomposed, and although it often appears solid, crumbles away at once before the hammer. Closer investigation shows that it is made up of coarse grains of light-grey or white felspar, much decomposed, a fair amount of quartz, and a little black mica (biotite). In places there are patches composed almost entirely of this mica, but soft and crumbling like the rest. It is sometimes a little difficult to say whether the rotten granite has decomposed *in situ*, or whether the materials have been washed down from a higher level. In some cases no doubt the latter is the case, as bands of pebbles occur at a considerable depth from the surface. On the higher ground, however, the granite has no doubt decayed where we find it, and it is often traversed by hard veins, which are very distinct from the surrounding matrix. These veins appear to correspond very closely to some of those described by Mr. Howitt as occurring in the granite of Gippsland. They vary in thickness from less than an inch to about a foot, and may be traced sometimes with great regularity for a considerable distance. In texture they vary greatly, some being excessively coarse-grained, the crystals of pink orthoclase and quartz being several inches in length. These crystals are sometimes coated with fine scales of white mica, while coarse plates of brown mica (muscovite) are also found occasionally, but are not very common. Other veins, however, are very fined-grained, almost micro-crystalline, and are a good deal like some Cornish elvans. Mr. Howitt calls his veins aplite, and considers they are all intrusive, I believe. Ours may also be intrusive, but I am yet not quite convinced that they are so in all cases. Some of the veins are found in the heart of the granite quite close to Bathurst, while others occur at the junction with the schists into which narrow veins sometimes penetrate, but for no great distance. Besides the rotten granite described above, we have plenty of the solid material in the neighbourhood. At several places near the town, hard bars of a coarse-grained variety of granite come to the surface, and it may also be found at many other places by sinking a few feet, so that it is quite possible that it extends under the whole area, but there have not been enough deep wells sunk to decide the question. The felspar in the hard granite is white or light grey, but sometimes is in large crystals of a reddish colour. The latter variety is doubtless orthoclase, and also much of the white, but there is likewise a good deal of plagioclase. I have not thoroughly analysed the felspars, nor am I aware that any analyses have been made. It would be interesting to learn their exact composition, and a more complete examination of their optical characters than I have been able to make as yet would also be interesting, as already I have noticed several peculiarities of structure which would repay further investigation and probably throw some light on the manner in which the crystals have been formed. Besides the felspar, there is a good deal of quartz and biotite, as well as hornblende. The mica and hornblende are generally very opaque, so that except in very thin sections it is difficult to study their optical characters. Scattered through the coarse-grained rocks are patches of much finer grain consisting largely of mica, and at first sight suggesting the idea that they are extremely altered inclusions of slate, but as they occur in the very heart of the granite they can hardly be such. Besides the normal constituents, various accessory minerals are developed such as sphene, while, where the granite is slowly decomposing, I have detected calcite and prehnite filling cracks in the rock.

It is probable, but not certain, that the rotten granite has resulted from the decay of the hard variety, and that the latter owes its preservation to some local difference of texture and composition.

As we travel out from Bathurst, and approach the metamorphic rocks, the granite seems to change its character. The hornblende disappears, the biotite is partly replaced by muscovite, and the felspar becomes distinctly red; so that, near the junction, the rock appears to be entirely different from the one we have studied at Bathurst. It may really be distinct and of different age, or, on the other hand, the change may be a gradual one; but, owing to the surface rock being generally so much decomposed, it is difficult to decide the question. I hope to continue my study of the Bathurst granites, as I consider them a very interesting group of rocks; but for the present we must leave them. Before doing so, however, it may be of interest to mention that the area over which they form the surface rock is tolerably extensive, being something like 450 square miles.

On proceeding outward from Bathurst in any direction, one finds, at a distance of about eight miles in some directions, ten or twelve in others, that one has passed off the granite and entered a metamorphic area. Even in travelling along roads the transition is seen to be abrupt, but good exposures of the junction are not very easy to find. By examining railway cuttings and creeks, however, a good many very satisfactory sections may be obtained. In all of these that I have seen the granite finishes abruptly against a much darker rock, and there is no sign of a gradual passage from one to the other. The junction line, moreover, although so sharp, is not a straight line, but winds about in such a manner that there can be no possibility of a faulted junction, while small veins from the granite run into the contiguous rocks. These veins are very narrow, and often one about an inch in thickness can be traced for thirty or forty feet as straight as if the boundaries had been ruled. The rock abutting against the granite is rather an interesting one. It is, in most cases, an evidently foliated rock, but can hardly be called a typical mica or hornblende schist. In some cases it is rather coarse-grained, and almost gneissic in appearance, while in others it is very fine-grained, and suggests a felstone. Examined under the microscope, it is holocrystalline, largely made up of quartz, with a good deal of mica, probably biotite, perhaps a little hornblende, but with more of a rather indefinite greenish mineral, which may be called viridite in default of a more definite name. In the coarser grained varieties felspar may be recognised, while even the closest specimens I have found show a distinctly schistose character when cut.

This rock may be found at Locksley, to the south-east of Bathurst; at Peel, to the north-east; near Vittoria, west; Wimbledon, south-west; as well as at intermediate points, some of these places being more than twenty miles apart. On first viewing some of these rocks, one is tempted to consider them as igneous and intrusive, but on comparing a large series of specimens from different localities, one finds so many intermediate gradations that it appears almost certain that they are of essentially similar character, and are probably a very good example of contact metamorphism produced by the granite, partly by heat and partly by the introduction of new, especially silicious, matter, and that they form a fringe completely surrounding the granite.

As we pass off the contact rock, we find that the character of the rocks soon changes. At Peel we find a rather curious spotted schist, *i.e.*, a silky-looking schist with numerous black spots. I have not critically examined the spots, but doubt if they are of one definite mineral. The schists reminded me of some of those found in Cumberland, in the neighbourhood of the Skiddaw granite. I have searched, but hitherto in vain, for chiastolite, slate or schist so well known in Cumberland. The spotted schist passes into a series of silky slates, or schists which may be called phyllites, and these again, near Vittoria, into soft black slates, not unlike the Skiddaw slates. To the east of Bathurst I have not seen any well cleaved slates, but rocks of various types occur, such as gribs filled with casts of brachiopods, especially *Spirifer disjunctus* and *Rhynconella pleurodon*, and a few corals. There are also limestones with encrinite stems. Some of these rocks are traversed by dykes of felstone and dioritic rocks, mostly highly silicious. The slates and similar rocks are probably Upper Silurian or Devonian. Rather to the north of Bathurst we find a series of massive rocks of slaty character, but with no distinct cleavage. I have found no fossils in these as yet. To the south we have an interesting area, near the old mining township of Cow Flat, now nearly deserted. The rocks in this district are highly metamorphosed, some of them being more gneissic than any other I have seen in our district, although even these are hardly typical gneiss. They are, however, foliated rocks containing quartz, felspar, and mica. These gneissic rocks appear to be interbedded with micaceous schists and crystalline limestones; the latter being pure white or cream-coloured, with bluish veins.

The celebrated petrified man is thought by some to have been formed of Cow Flat marble. There are numerous quartz veins traversing the schists, and the phyllites are often very much crumpled and contorted. Quartz reefs are common in all the slate country round Bathurst, but are seldom auriferous. The Cow Flat copper mines were once rather extensively worked, but have now been closed for several years. In the case of the carbonate ores I was informed that they sometimes found lumps of unaltered limestone in the centre of masses of carbonate of copper, thus indicating that the copper had replaced the lime. The rocks about Cow Flat are too much altered for one to have much hope of finding fossils, but they may very possibly be Lower Silurian.

To the east and west of Bathurst the rocks dip roughly in those directions respectively, and there seems little doubt that the area represents the crest of an anticlinal. An immense amount of denudation must have taken place, all the overlying rocks having been removed, and a considerable thickness of the granite itself. To what height the granite originally reached is uncertain, but drifts resting on granite are now found at least 400 feet above the town. The so-called Bathurst plains really form a plateau, about 2300 feet above the sea, surrounded by higher ground.

The rate of denudation of the granite would probably be rather rapid, to judge from the speed with which the gullies and creeks are now formed and deepened by the present low rainfall. The numerous gullies, with vertical walls from ten to twenty feet deep, struck me very much on first arriving from the old country, being quite new to me, and bearing a ridiculous resemblance in miniature to the pictures of the cañons of the Colorado, and also bearing some resemblance to the scenery of the Blue Mountains on a very small scale.

We have, then, in the Bathurst district a rather extensive granitic area surrounded by one at first of contact, and afterwards of regional metamorphism, if we use the latter term to include cases in which sedimentary rocks have been converted into slates and phyllites. If, however, we mean by regional metamorphism an extensive area made up of true gneiss, crystalline schists and limestones, such as one finds in the Highlands of Scotland, then it must be admitted we have not such an area about Bathurst. I am conscious that in giving this short account of a few rocks, I have not brought forward anything which can be considered novel or striking, and that I have only dealt with a small part of one district of New South Wales. The descriptions, however, may be of interest to those engaged in the study of metamorphism, and the specimens exhibited will serve for comparison with those of other areas. It may thus be possible to form an opinion as to whether the upheaval which produced our Bathurst anticlinal is likely to have been connected with the upheaval and metamorphism of Gippsland and other districts of Victoria and New South Wales. The most probable date of our upheaval seems to be about the close of the Devonian period. When I first made the acquaintance of the Bathurst rocks, I had hopes that I might be able to trace the passage from a true sedimentary rock to a typical mica schist, and thus do something towards settling the question of the origin of the latter class of rocks. Unfortunately, I have not been successful in finding anything which a critical authority would be likely to admit as a true crystalline mica schist. It is true that some of our schists and phyllites bear some resemblance to the so-called pebidian rocks of Anglesea. Pebidian, it will be remembered, was one of the divisions into which Dr. Hicks proposed to divide Archæan rocks. One is not sure, however, whether pebidian has not now been given up even by its author.

In my paper of last year I expressed the opinion that the problems of metamorphism could only be settled by each observer studying, and, if possible, mastering the rocks of his own area, and recording facts without much regard to theory. I have not, by any means, mastered the Bathurst district; indeed, the more I study it the farther I seem to be from mastering it. I have, however, tried to record a few facts, and these I now present for what they are worth.

Before concluding, I should like to say that in my work in the field during the past year I have several times been accompanied by the Rev. J. M. Curran, F.G.S., with whom also I have had the advantage and pleasure of discussing the various problems which presented themselves. I must also acknowledge my indebtedness to one of the students of my geology class, Mr. W. Pascoe, who very kindly ground and mounted a series of sections. Some months ago I sent a collection of rocks to England to be cut and submitted to some of the leading English petrologists. The slides have not yet come to hand, and had it not been for Mr. Pascoe's kindness I should have been at a great disadvantage, as I had not time to grind the sections myself.

4.—NOTES ON THE DEVELOPMENT OF QUARTZITE, MALDON.

By Jno. Hornsby.

5.—NOTES ON THE CRYSTALLINE ROCKS OF BETHANGA, VICTORIA.

By FREDK. DANVERS POWER, F.G.S.

[*Abstract.*]

THE township of Bethanga is situated about three miles east of the junction between the Upper Murray and Mitta Mitta rivers. The rocks in these parts consist of crystalline schists pierced with granite veins. The former insensibly pass from one variety to another, but the granite veins which intersect the schists are sharply defined, and there is no transition rock between them. The schists have a distinct bedded structure, striking 30 deg. east of north, and show a system of fine anticlinal and synclinal curves, which also divert the granite veins. The main ranges in these parts run 20 deg. east of north, *i.e.*, about parallel with the Australian Alps to the east, and also parallel to the coast in these latitudes. From the fact that a fairly continuous range of mountains runs parallel with the coast line so tenaciously from North Queensland down to Victoria, it is only natural to suppose that whatever the original force that caused our continent to assume its present form, it is the lateral pressure of the ocean on our coast that has a large say in the formation of our mountains. Dr. W. D. Carpenter, in a paper read before the Royal Institution of Great Britain, in January, 1880, on "Land and Sea. Considered in Relation to Geological Times," says that the largest mountain chains characterise the borders of the greatest ocean, showing that the lateral pressure from the direction of the ocean was approximately proportional to the extent of the oceanic basin. Lateral pressure and other earth movements commenced early in the earth's history, and continue to the present day, but since the older rocks have been subject to these influences for a longer period than the younger ones, they are more likely to be tilted up, contorted and altered.

The spurs of the Bethanga ranges tend to run in the direction of 60 deg. to 70 deg. west of north. Now, on referring to the map of Victoria, although the coast in these latitudes runs parallel with the main ranges, still, at the south-west and south of Victoria, the coast takes a turn 50 deg. east of north, and 80 deg. west of north respectively; so the pressure of the ocean in these parts would also influence, in a minor degree, the formation of our mountain system. There are, besides, other varying factors to be considered, *e.g.*, the shifting of the coast nearer or further from the ranges, the pressure of accumulated rock, the contraction consequent on the cooling of the globe, &c. Lateral pressure coming from two or three directions would tend to cause a tortional strain which would rupture the rocks and otherwise

affect them. The common strike of the Bethanga lodes is between 20 deg. and 30 deg. east of north. They are in reality strike faults, cutting the country rock obliquely at a high angle. Passing through the different bands of rock in this way is found to greatly influence the richness of the lode. Pressure causing the folds in the country rock, no doubt defined the lines of weakness by drawing out the legs of the curves; a gradual horizontal motion then took place, as may be seen by the highly polished and striated nature of the *Gangthonschiefer*, which sometimes occupies the whole space between the walls when in gneiss rock; and also by the striations on the polished faces of the quartz when lying on quartz, the striations having a horizontal direction, sometimes with a slight dip to the south; also a mineral once formed may be found to be broken up and cemented together again, giving some parts of the lode the appearance of a quartz and pyrites breccia. The lodes have a steep underlay to the west. I do not think the rocks have been much displaced by faulting, as the rocks on each side of the lode do not differ much from each other. The dig, partings of clay, and rubbed-off pieces of country rock found among the lode material, go to uphold the theory of gradual movement, which probably took a long series of years.

The lode is most productive when it passes through belts of altered granite of a greenish hue, containing white mica. This granite, being unable to give to the strain brought to bear on it, has fractured and broken up more than the gneisses, so that waters carrying minerals in solution, being relieved of their pressure when percolating in the open spaces between the broken off pieces of rock, would deposit their over-burden, and would also meet with precipitating agents in larger quantities than in tighter rocks. When the lodes cross hard garnet gneiss, the deposit shows little or no metalliferous minerals. This rock seems to have adapted itself to circumstances, and slid over itself, forming a series of lenticular masses, containing much chloritic minerals, which appear to have served as a lubricant, the lenses fitting so tightly as to have left no space for foreign deposits.

The lodes and rocks in the vicinity of the upper township are dislocated by a dip fault, which is occupied by a dyke of amygdaloidal diabase. The heave is about 125 yards; this must be a horizontal displacement, as the underlie of the lodes is so steep. The dyke, which is 8 feet wide, strikes 85 deg. east of north, and dips at a high angle to the north. Even where not seen, this dyke makes its influence felt; on driving from the "Gift" shaft towards the other side of the gully, the country was found to be much broken up, and there was an influx of water; the dip joints of the granite exposed in a quarry near the "Excelsior" shaft are so frequent as we near the dyke as to give the rock quite a fissile character. A lode formation in H. Uren's paddock, situated east of the "Gift" and "Excelsior" lines, strikes 35 deg. east of north, but as it goes further north, to where the strike of the dyke would cut it, it has turned 45 deg. east of north. As the easterly lode formations tend to bend out of the prevailing course towards the east more than the westerly ones, I rather fancy this dyke will prove to die out about a mile east of the "Excelsior" shaft, as the rocks are evidently strained there, but not sufficient to bring them to the breaking point. This dyke runs fairly parallel with the lay of the chief mountain spurs, and was formed after the lodes which it displaces; it was also sudden in its formation, to allow the molten rock to take its present position, and not slow like the lodes.

I consider that the crystalline schists of Bethanga belong to the earliest sedimentary rocks, which were deposited mechanically, and probably chemically, and that intrusive granite in tongues were forced through the deposits along their bedding planes, the whole being afterwards folded into anticlinal and synclinal curves by the same terrestrial movements that caused our mountains, but chiefly by the lateral pressure of the ocean on our eastern coast. A system of strike and dip joints, having approximately the same bearings, being seen both in the crystalline schists and granites, but especially distinct in the latter, show that both classes of rock have been subjected to the same strains; and since they have been affected somewhat differently by these forces, and show no transition from schists into granite, or *vice versâ*, they must have been different in their origin. The regional metamorphism, due to intense and continued pressure, has left traces in the granite, where the mica frequently shows a tendency to arrange itself in lines parallel with the strike. Black mica is mostly found in the body of the rock, while the white mica occurs on the joint faces. Bands of hard, dark granite course through the country in a more easterly direction than the softer granites, and appear to be of a later date. The same earth movements, assisted by water, caused the early sediments to change their physical and mineral composition. We hear much about the heat given off by chemical and mechanical means playing an active part in the metamorphism of our rocks. I am inclined to think that the value of this agent is much exaggerated, for in regional metamorphism, due to pressure, the force will be exerted gradually, during which time the rocks will both conduct and radiate the heat away. Terrestrial forces are being exerted at the present day, and yet we do not notice any extraordinary change in the temperature of the rocks; tests made to determine the temperature at different depths vary so much as to be of no practical universal value. Chemical heat, again, we know to be great, but much of our direct knowledge is obtained from underground workings, which expose a larger surface of oxidisable minerals to the action of the moist atmo sphere than would occur naturally in the fine cracks and fissures of a rock, where the action would be slower. Moreover, it is highly probable that, although we may be able to form many minerals artificially, both in the wet and dry way, still, similar minerals may not always be constructed by Nature according to our methods ; for natural solutions are so much weaker than those used in the laboratory, besides being impure, and time is no object; so we cannot say for certain that such and such a reaction took place among the many possible combinations, although we may be aware of the final result.

I further consider that lines of weakness having been determined along legs of the anticlinal and synclinal folds, a tortional strain caused a gradual displacement for a few feet, giving mineral solutions an opportunity to deposit their burden between the fractured particles of rock. The tortional strain that caused this movement culminated in a crack, which was filled with diabase ; the rocks thus relieved of the strain sprang back in opposite directions, causing a total lateral displacement of 125 yards. That this took place after the lodes were formed, and the original country rock was metamorphosed, can be seen by the faulting of the lodes, and by examining the *horses* of country rock enclosed in them.

6.—ON THE APPLICATION OF PHOTOGRAPHY TO GEOLOGICAL WORK.

By J. H. Harvey.

7.—ON THE GEOLOGICAL STRUCTURE AND FUTURE PROSPECTS OF THE THAMES GOLDFIELD, NEW ZEALAND.

By James Park, F.G.S., Director, Thames School of Mines.

Although over twenty-two years have elapsed since gold was first discovered at the Thames, the geology of this goldfield has always been a subject of much discussion among New Zealand geologists, and even at the present time the most opposite and divergent views are held by different authorities, both as to the structure and true character of the rocks themselves.

The mining operations of this field have so far been confined to an area little more than a square mile in extent, and as the more accessible and readily obtainable gold is being rapidly worked out, the question of deep-sinking and going further afield must sooner or later claim the attention and serious consideration of mining men and those dependent upon the production of gold. It is abundantly evident that the time has arrived when the future prosperity of the field must depend upon the successful development of new ground, and in order to accomplish this, we must possess an intelligent knowledge of the structure or arrangement of the gold-bearing rocks, and the character of the reefs. When we are in possession of these, as well as the experience accumulated during twenty years of successful mining, we will be in a position to direct prospecting operations so that they may be conducted in the most favourable places, and the money devoted to this purpose expended to the best advantage.

With this object in view, in the beginning of September of this year, I commenced a detailed survey of the line of section extending across the field from Tararu to Hape Creek, the results of which are embodied in this paper.

General Structure.

The rocks of this goldfield, as disclosed by the above line of section which supplies the key to their structure, divide themselves into three distinct formations as follows:—

1. Slaty shales and silicious mudstones.
2. Felspathic and tufaceous sandstones, passing into breccias, with gold-bearing veins.
3. Coarse volcanic breccias and tuffs, with coal and coaly shales at base.

The slaty shales and associated rocks form the old floor of the district, upon which rest unconformably the two succeeding formations, between which no marked break or unconformity exists. Between Shellback and Hape Creeks, these younger formations are arranged as an anticline, the dome of which, formed by the coarse volcanic breccias and tuffs, has been largely denuded, thus exposing the gold-bearing series below. Near the core of the anticline, which is situated between the Saxon mine and the old Queen of Beauty shaft, the strata are inclined at high angles, being much disturbed, but towards the sides of the anticline they are lying flatter, the dip varying from 30 to 50 deg.

Section from Bonemill Creek to Hape Creek.

The first rock seen on this line of section after passing Bonemill Creek is a tough grey-coloured felspathic rock, containing nests and disseminated grains of iron pyrites. It decomposes to a great depth from the surface into a rusty-coloured tufaceous-looking rock. It is intersected by a number of parallel joints, sometimes showing slickensided surfaces. The joints run N.N.E.-S.S.W., and are almost vertical.

About five chains south of the mill, following the beach in the direction of the Thames, this felspathic rock is followed by an intensely hard greenish-coloured volcanic breccia, often containing large rounded boulders or masses of andesite, numbers of which occupy the beach for a further distance of five chains. This breccia frequently passes imperceptibly into a fine-grained green tufaceous sandstone, which, at a casual glance, might be mistaken for a solid lava or dyke rock. Like the underlying grey felspathic rock near the mill, these rocks decompose to a considerable depth into rusty-coloured sands and clays. About three chains past the second point the breccias rest upon a highly-denuded surface of blue and grey-ribboned slaty shales. Near the point of contact the breccias contain small rounded fragments of blue shale and jasperoid quartz, as well as numbers of large well-developed crystals of iron pyrites.

The old rocks consist of hard blue and grey slaty shales, showing very distinct lines of stratification. Their strike is somewhat irregular, the dip varying from S.S.W. to W.S.W. at angles of 26 deg. or 30 deg. They are exposed on the beach at highwater mark, their outcrop measuring about 60 feet by 100 feet. At low-water mark they are seen to be interbedded with, and to pass upward into, grey and yellowish-coloured silicious mudstones, which dip S.S.W. at angles varying from 45 deg. to 70 deg. The actual point of junction can be seen to great advantage on the beach, between high-water and low-water marks. At their base the mudstones are of a bluish-grey colour in the solid, weathering to a pinkish-grey on the surface. They are highly pyritous, and are interlaminated with thin layers of grit, consisting of small rounded particles of hard mudstone, mostly of uniform size. The ribboned shales contain similar grit layers near their upper surface.

Passing southward, the fine-grained silicious mudstones rise into steep rugged cliffs, and form Rocky Point itself. About three chains past the point they terminate abruptly, and are followed unconformably by very hard green tufaceous sandstones, containing small angular blue slaty fragments. At the mouth of Waiohanga Creek may be seen large boulders of these sandstones, containing angular masses of blue shale. These boulders were, no doubt, brought down by that stream, which cuts across the outcrop of the older rocks in the upper part of its course.

On the beach near Waiohanga Creek the tufaceous sandstones are intersected by a number of parallel veins, many of which are filled with material derived from the enclosing rock. They strike N.E.-S.W., and are generally standing vertical. The two largest veins are four inches and six inches in width respectively. The smaller of these divides near high-water mark into two distinct veins, one of which joins the larger.

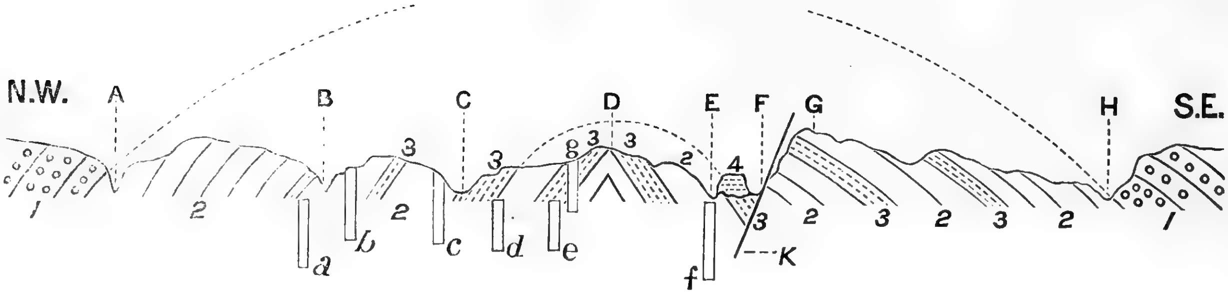
A few chains further along the beach, still going in the direction of Tararu, veins of pyritous quartz and large segregated masses of calcite are plentiful. In the road cutting under Tararu Cemetery the tufaceous sandstones dip S.S.E. at an angle of 40 deg., and soon after passing Tararu Creek the dip changes to the north-west, the strata thus forming a syncline, by means of which the whole of the sandstones and breccias just described are again repeated before the boundary of the goldfield proper is reached.

A few yards past Magazine Point the coarse volcanic breccias and associated rocks rest upon the upper member of the auriferous series, which is well exposed at Kurunui Creek. There does not appear to be any unconformity or stratigraphical break between the two formations, but the line of junction is very plain, the character of the sediments of each being very distinct.

The auriferous series consists of grey and yellowish-grey and sometimes ferruginous sandstones, which alternate with wide belts of hard greyish-blue, coarser-grained sandstone, often of a felspathic nature. The former are of moderate hardness, are generally highly decomposed, and at the surface look as if at one time they had been permeated in every direction by thermal waters. The gold-bearing veins are almost exclusively confined to the softer decomposed sandstones. In places the harder sandstones pass imperceptibly into angular breccias, which weather on the surface into bright-coloured clays, being very subject to decomposition by atmospheric agencies.

From Kurunui Creek to the Waiotahi the strata dip to the north-west at angles varying from 40 deg. to 50 deg., but after passing the latter place the dip rapidly steepens, and soon after passing the Saxon shaft becomes vertical, and then changes to south-east, the core of the anticline passing through a point between the Saxon mine and Waiokaraka Gully. From the latter place to Hape Creek the whole of the auriferous rocks are repeated. The low flat spur lying between the Karaka and Waiokaraka is composed of a series of flat-lying bedded clays, sands, silts, and coarse cemented gravels, which from their situation must have been formed by the former during Pleistocene times. At Hape Creek the gold-bearing strata disappear below the coarse volcanic breccias and tuffs which follow in the order of their superposition.

The following sketch illustrates the arrangement of the gold-bearing strata and the position of some of the principal mines along this line of section :—



Section across Thames Goldfield from Kurunui Creek to Hape Creek.

A—Kurunui Creek. B—Moanatairi Creek. C—Waiotahi Creek.
D—Waiotahi Hill. E—Waiokaraka Gully. F—Karaka Creek.
G—Una or Murphy's Hill. H—Hape Creek. K—Moanatairi fault.

1—Volcanic breccias and tuffs. 2—Gold-bearing country.
3—Hard bands of barren country. 4—Pleistocene deposits.

Summarising the evidence disclosed by the above section, we find that there are three great formations of sub-aqueous origin represented on the Thames Goldfield. Tabulating them according to their probable age, they are as follows :—

1. Upper Eocene—volcanic breccias and tuffs—Mount Brown series.
2. Lower Eocene—auriferous series—grey marl series.
3. Palæozoic—slaty shales, &c.—Te Anau series.

1.—*Upper Eocene.*

This formation covers by far the greater part of the peninsula. It consists of a great succession of trachyte tuffs, andesite-breccias, and fine-grained tufaceous sandstones passing into dirty greenish-coloured grit beds. Its thickness varies considerably, but is generally between 1200 feet and 1500 feet. It is frequently intruded by dykes of hornblende-andesite, augite-andesite, and trachyte. A fine example of the former may be seen on the coast three miles past Tararu, and of the latter in the valley of the Kauaeranga, opposite the Orphanage. Veins of jasperoid, chalcedonic and opalline quartz, calcite and ironstone are not uncommon in the breccias and finer-grained tufas; but no gold-bearing quartz, so far as I can ascertain, has up to the present time been found in this formation.

In a bed of blue tufaceous clay exposed in a road-cutting on the beach, about two miles north of Tararu, there occurs a quantity of selenite, as well developed crystals and radiating fibrous masses. Near their junction with the underlying auriferous series the breccias often contain large quantities of silicified wood, as at Hape Creek and Kauaeranga, and thin seams of brown coal and coaly shales, as at Paeroa and Owaroa. The presence of the latter would indicate an approach to land conditions at the close of the Lower Eocene formation, but, as has already been stated, there is no stratigraphical break to mark an unconformity. At Waiohanga they overlap an isolated rocky ridge of the palæozoic rock; elsewhere they rest upon the auriferous series.

Between Cape Colville and Te Aroha this formation is arranged as a succession of synclinal and anticlinal folds, the axes of which have a general north-east trend. The underlying auriferous series at the Thames, Tapu, Puriri, Hikutaia, Karangahake, Waitakauri, Te Aroha, and all the other goldfields on the peninsula, are exposed in the denuded cores of the anticlinal folds.

It may be interesting to note that the Waitakerei range, extending between the Kaipara and Manukau harbours, and the great Pirongia range, lying between the Waipa and West Coast, are composed of similar rocks. It is evident that, during the period of their formation, the province of Auckland must have been the scene of the most violent and intense volcanic activity. From stratigraphical reasons I am inclined to think that this great series is probably of Upper Eocene age, and contemporary with the great volcanic outbursts which took place around Oamaru during the deposition of the Mount Brown or Hutchison quarry beds.

2.—*Lower Eocene, Auriferous Series.*

This formation, as we have seen, consists principally of fine-grained sandstones, generally pyritous and highly decomposed, alternating with subordinate bands of harder and coarser sandstone, which sometimes pass imperceptibly into breccia beds. It is exposed in the denuded core of an anticline, both sides of which are overlain by the great volcanic breccia and tuff series just described.

In his report on the Thames Goldfield in 1882, Mr. S. H. Cox, F.G.S., late Assistant-Geologist, makes the dip of the auriferous series north-west along the whole line of exposure from Kurunui Creek to Hape Creek. (*Geological Reports*, 1882, pp. 10-12).

The effect of this is to place the coarse breccias and tuffs as the lowest member of the auriferous series. At the Tararu end of the section these breccias are found overlying the auriferous rocks, but Mr. Cox gets rid of this difficulty by calling in the aid of a hypothetical fault, the throw of which, he says, would not be less than 2000 feet; (*l.c., p.* 12), but it is evident that 5000 feet would be nearer the amount, as the two outcrops are separated by over a mile and a half. The hard sandstone and breccia band forming the apex of the anticline, which follows the trend of Waiotahi Hill (see D on Section), is shown by Mr. Cox on his map and section as lying on the highly denuded edges of the auriferous series. An important result of my survey of this line of section has been to place these rocks in their natural position.

It is usual among most writers to speak of the reefs at the Thames as occurring in volcanic rocks. This, however, is not the case. The gold-bearing rocks are closely hemmed on both sides of the field by coarse volcanic breccias, tuffs and agglomerates, frequently intruded and interbedded with solid dykes and lavas, and this has probably led to the error. The whole of the auriferous series is of undoubted sub-aqueous origin. No doubt much of the material composing some of the members of this series has been derived from the destruction of volcanic rocks, more especially the coarser breccia bands, which, however, are distinctly stratified and sometimes contain large fragments of partially-carbonised wood, showing that the conditions of deposition were probably estuarine.

In his paper "On the Rocks of the Hauraki Goldfields," read before the Geological Section of this Association at last year's meeting at Sydney, Professor Hutton describes a number of igneous rocks which are said to come from Waiotahi Creek, Karaka Creek, and other places on this goldfield. He mentions hornblende and enstatite-dacites, hornblende-andesite, augite-andesite, and enstatite-andesite. This is a subject to which I have devoted some study, and I regret that I am unable to confirm this author's conclusions. As a result of the closest investigation, I have been unable to find any of the above rocks *in situ* within the boundaries of the goldfield. Rounded boulders of hornblende and augite-andesites are common enough in the beds of the Waiotahi and Karaka streams, but they are obviously derived from the overlying breccia and tuff formation, which, as I have pointed out, is often intruded by igneous dykes, and in places contains huge angular masses of solid lava many feet in diameter. I have also examined many of these so-called dykes, both in the mines and on the surface, and have no hesitation whatever in stating that they are all of clastic origin. The rocks composing these hard bands are generally extremely hard, and of a dark bluish-grey or green colour when obtained in the solid. They are highly felspathic, and hence very subject to decomposition near the surface, and usually contain disseminated nests and grains of iron pyrites, and not uncommonly well-developed prisms of hornblende. They are, in fact, indurated tufas of fine texture, the true character of which can only be determined by a close study of their disposition and arrangement in the field.

The Character of the Auriferous Veins.

So far as my observations go at present, I am inclined to think there are no true *fissure* reefs on this goldfield, a circumstance which may be partly accounted for by the absence of intrusive dykes cutting through the auriferous strata. The gold-bearing veins occur as *bedded-segregations*, possessing in most cases the strike and underlie of the country. A peculiarity of these deposits is that, while the foot-wall may be well defined, the lode-stuff is found to pass upward into the country without any approach to a hanging-wall or defined line of demarcation. They are also very irregular in character, being often elliptical in shape and subject to great variations in width. They often split into a number of parallel veins, and receive leaders or droppers from the hanging-wall side. The country has a general strike between N.N.E. and N.E., and the auriferous veins follow the same general course. The underlie of the veins is also dependent on the dip of the strata. Thus, where the dip is to the N.W., the veins underlie in that direction, and where it is to the S.E., the veins also underlie that way. Looking at the section on the preceding page, it is obvious that the anticlinal arrangement of the auriferous strata causes the repetition of the auriferous veins, first between the Saxon mine and Shellback Creek, and again between the former and Hape Creek; or, in other words, the gold-bearing veins being worked at Kurunui Hill are the same as those at Una Hill, while those between the Saxon mine and the Waiotahi find their equivalents on the opposite side of the anticline, the great dome of which has been cut down almost to sea-level by the Karaka stream.

Besides these gold-bearing veins, the auriferous series contains what are locally termed *buck reefs.* These consist of great segregated bodies of flinty quartz, which sometimes run parallel with the country, sometimes across it, but are not continuous either in length or depth for any distance. In his report on this goldfield, in 1882, Mr. Cox speaks of these deposits as *cross-courses,* but their character and behaviour are altogether different from those of cross-courses, and they certainly do not deserve the name. Tests of samples from a number of these reefs at the School of Mines in all cases proved the presence of gold and silver, the bullion, in a few instances, being worth as much as £11 per ton, largely made up of silver. When the richer parts of the field become worked out these will, no doubt, form a valuable asset.

The Great Moanatairi Fault.

This fault is of more than usual interest and importance. In the first place it is of recent date, a fact which is satisfactorily proved by its having drawn down the old floor of the harbour, with its accumulations of recent shells, sands and gravels, a distance of several hundreds of feet. On the other hand, its course is as plainly marked on the surface as that of the great Kaikoura fault, a slight displacement of which, it will be remembered, last year caused the alarming earthquakes at Christchurch and the Hanmer Plains. Where it crosses compact rocks on the surface the striations and slickensides are as fresh as if the faulting or sliding had only taken place yesterday.

This fault is an important factor with regard to the distribution of the gold. It runs almost at right angles across the general trend of the gold-bearing strata. It crosses Hape Creek, as shown on the accompanying geological sketch map, immediately below the gorge, and thence follows along the foot of Una Hill to Karaka stream, whence it passes across the ridge to the Waiotahi, and then onward to Moanatairi Hill, beyond which it bends slightly to the north-west, and enters the sea a little beyond the mouth of Shellback Creek. The course of this fault is marked on the surface by a line of depression, which can easily be traced by the eye. Its *hade* is towards the harbour, that is, to the westward, thus indicating this as the downthrow side. A moment's consideration will show that the country at the sea level is the same, or corresponds with that at a height of about 300 feet above the sea on the upper side of the fault, the amount of vertical displacement being about 300 feet. The effect of this will be better understood when it is stated that a bore put down from the Moanatairi tunnel, on the upthrow side of the fault, would explore lower country and reach the old floor or basement rock in a shorter distance than a bore put down from the foreshore, which has been carried down in recent times several hundreds of feet from its original position. Besides vertical downthrow, this fault has also caused a certain amount of lateral displacement, which must always be taken into consideration when conducting explorations from the low side to the high side of the fault. Besides the Moanatairi fault, there is what is locally known as the *beach-slide*. It appears that in driving from the mines on the foreshore towards the harbour a loose formation of shelly sands and gravels is met with, which has led to the belief that the country is cut off in this direction by a slide or fault. I am inclined to think that no fault exists along this line, the appearance being simply caused *by driving out of the country* into the old harbour.

3.—*Palæozoic—Te Anau Series.*

This formation forms the floor or basement rock of the peninsula, but it does not reach the surface within the limits of the Thames Goldfield proper, nor has it been reached in any of the mines. It crops out on the shores of the firth, about a mile north of Tararu stream, forming Rocky Point, whence it extends eastward to the upper part of Waiohanga Creek. It consists of blue and grey banded slaty shales, which are followed by yellowish-grey silicious mudstones, which seldom show distinct stratification, but are jointed in all directions, the joints being often stained or filled with yellow ocherous clays. Professor Hutton in 1869, and Mr. Cox in 1882, spoke of this mudstone as a felsite. In 1887 the former re-examined this point, and in his paper on the "Rocks of the Hauraki Goldfields" states that he is now convinced of its clastic origin, a conclusion which I can fully endorse.

These shales and mudstones are of uncertain age, as no fossils have yet been found in them, but they most probably belong to the Palæozoic period. At any rate, they bear a strong resemblance to the rocks forming the Taupiri range, on whose flanks occur fossiliferous rocks of undoubted Triassic age.

At the Thames the gold-bearing veins occur in the felspathic and tufaceous sandstones of Eocene age, at Taupo and Coromandel goldfields they occur both in the tufaceous sandstones and in the underlying slaty shales and mudstones. At Coromandel, for instance, we have the celebrated Kapanga mine in the tufaceous sandstone, and the Tokatea and Bismark mines in the slaty shales, near their junction with the overlying tufaceous sandstones.

On the coast between Waikawau and Tapu the slaty shales are intruded by eight dyke-like masses of hornblende-andesite, which are well exposed in the road cuttings.

Future Prospects of the Thames Goldfield.

Up to to the present time the mining operations on this field have been almost exclusively confined to a small area on the foreshore, embracing altogether little more than a square mile of country. I have already pointed out that the auriferous series, with its gold-bearing veins, possess a general N.N.E. or N.E. strike, and a reference to the accompanying map will show that it passes as a narrow belt, about a mile and a quarter wide, north-eastward to the upper parts of Tararu and Otonui streams, and thence onward in the direction of Mercury Bay. I am fully convinced that the prospects of finding payable gold in the forest country just indicated are sufficiently encouraging to warrant the thorough exploration of that portion of the field. The country is broken and heavily timbered, but these obstacles could easily be overcome by a judicious expenditure in making pack or even blaze-tracks in the more inaccessible parts.

Coming back to the limits of the present goldfield, it is obvious on all sides that the mining of the past has been confined to the winning of gold from the veins near, or only a few hundred feet below the surface. Yet veins carrying payable gold have in many instances been proved to live into the "low levels," the term generally applied to the country below 400 feet. A large and wealthy area of deep ground exists between the Saxon mine and the Big Pump, and even a larger and richer between the old Queen of Beauty mine and Hape Creek, extending right across Block No. XXVII. The neglect of this rich ground is no doubt due to the fact that hitherto the gold has always been found accessible to the surface, and, in consequence, mining companies have not considered it necessary to incur expenditure in seeking gold at lower levels; but as the accessible gold must soon become exhausted, the working of the deep ground must attract the attention of the mining community at an early date, and it would, I think, be a matter for regret if its development is left to foreign skill and capital rather than to local enterprise. As the lower levels are opened out, the Thames will become one of the richest and most productive goldfields in Australasia.

8.—COAL: ITS ORIGIN AND PROCESS OF FORMATION.

By James Melvin.

9.—NOTES ON AN ANNELID FORMATION IN QUEENSLAND.

By JAMES SMITH.

[*Abstract.*]

I DESIRE to draw attention to a discovery of fossil annelids near Rockhampton, in Queensland. Argillaceous shales which, so far as I am aware, are azoic, occur at intervals from Broad Sound to Brisbane, and from the islands in the sea at Emu Park on to the Dawson River. They are interrupted by layers of basalt, which appear to have come to the surface through weak points in the shales, and to have partly overflown them. The Fenestella and annelid beds were, I think, laid unconformably upon them. The entirely different composition, the unique character of the enclosed fossils, the opposing dip and the altered slope in the short distance warrant, I think, the supposition of unconformability, though the junction is not absolutely seen.

The annelids also are found lying loose in little slabs all over the country, and away in the upper reaches of the Fitzroy, over a country one hundred square miles in extent. The one drawn by Mr. Etheridge was found on the top of the Athelstane Range, along with others in my collection. They are got in all the neighbouring gullies, and help to macadamise the streets of North Rockhampton. They have for the most part been lost to us by denudation.

These annelids seem to have been in solitary possession of the sea bed at this point, not a sign of coral, shell, or other form of life appears amongst them or in the intervening beds. They occur only in the blue thin beds, made of mud, in which, during life, they grovelled and burrowed, disappearing entirely during the formation of the hard indurated sandstones, and apparently returning some half dozen times at intervals.

The lowest bed in which they appear is the richest in them, and here they attain their maximum size of 12 inches in length and ½ inch in width (the head and hinder part being wanting). They are curved in a serpentine manner. In the higher beds they dwindle away to small dimensions, becoming thread-like in size. They were distinctly segmented, and supplied with cirri and with processes like the legs of centipedes.

These annelids are not to be confused with another series of which I have, at Wilangi, found the tunnels occupied by them during life in the upper beds of the desert sandstone (?) These tunnels ramify in all directions, and the worms appear to have lived in communities, and used the passages in common, just like ants in their galleries.

10.—OBSERVATIONS ON THE TERTIARY AND POST-TERTIARY GEOLOGY OF SOUTH-WESTERN VICTORIA.

By JOHN DENNANT, F.G.S., F.C.S., Corr. Mem. Roy. Soc., S.A.

THE region referred to in this paper forms the basin of the Glenelg River, and comprises the counties of Follett, Normanby, Dundas, and the southern half of Lowan. With the exception of Dundas and a small portion of Normanby, it may be described generally as an extensive limestone formation, of Tertiary age, overlain either by basalt or by drift sands and gravels. In places the limestone crops out in ridges, but, when covered by the more recent deposits mentioned, it is always found at a short distance below the surface, and is thus frequently exposed in the channels of creeks and rivers. The Glenelg has for more than a hundred miles of its course carved out a deep as well as wide gorge through beds of limestone. One is much struck by the height of the cliffs on the Glenelg at Dartmoor, and also by their great distance apart—that is, by the width of the gorge through which the river runs. Not only is this noticeable for the Glenelg, but even in the case of insignificant streams, or rather creeks, which flow into it. The Glenelg gorge is, at Dartmoor, perhaps as much as a mile across, and that formed by the Glenaulin Creek nearly half a mile, though it is but a puny stream. The actual channel of the Glenelg is much increased in volume during winter floods, but even then it never approaches the top of the cliffs. From Drik Drik the width, but not the depth, of the gorge gradually diminishes, and close to the mouth of the river it is only from 100 to 200 yards across. The friable nature of the limestone causes it to suffer degradation rapidly when once it becomes subject to atmospheric wear, and it is possible that in course of time the gorge, even there, may yet widen out from this cause alone. If this is the only cause, then at Dartmoor and upwards the river must have been flowing a longer time than near its mouth.

From various portions of the strata, I have, during the last few years, collected nearly a thousand species of fossils, the majority of which have been determined by Professor Tate. With their aid, and by noting the relative positions of the beds, the Tertiaries and Post-Tertiaries of the district can be classified into several well defined groups, which will be discussed in the order of their deposition, beginning with the lowest.

I.—LOWER TERTIARY.

As the celebrated shell beds at Muddy Creek have been described by me quite recently, the remarks now made upon them will be brief, and confined mainly to their relations to other members of the Tertiary series.

In the Grange Burn, and at a lower level than any of the Muddy Creek sections, a great change is observed in the character of the strata. The soft clayey beds, so rich in molluscan forms, give place to a hard polyzoal limestone, containing numerous spines of echini, but only occasional shells. A similar rock forms high cliffs on the Glenelg and Crawford rivers, and crops out, amongst other localities, on the South Australian border near Apsley, and in the Salt Creek at Dergholm. Professor Tate records the occurrence of strata presenting the same general characters on the Murray Cliffs near Morgan, where, just as in the Grange Burn, the gastropod beds are succeeded by limestones and calciferous rocks, with pectens, palliobranchs, echinoderms, polyzoa, &c., as the prevailing fossils.*

In speaking of the River Murray section, Professor Tate says, "Here, because of the slight admixture of argillaceous matter in the matrix, the tests of gastropods and of many bivalves have been well preserved, but this condition is maintained only for about 350 yards, measured along the front of the cliff; beyond that the shells gradually disappear with the diminution of the clay, and finally, at half a mile distant, the beds have merged into the limestones, caverned with casts, and the ordinary calciferous rock."

This description would serve almost as well for the sections on the Grange and Muddy Creeks, the only difference being that the change from argillaceous deposits, with their profusion of fossils, to the polyzoal rock is here a sudden and not a gradual one. Collectors at Muddy Creek have always found it difficult to tear themselves away from the prolific shell beds, and the less inviting polyzoal rock, close at hand, has thus been almost entirely neglected. Whoever undertakes its examination is likely, however, to be amply rewarded, and I strongly advise some of our young Victorian geologists to commence the work.

From a portion of the rock, detached on a late visit, I obtained a few specimens, which were sent to Professor Tate for determination. His report upon them is so interesting, and so fully supports the argument of this paper, that I quote it *verbatim*, "The Grange Burn fossils are Eocene. I identify them as follows :—

Terebratulina scoulari, *Tate ;* a common Eocene species.
Terebratella tubulifera, *new sp.*
Isis, *sp. undescribed ;* Eocene at Mount Gambier, Muddy Creek, and Yorke Peninsula.
Temnechinus novus, *Laube ;* Eocene, River Murray cliffs.

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* "Notes on the Physical and Geological Features of the Basin of the Lower Murray River." *Roy. Soc. of South Australia*, 1884.

Orbitoides stellata, *Howchin*; Eocene, Muddy Creek.
Nummularia variolaria, *Sowerby*; Eocene, Europe, Muddy Creek.
Pecten sp., perhaps a variety of *P. foulcheri*."

On the Glenelg no argillaceous deposits have been met with, the cliffs being composed either of limestone, in which fossils are rare, or of the polyzoal rock. At the Bluff, a few miles south of Casterton, the following were gathered :—

Waldheimia grandis
Waldheimia insolita
Waldheimia garibaldiana
Magasella compta.
Pecten deformis
Echinus woodsii
Eupatagus murrayensis.
Echinolampus sp.

From the perpendicular cliffs at Dry Creek, about six miles from the mouth of the same river, I obtained

Terebratula vitreoides
Waldheimia garibaldiana
Monostychia australis
Ostrea ? arenicola
Pecten gambierensis
Pecten foulcheri
Brissiopsis archeri
Echinolampus gambierensis
Echinolampus, n. sp.
Pecten sturtianus
Pecten semi-lævis
Pecten polymorphoides
Hemiptagus forbesii
Eupatagus murrayensis
Magasella compta
Leiocidaris australis

A collection from the Crawford River contained

Waldheimia insolita
Waldheimia sp.
Pecten foulcheri
Pecten sturtianus
Conus sp.
Cypræa sp.
Magasella woodsiana
Echinolampus sp.
Turbo sp.

and some casts of bivalves which cannot be determined.

A few years ago some fossils were found in the Border quarries, near Apsley, by a road contractor, who obligingly allowed me to choose what I pleased. I selected one or two specimens of every fossil he had, which comprised—

Waldheimia garibaldiana
Magasella compta
Cypræa, ? gigas
Cypræa sp.
Aturia, ? australis
Cassis, textilis
Trochus sp.
Cerithium sp.
Siliquaria sp.
Cardium victoriæ
Chione sp.
Pecten gambierensis
Pecten sturtianus
Echinolampus gambierensis
Echinolampus sp.
Hemiptagus forbesii
Arachnoides australis
Echinus woodsii.
Mactra sp.
Natica sp.
Leiocidaris australis

The identified fossils of the above lists are, with one or two exceptions, also recorded from the Murray cliffs, either from the gastropod beds or from the calciferous rock. A large proportion of them occur also in the lower beds at Muddy Creek. In his article on the Basin of the Lower Murray, Professor Tate classes together the three beds just named in the Middle Murravian group, which corresponds very nearly with that which is here called Lower Tertiary. By Victorian geologists the Muddy Creek beds are usually termed Oligocene, and those on the Glenelg, Miocene, but this classification is not universally accepted. Professor Martin Duncan, F.R.S., in remarking upon the Australian Tertiary beds known to him from fossils and rock specimens submitted, as well as through survey reports, advised that they should all be called Cainozoic, without further subdivision, as he considered the upper member of the fossilferous series to be merely a deep-sea deposit (in a general sense), and contemporaneous with those below it.* From a perusal of his article, I understand Professor Duncan to mean, by the upper member of the series, the calciferous rock of the Glenelg and its equivalent on the south coast, and by the lower, the gastropod beds of Spring Creek and other places on the same coast.

The recognition of two separate zones in the Muddy Creek beds has materially modified the estimate formed of their age when they were supposed to consist of a single deposit. On the basis of the percentage of living to extinct forms, the upper may still be regarded as Oligocene, or perhaps early Miocene, but the lower should now be referred to the Eocene period. That the fossils of the Grange Burn polyzoal rock are of a marked Eocene type has already been noted. The Glenelg and Apsley deposits must, I think, be placed in the same group, not only on account of the community of fossils, but also because of the significant fact mentioned by Professor Tate, that the equivalents of the two sets of strata, viz., the gastropod bed and the calciferous rock, are, in the River Murray sections, inseparable.

This view is confirmed by the occurrence of fossils belonging to the lower zone of Muddy Creek at several localities in the Glenelg basin, as well as in the neighbourhood of Apsley. They have been mostly found in well-sinkings, and their number is therefore not great, especially as the settlers seldom think it worth while to preserve such apparently useless articles as fragile or, perhaps, even fragmentary shells. In common with other searchers after natural curiosities, I have often been as much annoyed as interested by being *told* of strange-looking objects unearthed by a hospitable friend, but which he had unfortunately *lost* some time previously.

At Tea-tree Creek, near Harrow, casts in ironstone of the following species were obtained :—

* *Quart. Jour. Geol. Soc.*, xxvi., p. 284 (1870).

Cypræa contusa	*Marginella propinqua*
Cypræa platypyga	*Pleurotoma haastii*
Cypræa sp.	*Natica ? limata*
Trivia ?	*Trochus sp.*
Voluta ? mc'coyii	*Pecten ? foulcheri*
Voluta two sp.	*Cucullæa corioensis*
Triton tumulosus	*Chione sp.*
Conus sp.	*Waldheimia grandis*
Ancillaria sp.	*Waldheimia garibaldiana*
Eburna ?	*Terebratulina scoulari*
Semicassis transenna	

Some well-preserved Lower Tertiary shells were also got in a well-sinking as far east as Mount Arapiles, a few of which were given to me, viz. :—

Cypræa murraviana	*Cytherea sub-multistriata*
Voluta anti-cingulata	*Chione aff. C. cainozoica*
Daphnella sp.	*Pectunculus mccoyii*
Clathurella sp.	*Myodora tenuistrata*
Pleurotoma sp.	*Entalis mantelli*
Turritella aldingæ.	

At Portland there is an outcrop of a chalky limestone, from which, in addition to numerous specimens of *Hemiptagus forbesii* and *Magasella compta*, I have also obtained a cast of *Cucullæa corioensis*. Though this rock has yielded so few fossils, it should, no doubt, be classed with the Glenelg and Apsley strata.

Before concluding my remarks upon this division of the tertiaries, it may not be out of place to advert briefly to the interesting fossiliferous formation at Schnapper Point. Numerous specimens have been obtained from it, but they have only lately been even partially catalogued. In his revision of the Australian Tertiary Mollusca, Professor Tate has described 96 fossils from this place; but his work, though well advanced, is not yet complete, and many more species remain to be dealt with. On a late visit I collected 63 species, additional to those already mentioned, making a total of 159 species known to me. They include 131 Muddy Creek shells, of which no less than 121 are peculiar to the lower zone, while seven others belong to both zones. The remaining three are characteristic shells of the upper zone, viz., *Myodora æquilateralis*, Johnston; *Nucula tumida*, T. Woods; and *Marginella* aff. *ovulum*, Sowerby, of which the two last have been found, though very rarely, in the lower also. We may conclude, therefore, that the Schnapper Point section is nearly, if not exactly, on the horizon of the older beds at Muddy Creek.

II.—Middle Tertiary.

This division contains the Ostrea limestone and the upper deposit at Muddy Creek, the latter of which has not been recognised elsewhere in Victoria. The deposit at Cheltenham, that at Jemmy's Point, and the superior beds of Table Cape, Tasmania, possess some of its characteristic forms; but though they all belong, probably, to the same group, none of them can be considered the full equivalents of this well-marked zone.

In South Australia a group of strata, comprising the oyster beds of the Murray Cliffs, Aldinga, &c., has been termed Upper Murravian by Professor Tate, who has described fifty-two fossils from it. Amongst them, twenty-two are identical with Muddy Creek species, eight of which, or fifteen per cent., are represented in the lower beds, and sixteen, or thirty-two per cent., in the upper. The percentage of living to extinct species in the latter has been shown to amount to 6·5,* or much the same as in the Upper Murravian, where it is 5·8. It is not possible to correlate these two sets of strata definitely, but from the general resemblance of their fossils, as well as from other considerations, they may be regarded as near equivalents.

Oyster beds of considerable thickness also overlie the Older Tertiary, at Portland, on the Glenelg Cliffs, and in other portions of the counties of Normanby and Follett, but they are evidently younger than those on the Murray. In the neighbourhood of the Glenaulin Creek, at Dartmoor, and throughout the south of Follett, oyster shells are often turned up by the plough, while on the banks of the Glenelg, interesting sections of the beds are visible at intervals, from a few miles north of Limestone Creek almost to its mouth. Usually the only fossil is the prevailing oyster, but at Ascot Heath, near Dartmoor, several others occur, including numerous and fine specimens of *Pecten meridionalis*, Brazier, and *Mytilus chorus*, Molina (*M. latus*, Lam.). In all, however, only six identifiable fossils have been found, but, as four of them belong to existing species, the deposit may be fairly classed as the youngest member of the Middle Tertiary.

At Ascot Heath it merges gradually into the underlying calciferous strata, but at Portland it is sharply separated from the chalk rock beneath by a thin layer of rounded pebbles. Just as in the case of the remarkable nodule band, which divides the upper and lower zones at Muddy Creek, this indicates a break in the succession of the tertiaries, and serves as a line of demarcation between the older and younger groups.

III.—Upper Tertiary.

On the completion of the Ostrea Limestone deposit, a long interval elapsed, unrepresented in south-western Victoria by any

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* "Notes on the Muddy Creek Beds." *Roy. Soc. S.A.*, 1889.

known fossiliferous strata. A large portion of the area must still have been submerged, but such was not the case for all of it, as the high lands of Dundas and the northern part of Normanby are old land surfaces.

One deposit recognised consists of the disintegrated remains of granitic, metamorphic, and sandstone rocks belonging to the Grampian series.

There are also beds of ironstone gravel, of no great thickness, but covering the surface of the country like a mantle, and resting alike on palæozoic, mesozoic, and tertiary strata. A gentleman of my acquaintance, who travelled a good deal in this region, was so struck by the prevalence of gravel over such wide areas, that he could only explain its origin by supposing that it had fallen from the clouds. A much more feasible explanation can, however, be given. The iron has been precipitated as limonite, or bog-iron ore, from water holding it in solution. Fine mammillated nodules of bog-iron ore can be obtained at the bottom of some of the swamps in various parts of the district, while small pea-shaped fragments are abundant in every watercourse. The iron oxide has also served as a cementing material for masses of sand derived from the decay of the rocks just mentioned. The iron itself has probably come, in the first instance, from decomposed trappean and basaltic rocks, remnants of which still exist in certain portions of the region. This explanation would not, perhaps, suffice if the swamps and morasses had always been confined within their present limits, as ironstone, evidently *in situ*, is abundant in places where water now seldom remains on the ground for any length of time. But the country is generally level, and it would only require a heavier rainfall to flood a great part of it. Professor Tate has given sound reasons for concluding that Southern Australia has undergone a gradual dessication, the rainfall in past ages having been much greater than at present.* Such being the case, large tracts would be covered by permanent swamps, and the precipitation of iron oxide over an extended area is easily accounted for. In fact, the presence of these extensive deposits of bog iron-ore lends, I think, strong support to the arguments of those who claim for Victoria a humid climate in the Pliocene period. It is not, of course, contended that this ironstone gravel was wholly formed *in situ*, a great part having undoubtedly been transported by creeks and rivers, whose course has been changed, or which have now ceased to flow.

Incidentally, I may refer here to the numerous lakes and swamps which are scattered about the southern half of Lowan. The minds of not a few of the more observant residents in the county have been much exercised concerning the mode of their formation. Being mostly salt, the first idea has generally been

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* "Post-Miocene Climate in South Australia." *Roy. Soc. S.A.*, 1885.

that they were left by a retiring sea. Another explanation sometimes given is that they are due to the action of Post-Miocene glaciers, which are supposed to have scooped out the hollows; but as I have failed to discover any evidence for the former glaciation of the province, I regard the theory as untenable. In my opinion most of them are simply the remnants of former rivers, which have dried up owing to a diminished rainfall. On one occasion, when standing on the top of Mount Arapiles, it appeared to me that the lines of these ancient rivers could be fairly traced. As this mountain rises out of a plain, the whole country around is spread out before the eye, and many of the lakes, which dot the landscape, could easily be supposed to be merely chains of water-holes in the course of former streams, the channels between them having been choked up by sand. The country falls northwards, that is, towards the Murray, the watershed between that river and the Glenelg being a little to the south of Edenhope; and I am told that, even yet, after an unusually heavy downpour, there is an actual current from Lake Wallace to Booroopki swamp. None of these lakes are deep, and many of them are for years together perfectly dry. In one instance, a small lake, near Apsley, was regarded as permanently dry, and a house was built by one of the early settlers in the middle of it. The succeeding winter proved, however, a wet one, and the lake was not only then filled, but has never been dry since.

But to return to the strata of the Upper Tertiary. An exceedingly interesting deposit is found on the Glenelg, in the neighbourhood of Limestone Creek, and thus about 25 miles, in a direct line, from the coast. The river gorge is here very wide, and the beds now referred to lie just on the margin of the stream, at the foot of the cliffs, which consist as usual of Lower Tertiary rocks, overtopped by the Ostrea limestone. In describing them a few years ago,* a list of 141 fossils was given, but since then many additional species have been collected, the names as well as the distribution of which have been, with his usual kindness, supplied by Professor Tate. The material available for comparison has thus much increased, and a slight modification of the conclusions formerly arrived at will be necessary. Altogether, 242 species are to hand, of which 212 are well identified, and the following remarks will apply to them only. The living species amount to 171, and the extinct ones to 41, so that the proportion of recent forms is about 81 per cent. In my previous paper a similar calculation gave a much higher percentage, but the number of determined species was then only 121, and it is a curious circumstance that the later collections include a much larger proportion of extinct species than the earlier ones. Of the extinct shells, 20 are peculiar to the Lower and 8 to the Middle

* *Trans. and Proc. Roy. Soc. Victoria*, 1887.

Tertiary; 6 belong to both groups, while 7 others are not known elsewhere, either fossil or recent. Professor Tate thinks that there are good grounds for supposing that many of the extinct species are derived from an older formation, and that the beds are thus really younger than the percentage of recent forms would indicate. They rest upon the Lower Tertiary, which must have been cut through just before, or concurrently with, their deposition, so that the supposition is likely enough to be correct. The results of the later gatherings are certainly favourable to this view. The older Tertiary species are represented by rare, or even by single, specimens, while there are usually numerous examples of the recent ones. The latter also are often as fresh-looking as if they had just been picked up on the beach, while the former are worn and faded. If not actually Post-Tertiary, as I previously classed them, the beds cannot be assigned to an earlier period than late Pliocene.

At the time of their deposition, the mouth of the Glenelg must have been nearly as far north as the present Limestone Creek, when of course a great part of the province would still be submerged. The river, no doubt, entered the sea by a wide estuary, up which the tide could advance for a considerable distance. Tall cliffs bounded it on either side, the outlines of which were probably much the same as now. As the shells are found also in the lower course of Limestone Creek, this stream must have been in existence at the time, entering the Glenelg not far from its ancient mouth.

I know of no equivalents to these beds in the south-west, or, indeed, in any other part of Victoria.

IV.—Pleistocene and Recent.

Next in order come, I think, the immense sheets of basalt which overspread a great part of Normanby, as well as the counties to the east. The whole of it belongs to the division known as Newer Basalt by Victorian geologists, though possibly it may consist of more than one flow. All of it, however, is younger than the oyster beds, and older than the dune limestone, the next succeeding formation. In the well-known section at Whaler's Bluff, Portland, the earliest flow, if there be more than one, rests directly on the Ostrea limestone, while at Capes Grant, Nelson, and Bridgewater, where the dune limestone is best seen, the basalt is invariably the inferior rock. That it is younger than the Limestone Creek beds cannot be directly proved, but for reasons which I have given elsewhere,* and need not therefore repeat, I believe it to be so.

With the exception of that at Cape Bridgewater, the various vents from which the lava streams issued appear to have been

* *Op. cit. Roy. Soc. South Australia*, 1889.

sub-aërial. Even there, it is probable that the ashes and scoria ejected soon raised a mound, which rose above the waters, while the lava continued to well out and spread for a long distance on the sea bottom.

While speaking of the igneous rocks of the district, I may briefly refer to the singular obsidian bombs, which are so frequently picked up. They have been gathered in the drifts near Portland, on the surface of the basalt at Hamilton, and in the Byaduk Creek, near Mount Napier. But, curiously enough, they are also found in ironstone gravel at Harrow, amongst the *débris* of metamorphic rocks at Balmoral, and very abundantly on the mud plains to the north of the Glenelg. There are not now any signs of volcanic rocks very near the last-mentioned places, so that the origin of the bombs is somewhat of a puzzle. They vary in size from $\frac{1}{4}$ inch to $1\frac{1}{2}$ inches in diameter. The smaller ones are flattish, and look much like black buttons, but the larger ones are thicker and almost basin-shaped. Boat-shaped, and even amorphous, pieces are not rare, and a very fine elongated specimen was once shown to me, which was said to have been found near Lake Wallace. No doubt they have been carried about the country by blacks, who, as is well known, prize them highly, but those found near the Glenelg river must, from their comparative abundance, be near the source whence they were derived. That they have not been carried far amongst drifts is evident, since they are seldom, if ever, waterworn. The only explanation which suggests itself to me, is that they have come from some small volcanic vent in the neighbourhood, which is now concealed by waste material from adjoining rocks.

The dune limestone, which has been incidentally mentioned before, is not a very important formation; but, from its bold, striking character, it has attracted a good deal of attention, and has been described by more than one writer. The late Rev. J. T. Woods confounded it with the Pliocene crag of Suffolk, and attributed it to the action of ocean currents. In one of his later publications, however, he frankly acknowledged his mistake, and gave the true explanation of its origin, viz., the action of wind upon the sand washed up by the waves. In the course of his remarks he says:—"Professor R. Tate, who first asserted the formation to be Æolian, found small shells in portions, and these were land shells—not marine, and of the kind now existing on the coast. When I first saw this deposit I imagined it to have been derived from marine currents; but a better knowledge of the floor of the ocean shows us that marine currents do not leave such stratification. Besides the land shells, and the fact that the strata show no signs of upheaval, I found in subsequent years, by various sections on the coast, that this deposit is only an indurated portion of the sand-dunes with which it is always associated. It is an aërial rock, and is stratified by the wind alone."* In support of his argument he also instances the Bermuda sandstone, which is an exactly similar formation, quoting as follows from Jones' *Guide to Bermuda*:—"In the islands of Bermuda a similar formation is met with. Although generally very low, some parts of these islands rise to 250 feet above the sea level, consisting of various kinds of limestone rock, sometimes soft and friable, but very often hard, and even crystalline. It has been put beyond a doubt, by a long-continued series of observations, that the rocks are all due to the wind, which blows up the sand from the beach, and which itself is derived from coral and shells. The rain dissolves portions of the lime and consolidates it."

As might be expected from its mode of formation, the deposit is remarkable for its constant change of dip, which may vary from 0 deg. to as much as 30 deg in a few yards. It is chiefly developed in the neighbourhood of Portland and Bridgewater, but does not extend far inland, so that either the causes producing it have not operated for any lengthened period, or else the previously formed rock has been entirely removed.

From Cape Bridgewater to the mouth of the Glenelg, and for a long distance farther west, the low coast line is occupied by dunes of shifting sand, which sometimes rise to a height of from 200 to 300 feet. By examining these mounds, it is at once seen how the hardened rock of the cliff sections has been formed, as, wherever the wind has removed any considerable mass of sand from one of them, the remaining portion is found to be more or less consolidated. A little consideration will convince anyone that this result must be inevitably produced when a mound of sand, of the height mentioned, remains intact for any length of time.

Since the dune limestone is thus due to causes still in active operation, I have classed it as Recent, though I am aware it has also been referred to the Pleistocene period. For aught anyone can say to the contrary, its deposition may have commenced in Pleistocene times, but, as represented by the indurated dunes of Swan Lake and the hummock region of Discovery Bay, the action appears to have continued ever since.

One other deposit remains to be noticed. If I were asked to name the most striking feature of the plains bordering the Glenelg, and extending for many miles to the west and north, as well as for some distance to the east, I should certainly reply, "Sand," and whoever travels much in the region must have the same conclusion forced upon him. Sometimes one has to plod slowly along through sandy and almost desert tracts for fully forty miles at a stretch. It is true there are occasional swamps and morasses, but the tame monotony of the landscape is not thereby much relieved.

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* "The Hawkesbury Sandstone." *Roy. Soc. N.S.W.*, 1883.

There is no difficulty in accounting for all this sand when the geology of the country is understood. Much of it, especially towards the south, has evidently been produced by the degradation of the Ostrea limestone, for oyster-shells are often seen, not only in occasional outcrops of the rock, but also amongst the sand itself. Where the oyster beds are wanting, the calciferous rock is frequently near the surface, and its weathering gives rise also to loose beds of the same material. Towards the north of Follett, coarse granitic rocks are rapidly crumbling away, while in South Lowan a large area is covered by the degraded remains of a palæozoic sandstone. The sand derived from these is not, of course, precisely like that from the limestone, but to the casual observer there is very little difference, and it is at least noteworthy that such continuous and apparently similar deposits should have been formed, in contiguous localities, by the decay of wholly distinct rocks.

11.—THE GLACIAL CONGLOMERATES OF VICTORIA.

By E. J. Dunn, F.G.S.

The Glacial Conglomerates are among the most interesting of the rocks of Victoria. That certain conglomerates found at Bacchus Marsh, Wild Duck Creek, and elsewhere, owed their origin to glacial causes was surmised by Sir R. Daintree so long ago as 1866. Dr. A. R. C. Selwyn confirmed this view, and later observers coincided. Absolute proof, however, of glaciated stones and boulders was not obtained until quite recently. Now that indubitable evidences of glaciation have been secured, a wide and fascinating field of research has been opened up.

In the northern hemisphere glaciation in all its varying developments has been closely studied by the most eminent geologists, but in the southern this phase of geology has received but scant attention. In Victoria these conglomerates are so intimately connected with the coal measures that their investigation becomes indispensable to the correct understanding of the coal measures in their relation to the underlying rocks.

Distribution.

The conglomerate is spread over a wide area, and on both sides of the Dividing Range. On the north side it has been observed by the writer at Wahgunyah, Rutherglen, The Springs, El Dorado, Wooragee, Tarrawingee, Badaginnie, to the north-east of Costerfield, and at Wild Duck Creek, west of Heathcote. It is found underlying the auriferous beds at Carisbrook and at the Midas Company's mine, near Creswick. South of the Dividing

Range it is met with east of Gordons about four miles. The conglomerate forming the "false bottom" at Morrison's diggings, and on which the tertiary drift reposes, may possibly belong to the conglomerate under notice, although no direct evidence of glaciation was observed. At Bacchus Marsh the conglomerate is largely developed, attaining a thickness of over 100 feet. At Turton's Creek, a few miles N.N.E. of Foster (Gippsland), a conglomerate of well-rounded boulders and pebbles is found that in all probability is of glacial origin.

These localities, so widely separated, serve to indicate the wide diffusion of the conglomerate. Near Nhill a boring made for water also pierced a conglomerate that strongly resembles what is proved to be of glacial origin. The known limits of the areas occupied by such beds will be continually enlarging as knowledge is gained by borings, &c., of the strata beneath the surface where the rocks are newer than Devonian.

Underlying Rocks.

Granite, Lower Silurian and Upper Silurian are the rocks on which the conglomerate is most commonly found to repose. It should also rest on the Devonian, where the two occur together; but I have seen no instance of this.

Geological Horizon.

So far as present evidence goes, the position of the conglomerate appears to be at the base of our coal-measures. Above it the usual sandstones and shales, with coal seams occur. At what height the seams are found above the conglomerate has still to be determined; once settled, the conglomerate might prove a valuable bench-mark in further searching for seams. The conglomerate found in New South Wales, and described by Wilkinson and others as of glacial origin, may yet prove to be identical with the Bacchus Marsh and Wild Duck Creek conglomerates. In the sandstones associated with these latter are found three species of Gangamopteris, as determined by M'Coy.

From a personal examination of both, I can testify to the striking resemblance that exists between the Wild Duck Creek conglomerate and the widely-dispersed Dwyka conglomerate (glacial) of South Africa. Glossopteris is found in the shales overlying the glacial Dwyka conglomerate of South Africa known as the Ecca beds. These Ecca beds comprise thick beds of carbonaceous shale, and, it is believed, also coal seams. At a higher horizon, with an interval of several thousands of feet of sandstones, shales, &c., are the Stormberg coal-measures, in which are workable coal seams. These coal seams, in the character and quality of the coal, are identical with the seams found in the north-east of Tasmania. The seams occur under similar conditions as regards the containing strata in each case, and the fossil ferns also correspond. Now, the Victorian coal seams are considered to correspond to those of Queensland and the north-east of Tasmania rather than to the older coal seams of New South Wales. In the Victorian coal-bearing rocks, Tæniopterisdaintreei, Zamites, and Pecopteris have been identified. These same fossils abound with the coal seams of the Stormberg, South Africa, and are known as occurring in the upper coal seams of Queensland. Glossopteris has not been observed in the Stormberg beds, and there appears to be an absence of this fossil from where Tæniopteris is met with, as well in South Africa as in Queensland. The coal of the Victorian seams, however, is much higher in quality and less seamed with shaly films than is the case with the Stormberg coal seams.

The series as represented in South Africa is as under :—

Carboniferous and Triassic.	Stormberg Beds	Cave Sandstone.	
		Red Beds.	
		Coal Measures.	*Coal Seams, Tæniopteris Zamites, &c.*
	Karroo Beds	Karroo Beds.	
		Unconformity.	
	Ecca Beds	Ecca Beds.	*Carbonaceous Shales, Glossopteris, &c.*
		Dwyka (Glacial) Conglomerate.	

In Victoria the series is probably as below :—

Gippsland Coal Measures. *Coal, Tæniopteris, Zamites, &c.*

Possible Unconformity.

Bacchus Marsh and Wild Duck Creek, Conglomerate (glacial) } *Gangamopteris, &c.*

The glacial conglomerate corresponding to the Dwyka conglomerate of South Africa occurring at a considerable depth below the Gippsland coal seams, and perhaps unconformable to the beds in which these seams occur.

If the glacial conglomerates of Victoria correspond with those of New South Wales found below the older coal seams, coal-measures older than those of South Gippsland may yet be found.

Thickness.

At Bacchus Marsh over 100 feet of conglomerate is exposed. At Wooragee a shaft was sunk over 100 feet in coarse conglomerate without reaching the bottom.

Nature of the Conglomerate.

Almost every species of rock older than the conglomerate itself is represented, granites in great variety, gneiss, schist, quartz rock, sandstones, lydianite, agate, porphyry, amygdaloid, shales, &c., are met with in great variety, vein quartz and jasper are also present. As the great mass of the conglomerate consists of material derived from schistose and other ancient rocks, there appears no good reason why gold should not also be found, though it may be unprofitable to work.

In size the material of the conglomerate ranges from the finest silt up to great blocks several feet across, and weighing in some cases probably 20 to 30 tons.

From the well-rounded, almost polished, pebble or boulder to the rough angular fragment of rock that has been torn from its parent mass, and not subsequently abraded, all are represented in these conglomerates.

Generally the colour of the ground mass is dark grey, but there are local variations, such as might be anticipated from the manner in which the conglomerates have been deposited. Near the Springs and El Dorado, coarse agates of large size are not uncommon, and here it may be observed that the beautiful pebbles of jasper, agate, lydianite, &c., that were so commonly found when the alluvial gold was being won at the Woolshed, were all derived from the glacial conglomerate, of which so large an outlier remains in the Wooragee valley. Great numbers of well-rounded, large, hard granite boulders, having pink coloured felspar are found at Wooragee, but here, as elsewhere, the most numerous are pebbles of a very fine grained argillaceous rock that is free of laminations. It is of brownish colour, and soft, and on these most commonly are found the groovings, scorings, striations and fine scratches that stamp the conglomerate as of glacial origin. Not only are the pebbles, &c., scored and scratched, but great numbers are rubbed on one or more sides (facetted). Though rounded, many of the boulders, &c., indicate from their peculiar form that water alone was not the agent. Frequently the stones show broken edges, as though caused by one stone impinging with great force on another.

The contour of the country occupied by these conglomerates is rounded in places, the surface is dotted with the larger blocks and boulders. Some of these are of such a size as to deserve the term erratic-block, as, for instance, on Wild Duck Creek, where the railway from Heathcote to Sandhurst crosses it. One huge mass of granite, scored on the upper surface, can be seen from the train; it is on the west side of the creek on a slope, and on the south side of the railway. At this locality the glacial conglomerate can be studied to more advantage than at any other I have visited.

Associated with the conglomerate, and generally resting upon it, are soft silicious sandstones, as at Wild Duck Creek, Bacchus Marsh, &c. Soft, grey, thin-bedded shales cover the conglomerate in places at Wooragee.

Mode of Deposit.

Taking into account the composition and character of this conglomerate, as well as the arrangement of its constituents, no other conclusion can be arrived at than that floating ice has been the agent by which the material has been brought into its present position. Much of the material is foreign, and many of the rocks are not known to occur at present in this continent anywhere near Victoria. Probably in some distant land, not necessarily to the southward, glaciers slowly pushed their way into the ocean, laden with such material as glaciers generally carry. These became broken off eventually, and floated away to destinations governed by currents and winds, the dirt, stones, &c., being deposited on the floor of the sea, or possibly lake, in which the icebergs floated.

Unmistakeable ice scratches have been observed by Mr. H. Y. L. Brown, F.G.S., Government Geologist in South Australia. It would be interesting to ascertain if any conglomerates, similar to those under notice, occur there.

Whence Derived.

Although it is apparent that most of the constituents of the conglomerate are not of local origin, or even derived from Victorian rocks, it is by no means apparent whence these travelled stones have come. Tasmania may have furnished some of them, or the lands they came from may now lie beneath the ocean.

So many problems of intense interest centre about these rocks that it would be desirable to record every observation and collate what has already been recorded in some convenient manner. The geological section of this association could, perhaps, deal satisfactorily with this subject.

12.—UNIFICATION OF THE COLOURATION OF GEOLOGICAL CHARTS OF AUSTRALIA, TASMANIA, AND NEW ZEALAND.

By Arthur Everett.

[*Abstract.*]

Having had considerable experience in colours and colour printing, I was encouraged to write this short paper owing to an opinion expressed by the President of the Geological Society of London, in his anniversary address for the session 1888-89, to the effect that the question of colours to be adopted for geological maps was one of which very few geologists have any wide experience.

The following remarks apply to detail maps to a large scale, say from two to six inches to a mile.

I would first draw attention to a fact which appears to have been overlooked by the committee of the Bologna Congress, namely, the prevalence of colour-blindness. This peculiarity is far more common than is generally believed, as is shown by the results of the examinations in the Railway Department for guards and signal-men, where from two to three per cent. of those that present themselves are disqualified for this reason. Taking this, and the difficulty that many ordinary persons find in distinguishing between a series of tints of the same colour, the system that would appear to recommend itself as being most complete would be that adopted in the United States Geological Survey, of using light tints as bases and dark tints as overprints in various mechanical arrangements to represent the several formations in each system, or era, consisting of horizontal lines, vertical lines, right oblique lines, left oblique lines, broken lines, cross lines, dots, &c. This system admits of many variations, which can be used when desirable to represent a large number of members of an extended system.

It is an easy matter to distinguish a pattern, and to carry it in the mind's eye from the index to the map, or *vice versâ*, whereas many who are not experts would frequently be at fault in this respect, if they had several grades or tints to deal with. By this scheme each epoch is represented by one colour only, although easily distinguishable in its several stages by the grading or over-print, while all attempts to establish a system by using shades of the same colour must prove inefficient. To my mind, it is of no great importance what colours are used, so long as they are distinct, yet I should in this again lean towards those used by the United States Survey, with two exceptions. The colours used are for

Recent—Greys, for which I would prefer green.
Tertiary—Yellows.
Mesozoic—Green, for which I would substitute browns.
Permian and Carboniferous—Blues.
Devonian, Silurian and Cambrian—Purples, leaving the reds for the igneous rocks.

The colours used would be in different tones and not tints of the same; for instance, take the Cainozoic or Tertiary system—for

Pliocene	... ...	chrome yellow
Miocene	... ...	brown pink
Eocene	... ...	cadmium yellow.

In addition to the grading by lines, &c., the proposal accepted by the Congress that each system should be represented by a corresponding capital letter, is essential to render the scheme complete. Mr. Selwyn, formerly Government Geologist in Victoria, and now of Canada, adopted a system on his maps which at once conveyed the sequence of underlaying strata by printing letters on each formation, thus for example V. 1.3, on T.P. 1.3, on S. 1.2, signifying Volcanic 1 and 3, on Tertiary Pliocene 1 and 3, on Silurian 1 and 2.

The system of colouring referred to above, of course, could only be done by lithographic printing. The practice of colouring geological maps by hand for publication should, I consider, be abandoned as being too indefinite, liable to fade, and the darker shades so opaque as to destroy all trace of the topographical features, whereas, in lithographic printing, the darkest shades are always transparent, and if colours of the best quality be used there is little chance of their fading. Large portions of some of the maps of the geological survey of Great Britain and Ireland are covered with such dark opaque colours as to entirely obliterate the beautiful topographical work of the geodetic sheets. In conclusion, I will give an extract from the address of the President of the Geological Society of London:—"The fact is, that the distinctness of colours adjacent to each other is an essential requirement of any efficient system, though but few of those who have treated of map colouration with the Congress have referred to this important point. It must be remembered that all hues in contact should remain sufficiently distinct after a certain amount of fading from exposure, and that all should be easily distinguished by artificial light."

13.—ON THE THERMAL SPRINGS OF THE EINASLEIGH RIVER, QUEENSLAND.

By Robert L. Jack, F.G.S., F.R.G.S., Government Geologist for Queensland.

[*Abstract.*]

From five shallow wells, streams of water, estimated at 589 square inches section, issue at a temperature approaching the boiling point, and accompanied by gas-bubbles. The water has deposited a mound of travertin 15 feet in height and 260 yards in circumference. The mound is terraced with successive basins or cups.

After the denudation of the desert sandstone (Upper Cretaceous) and subjacent rocks in the valley of the Einasleigh to the depth of 1000 feet, lava-form basalts flowed down the valley. After the basalt had been itself denuded till mere fragments were left, the thermal springs burst out—probably, therefore, well on in Tertiary times.

14.—LEUCITE AND NEPHELINE ROCKS OF NEW SOUTH WALES.

By J. Milne Curran.

15.—NOTES ON THE CAMBRIAN ROCKS OF SOUTH AUSTRALIA.

By Professor Tate, F.G.S.

16.—A CORRELATION OF THE COALFIELDS OF NEW SOUTH WALES.

By T. W. E. David, B.A., F.G.S., Geological Surveyor, New South Wales.

[*Abstract.*]

This paper, though dealing principally with the relation to one another of the different Palæozoic coalfields of New South Wales, describes also the author's views with regard to the probable relation of the Palæozoic and Mesozoic coal measures of New South Wales to those, when represented, of Queensland, Victoria, New Zealand, and Tasmania. The coal-bearing strata of New South Wales belong to three distinct systems.

1st System.—The first system, probably of Lower Carboniferous age, has not yet been proved to contain workable seams. Two seams, however, 5ft. and 7ft. thick respectively, occur near the top of this system, but the coal in both is too dirty and full of bands to be marketable.

Both of these seams occur in the *Rhacopteris* series overlying the *Lepidodendron* beds, of which, however, they form a part, and this series is separated by a vast interval of time, as evidenced by a strong break in the flora, from the overlying Permo-Carboniferous system.

The *Lepidodendron* beds of New South Wales are considered to be the equivalents of the Avon River sandstone in Victoria, and of the Star Basin and Drummond Range beds in Queensland. The observations of Professor McCoy that the *Lepidodendron* of the Avon River in Victoria was not the Devonian variety—*Lepidodendron nothum*—but a variety of possible Lower Carboniferous age, is quite in accord with the recent observations of geologists in New South Wales, no true specimens of the above-mentioned plant, in the opinion of Mr. R. Etheridge, jun., having ever been found in New South Wales.

The discovery of *Lepidodendron* has not yet been recorded from Tasmania or New Zealand.

2ND GROUP.—The Permo-Carboniferous system of New South Wales, which comes next in order, and which is characterised by a predominance of *Glossopteris* in the flora, is extensively developed in New South Wales and Queensland. Productive coal measures occur in this system on three horizons in New South Wales, and on two horizons in Queensland. These three coal-bearing horizons in New South Wales are—(1), first and lowest, the Greta (Stony Creek) series, then (2), the Tomago (East Maitland) series, then last and uppermost (3), the Newcastle series. The total thickness of this system and its associated strata at Newcastle is about 11,000ft., containing a total thickness of about 150ft. of coal, without taking into consideration seams less than 3ft. thick.

With the exception of the small outlying coalfield of the Ward's River, near Stroud, this system is geologically united to form a single vast coalfield, extending from Bateman's Bay on the south to Port Stephens on the north, thence sweeping inland under the Blue Mountains to the Talbragor River, thence trending northerly to the Queensland border, where it dips under the newer Rolling Downs formation, and does not reappear until the head of the Dawson River is reached in Central Queensland, where the equivalents of the Newcastle or Tomago measures are found to be developed, and further north, near the junction of the Isaacs River with the Mackenzie, the Greta coal-measures are exposed. This coal-basin extends for a short distance beyond Fort Cooper, where it terminates, but its former further continuation in a northerly direction is probably marked by the outlying Bowen River coalfield, and possibly by the small concealed coalfield, discovered by Mr. R. L. Jack, F.G.S., the Government geologist of Queensland, at Townsville. The Little River coalfield between Cooktown and the Palmer Gold-field may also at one time have been united to the main basin, as the strata both in this and in the Townsville coalfield contain *Glossopteris.* The Permo-Carboniferous coalfields of New South Wales are nine in number, as follows:—(1) The Hunter River (Northern) coalfield; (2) the Ward's River coalfield; (3) the Sydney coalfield; (4) the Illawarra (Southern) coalfield; (5) the Mittagong (South-western) coalfield; (6) the Blue Mountain (Western) coalfield; (7) the Talbragar River coalfield; (8) the Namoi River coalfield; (9) the Gwydir River coalfield.

With the exception of the Newcastle and Tomago (East Maitland) coal-measures in the Hunter River coalfield, and possibly of the last three fields in the above list, which as yet are not much explored, all the other Permo-Carboniferous coalfields of New South Wales are considered by Mr. C. S. Wilkinson, F.G.S., the Government geologist of New South Wales, to be probably the equivalents of the Greta coal-measures, (see appendix note 1), as evidenced by the invariable association of kerosene shale, or cannel coal, with these measures. The unworked areas of these Palæozoic coal-measures are estimated to contain between 130,000,000,000 and 150,000,000,000 (one hundred and thirty thousand and one hundred and fifty thousand million) tons of coal (see appendix, note 2), a quantity more than equal to all the accessible unworked coal of Great Britain, assuming 4000 feet to be the limit down to which coal can be profitably worked, and not taking into account seams of less than three feet in thickness. The quantity of unworked coal in Queensland in similar formations is very vast, but the measures have as yet been so little tested that it is impossible to form even an approximate estimate of their coal contents. These Permo-Carboniferous coal-measures have no equivalents in Victoria, unless, as shown by Professor A. R. C. Selwyn and Reginald A. F. Murray, F.G.S., the Government geologist of Victoria, undenuded patches of them may occur under the newer formations of Western Port, South Gippsland, Cape Otway and Wannon. Possibly the Bacchus Marsh sandstone, containing *Gangamopteris*, may be the equivalent of part of the New South Wales Permo-Carboniferous system, as that plant occurs in abundance in New South Wales at the Ward's River coalfield, associated with *Glossopetris* and productive coal seams. (See appendix, note 3).

The author agrees with the opinion expressed by Mr. Murray, that it is improbable that the Permo-Carboniferous coal of New South Wales will be found in Victoria, except perhaps at great depths, beneath the newer formations of Mesozoic age, from which the local supplies of coal in Victoria are at present being chiefly obtained. The possible contemporaneity, however, of the Bacchus Marsh sandstone with some part of the Permo-Carboniferous system of New South Wales suggests the possibility that coal seams of the same age as those of New South Wales may yet be discovered in association with these Bacchus Marsh sandstones, but at present concealed under newer formations, whether volcanic or sedimentary. The line of country between Bacchus Marsh and Williamstown might perhaps be a favourable one to prospect, especially if prospecting were commenced at the Bacchus Marsh end of the line. In New Zealand the Permo-Carboniferous system has probably no exact representative, but in Tasmania the Mersey coal-measures are probably the equivalents of some part of it.

3RD SYSTEM.—The close of the Permo-Carboniferous period in New South Wales is marked by a strong break in the flora indicating a vast interval of time.

The system of rocks, which succeed, are all characterised by the predominance of *Tæniopteris* and *Thinnfeldia*. Near Sydney, this system comprises the Wianamatta shales, the Hawkesbury sandstone, and the Narrabeen shales, but it is only in the first-named series that coal seams of any thickness are known to occur, and none of these are workable. In the Clarence district, however, there are several seams belonging to this system, which may be of sufficient thickness and of sufficiently good quality to be worked for local use. The system characterised by *Tæniopteris* and *Thinnfeldia* in New South Wales is represented in Queensland by the Ipswich, Burrum, and Broadsound coalfields, each of which contains coal seams of workable thickness and quality; but the coal is slightly deficient in cohesive power, as compared with the Palæozoic coal of New South Wales. The thickness of these beds in Queensland is probably not less than 5000 feet. In Victoria, similar, though probably somewhat newer, Mesozoic coal-measures constitute the carbonaceous series of Wannon, Cape Otway, and South Gippsland. The thickness of these beds was estimated by Selwyn to be not less than 5000 feet, and Murray suggests that it may be even 20,000 feet.

The principal seams at present known to occur in this system in Victoria are the Mirboo, the Moe, the Bolara, and the Kilcunda, the respective thicknesses of the coal in which are stated by Murray to be four feet eight inches, two feet to two feet eight inches, three feet, and two feet. It is gratifying to learn that the Government of Victoria, recognising the great importance of the possible coal supplies in the Mesozoic areas in Victoria belonging to this system, have intrusted the work of making a complete survey of these coalfields to so energetic a geologist as Mr. James Stirling, F.G.S., and an exhaustive report on this subject may shortly be looked for from Mr. Stirling, as soon as his survey is completed.

The principal coal seams worked in New Zealand are probably much newer than the Mesozoic coal-measures of New South Wales, Queensland, or Victoria, and those which occur in the coal series are placed by Sir James Hector, F.R.S., at the base of the Cretaceo-Tertiary.

The thick lignite beds of Morwell, in Victoria, and the lignite beds of Kiandra and Twofold Bay, in New South Wales, may perhaps be homotaxial with part of the coal series of New Zealand. The principal seam worked, in this series, in the Nelson District, is stated to be from ten feet to forty feet thick, and is a good, hard, bituminous coal, resulting, as shown by Hector, from the alteration of brown coal by the heat and pressure to which it has been subjected in areas disturbed by the instrusion of volcanic rocks, as, when traced away from such areas, it passes into an ordinary hydrous brown coal. In this paper the author has for the most part followed the present classifications proposed by the Rev. W. B. Clarke, F.R.S., Mr. C. S. Wilkinson, F.G.S., Professor W. J. Stephens, F.G.S., J. MacKenzie, F.G.S., and the Rev. J. Milne Curran, F.G.S., for New South Wales, by Mr. R. L. Jack F.G.S., and Mr. W. H. Rands for Queensland, Mr. R. A. F. Murray, Mr. A. W. Howitt F.G.S., and Mr. J. Stirling, F.G.S., for Victoria, and by Sir James Hector, F.R.S., for New Zealand.

Appendix.

NOTE 1.—Since the above was written Mr. Wilkinson has made a geological examination of the Illawarra coalfield, which has led him to somewhat modify this view, and he now considers that a large portion of the Illawarra and Blue Mountain (western) coalfield is probably the equivalent of either the Newcastle or of the Tomago series. The author has also, since this paper was written, examined, for the first time, the Illawarra coalfield, and considers the Bulli coal-measures here, in their upper portion at any rate, to be the equivalents of the Newcastle coal-measures. The kerosene shale belongs, therefore, perhaps, to two distinct horizons, the lower one in the Greta coal-measures, and the upper one in the Newcastle or in the Tomago coal-measures, and cannot consequently be considered of so much classificatory value as was at first supposed.

NOTE 2.—This estimate gives the author's approximate idea of the total gross quantity of coal contained in the Palæozoic coalfields of New South Wales. These figures, however, should be taken as extremely approximate, and may be in excess of the true quantity. Mr. C. S. Wilkinson has made the following estimate of future available coal in New South Wales :—"Within depth of 4000 feet the New South Wales coal-seams, over $2\frac{1}{2}$ feet thick, are estimated to contain, after allowing one-fifth for loss in working, at 78,198,200,000 tons."

NOTE 3.—That *Gangamopteris* is a younger type of plant than *Glossopteris* is a statement which appears to be open to grave doubts. Mr. R. Etheridge, junr., and the author have lately observed the occurrence of *Gangamopteris* at the base of the Ward's River coal-basin, where *Glossopteris* is comparatively scarce, whereas the latter plant is very abundant in the upper beds of this same coal-basin. Also at Lochinvar, near Maitland, the same observers have collected a fossil plant, seemingly allied to *Gangamopteris*, from a low horizon in the lower marine series below the Greta coal-measures. The fact that *Gangamopteris* is a less highly organised type of plant than *Glossopteris* would also suggest that the former antedates the latter.

NOTE 4.—Table showing the positions in the Geological Scale of the Coal-bearing Rocks of New South Wales.

		Thickness. Feet.	Ins.	
MESOZOIC.	TRIASSIC.	0	0	Tæniopteris beds of Talbragar River, and part of the Clarence District.
		700	0	Wianamatta shales with *Macro-tæniopteris*, *Thinnfeldia*, etc.
		1000	0	Hawkesbury sandstone with *Thinnfeldia*, *Palæoniscus*, *Platiceps wilkinsonii*, etc.
		? —	—	Ballimore beds.
		800	0	Narrabeen shales, with *Thinnfeldia* and *Estheria* and intercalcated cupriferous tuffs.
		* * *		Unconformity, and strong break in the flora.
PALÆOZOIC.	PERMO-CARBONIFEROUS.	1150	0	(About). Newcastle Series, productive coal-measures, containing an aggregate of over 100 feet of coal and *Glossopteris*, *Vertebraria*, *Noeggarathia* and *Gangamopteris*.
		2000	0	(?) Dempsey Series; barren freshwater beds, containing a similar flora to that of the overlying series.
		5700	0	Tomago (East Maitland) Series, productive coal-measures. Containing an aggregate thickness of about 45 feet of coal, and a similar flora to the preceding.
		5000	0	(About). Upper Marine Series containing a marine fauna of Permo-Carboniferous affinities.
		300	0	Greta Series, productive coal-measures, containing *Glossopteris*, *Noeggarathia*, *Vertebraria*, &c., and 15 feet to 45 feet of coal.
		2000	0	(At least). Lower Marine Series, containing marine fauna similar to that of the Upper Marine Series.
		* * *		Unconformity, and strong break in the flora.

PALÆOZOIC.	LOWER CARBONIFEROUS.	1000	0	Andesitic dolerite n two sheets, separated from one another by Melaphyre tuffs.
		300	0	(About). Fine carbonaceous tuffs passing downwards into a coarse hard tuff.
		9	0	Coal and bands not workable.
		2000	0	Sandstone conglomerate and cherty shale with *Rhacopteris*.
		2	3	Inferior coal and indurated clay.
		2	0	Chert shale and conglomerate.
		5	0	Coal, inferior.
		3550	0	Sandstones, conglomerates and cherty shales with *Rhacopteris*.
		10	0	Marine hard calcareous shale, with conulariæ, producta, &c.
		4550	0	Arkose sandstones and hard shale with conglomerates, containing *Knowia*, *Calamites*, *Rhacopteris*, and *Lepidodendron*.
		2 to 3	0	Bed of magnetic and titaniferous iron ore.
		1000	0	Arkose sandstones and conglomerates, passing downwards into slightly oolitic earthy limestone.
		(?) 8	0	Limestones, encrinital.
	Strata unknown, probably of considerable thickness. (?) * * * Unconformity.			
	DEVONIAN.			Sandstones and quartzites, containing *Spirifer disjunctus*, *Rhynconella pleurodon*, &c.

Total thickness of Triassic (?) rocks 2,500. Total thickness of Permo-Carboniferous rocks 11,150. Total thickness of Lower-Carboniferous rocks 11,300.

17.—NOTES ON AUSTRALIAN CAVES.

By James Stirling, F.G.S.

18.—NOTES ON THE CARBONIFEROUS ROCKS OF THE CAPE OTWAY DISTRICT.

By J. H. Bignell.

[*Abstract.*]

The Mesozoic rocks of the Cape Otway Ranges are bounded by the coast on the south, and are more or less overlain by Tertiary rocks on the north and north-west.

During four years' prospecting the author found several seams of brown coal near Mount McKenzie, into the largest of which a tunnel was put for 300 feet. It averaged 3 feet 6 inches in thickness. Iron pyrites were abundant in that part of the district.

It would not pay to work the coal-seams of the Gellibrand River district unless the latter were made navigable or a railway brought near. The author believes the immense drift deposits of this district to have been brought down from the Grampians.

Passing over the dividing range between the Gellibrand and Barrum Rivers, the author found the Mesozoic rocks to be well exposed in the beds of the streams. Small veins of bright coal were visible, and on the coast, between the mouths of the Elliot and Barrum Rivers, five seams were found, varying in thickness from 5 inches to a foot. Between the mouths of these two rivers there also exist mineral springs, about one and a half miles inland.

In the Apollo Bay district the Mesozoic rocks dip from north to south, at an angle of about 25 deg., and contain patches and small veins of bright coal of the nature of cannel and anthracite, and in following down the dip a bluish-white fire-clay is found.

Some twenty chains up the Wild Dog Creek, which runs into Apollo Bay, Mesozoic rocks appear, standing at an angle of 75 deg., and seams of coal are seen between layers of sandstone and shale. These extend for some 80 chains, and have been exposed by the erosion of the creek waters; they vary in thickness from 3 to 18 inches. They all dip to the south-west, at angles varying from 10 to 71 deg. Some 50 chains to the east lies the Stony Creek, a short distance up which is a precipitous ledge, 100 feet in height. Under this cliff the author proposes to put in a tunnel to cut the 25 seams met with along the Wild Dog Creek, and expects to cut them about 700 feet below their outcrop. Above the cliff nine seams of coal were seen, varying in thickness from 3 to 17 inches, and in angle of dip between 49 and 61 deg., the coal being of first-class quality.

By the side of Skene's Creek the author found a seam of coal, which was not more than 6 inches thick at its outcrop, but which on tunnelling was found to increase to 26 inches. Close to this was found another seam, 18 inches thick, and the two dipping at different angles come to lie close to one another at some 35 feet below the surface, giving in all 3 feet 10 inches of coal. Higher up the creek more seams were found, varying from 6 to 18 inches thickness.

Altogether, the author has prospected for some 45 miles from east to west, and across the measures from north to south, and has opened 55 seams of coal, of which 50 consist of good black coal. From the rock-sections examined, the belief has been arrived at that an extensive coalfield exists in the Otway Ranges. In addition to coal, iron, fireclay, lead, copper, graphite, magnesium, cobalt, and manganese are to be found.

19.—ON THE DESERT SANDSTONE OF CENTRAL AUSTRALIA.

By PROFESSOR TATE, F.G.S.

20.—THE PHYSICAL CONDITIONS UNDER WHICH THE CHIEF COAL-MEASURES OF TASMANIA AND VICTORIA WERE FORMED.

By S. H. WINTLE, F.L.S.

IT has been the general impression among the earlier geologists who had visited Tasmania, notably, that the coal-measures of that island, which not only flank its mountain system for the most part, but encircle it as a zone, are of anterior age to the greenstone which rises above them. The result of over a quarter of a century's observation convinces me that the contrary is the fact. In a word, that the dioritic crystalline rock, most frequently highly columnar and diabasic, is truly plutonic, and that it existed long before the coal-measure strata, with the great thickness of alternating thick-bedded sandstones, clay-shales, mudstones, limestones, conglomerates, together with the Silurian beds were laid down. When the coal deposits are not found upon the mountain slopes in Tasmania at an elevation of from 500 feet to 1500 feet above sea level, they not only form an exception to the rule, but are of very limited extent, and much disrupted by subsequent local seismic disturbance, as, for instance, in the Mersey district, at Jerusalem, and the anthracite beds at New

Town. I believe I am right in assigning the position which the three last-mentioned coal-measures occupy, in the lower levels, to seismic depression of the surface of the area which they occupy, long after the deposits were formed, for the reason that they are intimately associated with eruptive and disrupted basalts corresponding to the older or Miocene basalts of Victoria.

The principal coal-beds of Tasmania, from a commercial point of view, are those at Mount Nicholas, in the district of Fingal, Mount Ben Lomond, 30 miles distant easterly, and at the Sandfly Rivulet Ranges, in the Huon River district, south of the island. These all occupy elevated positions on the sides of mountain ranges, the altitude of which vary from 500 feet to 1500 feet above sea level. These coal-seams, with their associated interstratifying clay-shales and sandstone, present a nearly horizontal position, the average inclination, or dip, being $2\frac{1}{2}$ deg. north-east, while the Upper Silurian strata on which they repose uncomformably, and which chiefly consist of purple and yellowish variegated arenaceous incoherent shales, with intercalating slates, have an average inclination of 70 deg. The Mount Nicholas coal-seams may be accepted as a type of these alpine coal-measures in the island of Tasmania. The summit of this range consists of crystalline diabasic prismatic greenstone, its greatest altitude being 1800 feet above sea level, or 1000 feet above the Break-o'-Day valley. The uppermost coal seam (which is that mined by the Cornwall Coal Mining Company, and exported to Victoria) has a thickness of 11 feet, but at the western extremity of the range, distant about two lineal miles, it attains a thickness of 15 feet in the clear. There are known to me five other different seams, varying from two feet in thickness to five feet. They are all bituminous coal, of a dense, laminated structure, possessing a well-defined cleavage conformable to the line of deposit. The coal-seams which obtain on the southern side of the range have their exact equivalents on the northern side. They have been cut through in the depressions at both ends of the mountain range. That they have not been subjected to any displacement, such as would be the result of telluric disturbance since they were deposited, is to be gathered from the fact that they only depart from the horizontal position by a mean dip of 6 deg. east by south on both sides of the range. All the associated strata of clay-shales, sandstones, marine mudstones, and limestones—the faunal palæontology of the two latter formations being striking analogues of the faunal palæontology of the carboniferous, *i.e.*, mountain limestone of Europe—are conformable to the coal-seams. The base of the system is a coarse, pebbly conglomerate, reposing immediately upon the edges of the upturned Upper Silurian shales and sandstones. In brief, these coal-measure strata, at one remote period, formed an unbroken zone, or belt, around these older greenstone heights to within, on an average, 500 feet of their summits, as at Mount Nicholas, Ben Lomond, and Sandfly Ranges. At this period, which is generally regarded as Mesozoic, the summits of the loftier mountains formed small islands in the southern ocean. Subsequently, seismic action took place in various centres, and produced depressions of areas of the coal-measures, and these terrene disturbances, by eruptions of diorite, shattered and in many instances overflowed the coal-measure strata. This is evidenced in the Jerusalem coal basin, Derwent Valley, and at the Mersey, north of the island. The coal-beds flanking the mountain sides are covered up, to a great extent, by fallen greenstone. At the Cornwall mine, before mentioned, the main adit level has been carried in for a distance of 950 yards towards the greenstone backbone of the mountain under fallen greenstone without meeting with the dyke of plutonic rock. Turning to the coal deposits of Victoria, in Gippsland, at South Moe, which are those I have examined and reported upon professionally, they are found to obtain to an elevation of little short of 1000 feet above sea level. Here, as in Tasmania, they have a very slight departure from the horizontal. The associated trap-rock, dark augitic basalt, is older than the coal, if I may venture to make such an assertion, from the fact that I saw a slightly-rounded erratic block of the same basalt taken out of the centre of a seam of coal two feet eight inches thick on the Moe Coal Mining Company's holdings. These coal-measures differ from those of Tasmania in having been laid down under fresh-water conditions. The complete absence of marine deposits is strikingly apparent.

My contention is that the diabasic greenstone of the island colony, and also the basalt associated with the Gippsland coal beds of Victoria, are older than the coal-measures. In short, the coal-measure strata were laid down in depressions, which, at that time existed, in contradistinction to the older accepted theory that the igneous rock had burst through them.

21.—THE SILVER ORES OF THE BARRIER.

By G. H. Blakemore.

22.—GRANITE: ITS PLACE AMONG, AND ITS CONNECTIONS WITH THE SEDIMENTARY AND IGNEOUS ROCKS.

By J. G. O. Tepper, F.L.S.

Section D.

BIOLOGY.

President of the Section: Professor A. P. Thomas, M.A., F.L.S.

1.—ON SOME POINTS IN THE MORPHOLOGY OF *ASTACOPSIS BICARINATUS.*

By J. Stephen Hart, M.A., B.Sc., University of Melbourne.

[*Abstract.*]

The common crayfish of the ponds and waterholes of Victoria, known as *Astacopsis bicarinatus*, or popularly as the yabbie or yabber crayfish, is a member of the family Parastacidæ, separated by Professor Huxley from the northern crayfishes on account of the absence of a well-developed lamina on the podobranchiæ, of appendages on the first abdominal segment, and of a transverse hinge dividing the telson. But although placed in a different sub-family, our Astacopsis resembles very nearly the European Astacus, and is substituted for it in our university courses and elsewhere as a representative of the higher crustaceæ. The aim of this paper is to serve as a supplement to the well-known text-books—such as Huxley's volume, in the International Series, or Marshall and Hurst's *Practical Zoology*—by pointing out what differences are to be looked for in the general anatomy of the two genera.

The external form is described by Professor McCoy in the *Prodromus*, decade iii., plate 29, under the name of *Astacoides bicarinatus*, and further details are given in decade xvi., plate 160. To this description it should be added that the first abdominal segment has pleura as large, in proportion, as the other segments, and not concealed, as in Astacus, by those of the second segment. The colour, as Professor McCoy points out, is very variable, the forceps alone being constantly blue, with red joints. The membranous parts of the last appendages of the abdomen are said by him to be constantly brown, but I have found them much more often of a bluish colour.

Appendages.—The thoracic and cephalic appendages are identical with those of Astacus, but those of the abdomen are very different. As already stated, there are none on the first segment.

On the second, third, fourth and fifth there are appendages, diminishing in size towards the posterior end, and consisting of a protopodite of two segments, a very small coxopodite and longer basipodite, surmounted by an exopodite and endopodite, which are similar in form and almost of the same size, the endopodite being generally rather the smaller, except on the fifth segment. Each has the form of a narrow, flat, membranous plate, bordered by more perfectly calcified serrations, from which arise large plumose setæ forming a close fringe to the appendage. The appendages of the sixth segment forming, with the telson, the tail fin, have much the same shape as in Astacus.

Gills.—The gill formula is as follows :—

		Arthrobr.		
Thorc. segt.	Podobr.	ant.	post.	Pleurobr.
I.	ep.	0	0	0
II.	1	1	0	0
III.	1	1	1	0
IV.	1	1	1	0
V.	1	1	1	1
VI.	1	1	1	1
VII.	1	1	1 rud.	1
VIII.	0	0	0	1
	6+ep.	6	4+rud.	4=20+rud.+ep.

This differs from the formula of Astacus, in having the posterior arthrobranch on the 7th segment rudimentary, and all the pleurobranchs fully developed.

The podobranchiæ have a somewhat complicated structure. The stem, or main axis, arises from a broad basal piece directed backwards, and covered with plumose setæ, with hooked ends. This is continued upwards as a narrow posterior wing to the stem, which is covered elsewhere very closely with branchial filaments. From its inner side a flat plate projects, lying between the arthrobranchs and covered, though much less densely than the rest of the gill, with branchial filaments. It is very small and narrow on the posterior podobranchs, those of segment 7, and gradually increases in size in the more anterior ones, in which it finally extends nearly the whole length of the gill. The epipodite on the first thoracic segment is a flat plate, furnished on the posterior surface with branchial filaments resembling the inner projecting plate of the podobranchs.

In front of each podobranch is a tuft of coxopoditic setæ, like those of Astacus, but much smaller, and provided with hooks. On the posterior edge of each segment there is a small flat plate, fringed with hooked setæ, and formed from the membrane of the joint.

The arthrobranchiæ consist of a simple stem, with very numerous filaments, except along the posterior inner surface, which is closest to the body, and has very few, or none. The posterior arthrobranch of segment 7 is reduced to a papilla, bearing some 9 or 10 gill filaments. The pleurobranchs have no filaments on the inner side, which is closely applied to the body.

The gill filaments are, in some cases, provided with distinct hooks at their free extremities, the distribution of which appears constant. All the filaments of the posterior arthrobranchiæ, and the pleurobranchiæ, are of this description. The anterior arthrobranchiæ bear hooked filaments only on the inner surface, while in the podobranchiæ they are confined to the projecting lamina.

Sense organs.—As in Astacus, the exopodites of the antennules bear setæ, supposed to be olfactory in function. There is one set on each joint, not two as in Astacus, and it consists of a transverse row of three or four hairs, each of two joints, the distal one very much flattened. These are supported by a pair of setæ, which are larger, and taper gradually towards the free extremity. Of the internal organs the circulatory and reproductive systems are most modified.

Circulatory system.—The heart, lying in the same position as in Astacus, has three pairs of valves leading from the pericardium. Two pair are placed towards the dorsal side at the anterior and posterior ends. The third is at about the middle of the ventral surface. The arteries arise as in Astacus, and, except the sternal artery, follow the same course. The sternal artery divides into two a short distance below the heart; the branches encircle the intestine, and again unite just above the endophragmal skeletal plates, after which they follow the same course as the single sternal artery of Astacus.

Reproductive system.—The ovary lies principally just in front of and below the pericardium. There is a median part between the pericardium and the stomach, from which project backwards two small lobes lying close together beneath the heart. In front it rises towards the dorsal surface, and there divides into two divergent halves. A long, narrow, tube-like prolongation of each half runs forward for some distance. At its extremity, between the large muscle of the mandible and the eye, it dilates into a small sack containing ova. The oviducts arise from the posterior end of the main undivided region of the ovary.

The testes lie in the same position as the ovary, in front of and below the heart. They are formed of two lateral halves united together, only in the region of the vasa deferentia, about one-third from the anterior end. The posterior end is not formed of a median lobe as in Astacus, but of two distinct from each other, and often unequal in size.

2.—NOTES ON THE FERTILISATION OF *KNIGHTIA*.

By T. F. Cheeseman, F.L.S., Curator of the Auckland Museum.

Some years ago I published in the New Zealand *Journal of Science* some notes on the fertilisation of *Knightia*, one of the two species of *Proteaceæ* indigenous to New Zealand. Since then I have had opportunities of examining the subject with more care, and it has occurred to me that a *resumè* of what I have been able to make out may not be without interest to the members of the Australasian Association.

Up to the present time very little has been published on the fertilisation of the *Proteaceæ*. Many years ago Mr. Bentham, in a suggestive paper printed in the journal of the Linnæan Society (" Botany," vol. 13, p. 58), pointed out that in most of the species the anthers open while the flower is still unexpanded, and discharge their pollen on an enclosed portion of the style often described as the stigma. Thus, on a superficial examination, it might be concluded that the flowers fertilised themselves, and several observers have fallen into this very natural error. In reality, however, either the stigma does not mature until long after the expansion of the flower, and until after all the pollen has been swept off the style, or else special contrivances exist by which the stigma is shielded from the pollen so liberally scattered around it, and reserved for the action of pollen brought from other flowers. The general plan of fertilisation is thus somewhat analogous to that of the *Compositæ*, where, as is well-known, the anthers cohere into a cylinder surrounding the style-branches, on the pubescent or papillose outside of which the pollen is usually shed. But fecundation cannot take place at this stage, for the stigmatic surface is always on the inner face of the style branches, which remain firmly closed together until some little while after the expansion of the flower; and before they separate the pollen has usually been brushed off by the visits of insects, or removed by other means; so that, to ensure fertilisation, pollen must be regularly conveyed from younger flowers to older ones. This is precisely what takes place in the *Proteaceæ*; but as in that order the style is always undivided, and the stigma consequently external, much more elaborate contrivances are often required to screen off the pollen of the same flower. Some of these contrivances are so remarkable that it has long been a matter of surprise to me that so few of them have been fully examined and described.

The curious inflorescence of *Knightia* is familiar to most settlers in the northern portion of New Zealand. The flowers, which are of a bright red-brown colour, and very conspicuous, are arranged in pairs on stout lateral racemes, each raceme containing from 40 to 80 flowers, or even more. Before expansion the perianth is cylindrical in shape, slightly swollen at the base and then contracted, but again gradually thickened towards the extremity. It is about 1½ inch long, and externally is everywhere covered with a dense velvety tomentum. In the young bud there is no appearance of segments, but some time before expansion the top of the tube splits into four minute teeth, the apex of the style showing between. Later on the segments come apart at the base of the perianth, and by degrees the separation extends higher up. For a long time, however, they firmly cohere in the upper swollen part of the tube, and the final separation always takes place suddenly and elastically, the four segments each coiling up into a tight spiral band, which is packed away at the very base of the flower. The fully-expanded racemes show, therefore, little more than a brush of long styles projecting from a mass of twisted perianth segments, and present a very different appearance to those in the bud state, so that I have had the two brought to me as the flowers of two distinct plants! The anthers are four in number, sessile towards the tops of the perianth lobes, and in the bud form a ring round the upper part of the style, to which they are closely applied. The style is over an inch in length, rather slender at the base, but much swollen in its upper half, forming a lengthened club-shaped termination usually considered as the stigma, but I very much doubt the whole of it being truly stigmatic. At the base of the flower are four rounded glands, secreting an abundance of nectar, which slowly exudes from them and usually surrounds the base of the ovary. The flowers have a strong and very peculiar odour, a single raceme being quite sufficient to unpleasantly scent a close room.

If a flower is examined just prior to expansion, it will be noticed that the anthers have opened down their inner face and deposited the whole of their pollen on the moist surface of the thickened portion of the style, on which it forms four little ridges. After the opening of the flower, and the coiling up of the perianth segments, the pollen is thus left exposed on the surface of the style. As mentioned before, this looks like a simple case of self-fertilisation, but a little examination proves that the stigmatic surface is not mature until some time after the flowers open; and that before it is in a receptive condition the pollen has all been removed. Some means must therefore exist by which the pollen is regularly transferred from the younger to the older flowers. It is natural to assume that this is done through the agency of insects, especially as the great abundance of honey induces many to visit the flowers. But in most cases they simply crawl about between the styles, and never touch either the pollen or stigma elevated far above them. It appears to me that large insects alone could aid in the work of fertilisation; and even among these the nocturnal or crepuscular moths could be of little service, as the styles are far enough apart to allow of their probosces being inserted without touching them. Possibly some of the larger *Diptera* or *Coleoptera*, as well as the honey-bee (which is a regular visitant), may be of use; but the conclusion I have arrived at is that the flowers are principally adapted for fertilisation by honey-feeding birds, such, for example, as the Tui *(Prosthemadera novæ-zealandiæ)* and the Korimako *(Anthornis melanura)*. That the former bird regularly frequents the flowers I have myself repeatedly observed, and old and observant residents, who were well acquainted with the habits of the Korimako before its disappearance from our northern forests, all agree in stating that it was equally ready to take advantage of the luscious supply of honey offered by the plant. In addition to these two species, I have noticed the Kaka Parrot *(Nestor meridionalis)* sucking the honey from the flowers, as also the little white-eye *(Zosterops cœulescens)*, but I do not think that either is such a frequent visitant as the Tui.

A glance at the flowers will at once show how fertilisation is effected. It is obvious that a bird, when thrusting its head between the styles of a recently-expanded raceme in search of the honey, must dust the feáthers of the forehead and throat with pollen. And if it should afterwards visit flowers in a more advanced stage, it is quite certain that much of this pollen would be rubbed off on the moist surface of the style, and fecundation consequently take place.

Knightia is not the only New Zealand plant in which the work of fertilisation is mainly performed by birds. The flowers of the red kowhai (*Clianthus puniceus*) rarely produce seed in our gardens, simply because that in such situations they are seldom visited by birds. Some years ago, a fine plant growing in my own garden, profusely loaded with flowers, was visited by a stray Kaka parrot, which spent the greater part of one day in sucking the honey from the flowers. That season the plant was loaded with pods, although in no previous year could more than two or three be obtained at one time. The yellow kowhai *(Sophoza tetraptera)* is largely (but not exclusively) fertilised by birds, as also is the tree fuchsia *(F. excorticata)*. There can be little doubt, too, that in the various species of *Metrosideros* there is a good deal of cross-fertilisation through the agency of birds.

It is now well established that cross-fertilisation possesses undoubted advantages over self-fertilisation; and an excellent argument in favour of this view may be inferred from the case of *Knightia*. We find that the structure and arrangement of the parts of the flower are such that the style and stigma are actually embedded for some time in a mass of pollen, so that no one can doubt that if self-fertilisation had been the preferable mode it might have been obtained with certainty, and with a minimum expenditure of force. But instead of this we see a number of contrivances all pointing in the opposite direction. The ripening of the stigma is delayed, in order that there may be no risk of contamination by pollen from the same flower. The summit of the style is enlarged to form a suitable stage on which the pollen may be presented to the visitors, to whom the task of transferring it from flower to flower is entrusted. The perianth segments are coiled up, and removed from their path, and a suitable attraction is afforded in the shape of an abundant supply of nectar. Surely these contrivances would not be provided if some great advantage were not expected in return. To my mind, cases similar to those of *Knightia*—and they are probably numerous enough—afford additional proof of the truth of Mr. Darwin's well-known aphorism—"That nature tells us, in the most emphatic manner, that she abhors perpetual self-fertilisation."

3.—ACCLIMATISATION IN VICTORIA.

By W. H. D. Le Souef, Assistant Director of the Zoological Society, Melbourne.

The subject of Acclimatisation is a record of great successes and great failures, and I regret that my experience of the subject tells me (and mine is the experience of all interested in this subject) that, as a rule, it would have been better for Australia if the great successes had been failures and the failures successes. Certainly, horses, cattle, and sheep, and, in fact, all domestic animals, have proved themselves very much at home in almost all parts of Australia, for no portion of the earth's surface produces finer stock or finer wool.

I do not propose in this brief paper to go into the subject of Acclimatisation generally, but only to mention those animals and birds that have been introduced into Victoria from other countries at different times during the past thirty-five years. I am unable to say how long ago it is that the first efforts were made in the direction of acclimatisation in Australia, but it most likely commenced in the older colony of New South Wales, and it is now nearly if not quite fifty years ago since efforts were first made to introduce the pheasant into Tasmania, but all efforts failed to establish this fine game bird in the island. Here in Victoria enthusiastic men, foremost among whom may be mentioned the late Mr. Edward Wilson, the late Mr. Samuel Winter of Murndal, and Dr. Thomas Black of St. Kilda, have for many years past endeavoured to introduce not pheasants only, but many other birds and animals, and, I regret to say, have met with but indifferent success. The Zoological and Acclimatisation Society of Victoria has also introduced many varieties; among them may be enumerated the alpaca, the Angora goat, the sambur, axis, rusa, hog, Formosa, and Barasingha deer, the hare, the ostrich, pheasant, Californian quail, thrush, blackbird, starling, &c., and it has to bear a certain amount of blame for assisting in the introduction of the house sparrow; but it had no share whatever in the introduction of that dreadful pest, the rabbit, which was brought out by private individuals; the fox, which promises to be almost as great a nuisance, was also introduced by private enterprise.

The two first-named animals, the alpaca and the Angora goat, were costly experiments, and both have failed. In Peru, the habitat of the alpaca, its home is on high mountain ranges; there these animals are found at an altitude of nearly 10,000 feet, seldom descending lower. The difference in altitude and climate soon told on the imported animals, and they gradually drooped and died out. It is doubtful if these animals will thrive in any part of Australia, but the most likely place would be in mountainous country far inland, where the rainfall is small.

The Angora goat, also imported by the Society, principally through the instrumentality of Dr. Black, of St. Kilda, at a very considerable outlay and much trouble, has also proved a failure; many persons have tried them, both in Victoria and South Australia, but all have failed to make them pay, and the only pure goats now in Victoria (excepting a few kept at the Zoological Gardens as specimens) are a small flock on the Mount Bute estate, the property of Sir Samuel Wilson. These animals have been tried in almost all parts of Victoria, and also in South Australia, by Mr. Price Maurice and others; but they have never been able to hold their own, and have in all cases been given up as an unprofitable industry, being not only delicate in constitution, but troublesome to manage, great care having to be exercised to keep them from common goats, which are now to be found almost everywhere; and although on one occasion the clip of Victorian bred Angoras reached as high as four shillings a pound, and on another three shillings and sixpence, yet as a rule the fleece, beautiful as it is, is not as valuable in the London market, pound per pound, as first-class merino wool; and, at the same time, the fleece is much lighter than that of a well-woolled merino. In a very interesting paper on the Angora goat, published in the Society's Proceedings in the year 1873, by Sir Samuel Wilson, that gentleman stated that, with careful management and sufficient pastures, his flock of a little over one hundred should increase in forty years from that date to over seven millions. Sixteen years have passed since then, and the pure flock mentioned in this paper has remained nearly stationary in numbers. If common goats had never been introduced into Australia, and the Angora only had been acclimatised, the result might have been very different, and the animal would have proved of great value, for they would then have fallen into the hands of small owners, who would have looked well after them for the sake of their fleece, and there would then have been no chance of deterioration from cross-breeding. This is the case in Angora in Asia Minor, the habitat of this particular breed of goats.

The Cashmere goat has also been tried here, a number having been introduced in 1862, but it did not succeed; in all probability the difference of climate and elevation having something to do with the failure, Cashmere being from 5000 to 6000 feet above sea level.

Deer, on the other hand, do very well in Victoria, and there are numbers of different varieties in the colonies. On the Upper Yarra the Fallow deer *(Dama vulgaris)* is well established; they have increased and spread from some turned out by Mr. Paul de Castella many years ago. On the Grampians the Indian Axis deer *(Cervus axis)* are numerous, and in the Koo-wee-rup swamp and surrounding country in Mornington the Sambur deer *(Cervus aristotelis)* are plentiful; they are the progeny and descendants of a few liberated many years ago by the Society; this variety of deer is also established at "Ercildoune," near Burrumbeet. In the Gembrook Ranges the Rusa deer *(Cervus hippelaphus)* and Formosan deer *(Cervus taëvanus)* are met with, but they have not had time to increase much yet, as it is not long since they were liberated by the Society.

Little need be said about the hare, which seems to be only second to the rabbit in fecundity in this climate, and it seems to have spread all over Victoria from a few pairs liberated nearly at the same time by the Society at the Royal Park, by Mr. F. R. Godfrey at Mount Ridley, near Donnybrook, and by the late Mr William Lyall at "Harewood," near Cranbourne. They are frequently found in scrubby, mountainous country, where no one would expect to see them.

The ostrich was first introduced by the Society in the year 1868; they were first sent to the Wimmera, to one of Sir Samuel Wilson's stations, and remained there for some years; they were then transferred to the care of Messrs. Officer Brothers, at the Murray Downs Station. Owing to the bad means of transit from the Wimmera to the Murray, and an accident to one of the hen birds soon after their arrival, the success of the experiment was nearly marred at the outset, as only one hen bird was left; fortunately she proved herself equal to the occasion, and laid a number of eggs, which were successfully hatched. The birds gradually increased in number until they reached one hundred, the Messrs. Officer Brothers going to considerable expense in providing suitable accommodation and food for them. Some years after the Murray Downs Station was sold, and Mr. C. M. Officer purchased the Society's interest in the birds and removed them to a property of his near Kerang, where they still remain; but the industry has not developed, as no one else has had the spirit to follow in their footsteps, and at present, though the adaptability of the lower Murray country to the ostrich has been fully proved, there seems very little probability of the industry being followed up; one reason, no doubt, is the great difference at times in the price of feathers, which suffer much from the caprice of fashion, and are not, like wool, always in demand.

That splendid game bird, the pheasant, was introduced by the Society many years ago and efforts were made to acclimatise it, numbers being liberated in various parts of the country; but no success attended these early efforts, and it was not till the Zoological Society secured a block of land at Gembrook, then a newly-settled district, that the birds increased to any extent. For some years a considerable number were liberated there every season, and they increased and spread considerably for miles around; but then came the rabbits, and in destroying these the pheasants also suffered. There are still a few to be found on different properties, but as a matter of acclimatisation the experiment cannot be said to be a success, although at one time it promised to be so, as the birds were breeding fairly well and many young broods were seen; but poisoned grain and domestic cats turned loose have done their work, and the pheasants have nearly disappeared.

Californian quail, a very fine bird, about two-thirds the size of a partridge, were a great success at Gembrook for some years, and the original fifty birds liberated there increased to many hundreds; but suddenly they began to disappear, and now there is not a bird to be seen, and it is a mystery to me what has become of them. They certainly were not shot, and I never heard of any that had been found dead, nor could we learn that they had migrated, but the fact remains that they have gone. It must be remembered that there are very few berry-bearing bushes in Victoria, and the birds have many enemies; the native cat, or Mange's dasyure, the tiger cat, or spotted-tailed dasyure, the iguana, or Gould's monitor, the snake, laughing jackass, or giant kingfisher, the hawk, etc., all prey on the young birds.

The partridge was introduced many years ago, and seemed to succeed for a time, but bush fires carried them off. Now that large tracts of land are under cultivation, it would be much easier to introduce and establish them than in former years; but it could not be done unless they were protected by law.

The European thrush has been successfully established, but has spread very slowly, although it is plentiful on the south side of the Yarra, in the gardens of Toorak and the surrounding districts, but it has not made its appearance in any numbers in the northern suburbs, although a few are to be seen occasionally.

The blackbird does not seem to thrive in Victoria. This is, no doubt, principally from the want of berry-bearing bushes, which form a large portion of its food. At the Zoological Gardens we are making another effort to establish this delightful songster by enclosing the birds in a large wire aviary filled with shrubs, and letting only the young birds go free.

Considerable sums of money have been expended by the Society in the introduction of the skylark, but so far almost without success. Here and there a few birds are still to be seen, and their delicious song heard, but they are few and far between. Yet everything is in their favour here in regard to climate and suitable country, but the reason of their non-success is apparently due to the ever-active and numerous hawks in the air, added to the many enemies I have already enumerated on the ground.

About ten years ago the Society liberated a few starlings, obtained from New Zealand, in the University grounds here and in the Zoological Gardens. The success of this experiment has been very marked. Not only have they succeeded, but they have increased to large numbers; flocks of several hundreds may now frequently be seen. They migrate every year, most likely to the north, and regularly return about November. This is strange, as the starling is not strictly a migratory bird. As is well known, these interesting birds are insectivorous in their habits, and are looked upon justly with favour even in quarters where most birds are viewed with a suspicious eye.

The Indian minah, introduced in the year 1862, has spread all over the neighbourhood of Melbourne. They are insectivorous birds, and no doubt do much good by destroying countless insect pests, but as they also eat fruit an outcry has been raised against them. Victorians have been so accustomed, of late years, to a plentiful supply of vegetables that thay forget that it is to such birds as the Indian minah and the sparrow that they are indebted in this respect. Before these much abused, but in many respects most useful, birds were introduced, cabbages, cauliflowers and many other vegetables could not be grown successfully, they were so covered with aphis, but now such a thing is rarely seen. The same may be said of roses, which were formerly infested with aphis. I have often watched a sparrow on a rosebush busy in clearing off the aphis with which it was thickly covered.

The English robin, the goldfinch, the linnet, and many other small birds have been introduced and liberated, but they have not succeeded. It is very different in New Zealand, where all the European birds seem to answer admirably. Pheasants, blackbirds, thrushes, skylarks, and numerous other birds have not only succeeded, but in some instances become a nuisance from their increasing numbers.

I may say that the result of acclimatisation in this colony has taken everyone interested in the subject by surprise. The rabbit goes on breeding at an astonishing rate all the year round. The hare, which in England rarely produces more than two at a birth, here frequently has five and even seven, while the sparrows have increased at a prodigious rate. On the other hand, many birds that would be highly beneficial will not adapt themselves to their new surroundings. Another troublesome importation from the old country has of late years made its appearance, in the European snail, no doubt introduced in wooden cases containing plants. It is now spreading far and wide over Victoria; wherever plants are carried the snail probably goes too. It seems, like the sparrow, the rabbit, and the fox, to increase very rapidly, and will yearly become more troublesome.

The introduction of English trout into Victorian streams has been, on the whole, a success. There are several fish acclimatisation societies in Victoria—in Ballarat, Geelong, and other places, all of which do good work; and Sir Samuel Wilson has a very complete fish-hatching establishment at "Ercildoune," which he maintains at his own cost, giving the young fish every year principally to the Zoological and Acclimatisation Society, the Society undertaking the transportation of the fish to suitable streams, and thus benefitting the whole colony. In this manner a great many fine streams have been stocked, and the number of trout streams is being increased every year. One or two costly experiments have been made with the English and the Californian salmon, but without success. But here again New Zealand is far in advance, as the streams of that fine colony are much better adapted to the trout and other European fish than ours are.

Both my father and myself have taken a deep interest in acclimatisation for many years past, and I sincerely wish I could write more hopefully on the subject; but I fear that but scant success will attend any efforts in this direction, as far as good game birds are concerned, without laws to prohibit indiscriminate shooting. At every holiday season parties of young people spread all over the country shooting everything they meet, and also, alas! shooting each other. This should be stopped, but in this free and democratic country such prohibitions are not popular. One thing is certain, that if birds are to be established they must be protected from pot-hunters, and individual effort must be more sustained in the future than it has been in the past.

The following list gives a summary of the principal animals and birds acclimatised in Victoria:—

The *Deer,* of which six kinds have now successfully established themselves, and are at large in the colony.

The *Alpaca,* which has not been able to accommodate itself to the great change from an altitude of 10,000 feet in Peru, its native land, to the Victorian climate, and has died out.

The *Cashmere Goat,* which has failed from the same cause.

The *Angora Goat,* which has proved unprofitable, and has been almost entirely absorbed into the breed of common goats.

The *Hare*, which is well established here, and, with the fox, bids fair to be a nuisance in some parts. Both the fox and rabbit were introduced by private enterprise.

The *Ostrich*, which has proved itself well suited to the plains of the lower Murray; but the enterprise has not proved profitable, owing to the uncertain market for the feathers.

The *Pheasant*, *Partridge* and *Californian Quail* throve well at first, but seem now to have succumbed to their many enemies.

The *Thrush* has been established here, but not as yet in large numbers.

The *Blackbird* has not as yet been established, but another effort is now being made at the Zoological Gardens.

The *Skylark*, too, has not met with suitable conditions here, and is now almost extinct.

The *Starling* and the *Indian Minah* have been very successfully introduced, and are to be found in great numbers.

The *Robin, Goldfinch, Linnet* and many other small birds have also failed to get a footing here.

Amongst fish, the *Trout* has been a success, and the *Salmon* has failed.

4.—ON THE DEVELOPMENT OF *CHILOBRANCHUS RUFUS (TELEOSTEI, SYMBRANCHIDÆ).*

By William A. Haswell, M.A., D.Sc., Professor of Biology, University of Sydney.

Chilobranchus rufus is a small eel-shaped fish, very abundant below stones between tidal limits in Port Jackson. The family *(Symbranchidæ)* to which it is referred includes only the two genera *Symbranchus* and *Chilobranchus*, and is regarded as most nearly related to the *Murænidæ*. With regard to the structure and affinities of the genus I shall have something to say in a later paper dealing with the more advanced stages in the development.

Chilobranchus rufus deposits its eggs on the under surfaces of stones between low and high water mark, occasionally, though not frequently, on the upper surface of small stones or shells lying under the shelter of a larger stone. In such shelters, in the breeding season, which extends over July, August, and September, male and female (which differ very strikingly in coloration and markings) are to be found together, and near them will usually be found a batch of eggs. The eggs are cemented to the surface of the stone in a single layer, and in one batch there will often be found from fifty to a hundred, presenting a variety of stages in their development, showing that they had been laid and impregnated at different times. Each egg is cemented to the stone by a little disc, formed apparently by a drop of a viscid material, against which the egg is pressed, and which becomes firmly united with the egg-membrane which it resembles in character.

In addition to the examination of living eggs, the following methods were followed :—

1. The eggs were put in a ten per cent. solution of nitric acid and left in it for half an hour, then thoroughly washed in water, and passed through ascending grades of alcohol to 90 per cent. This was found to be by far the best method for most phases in the development; the nitric acid readily passes through the egg-membrane and produces a strong whitening effect on the blastodisc, leaving the yolk unaffected and translucent; the shrinkage is very slight. With this, as with the other methods employed, series of sections cannot well be made by the paraffin method, owing to the great brittleness of the yolk, especially in the earlier stages, and recourse must be had to celloidin.

2. The eggs were fixed with Perenyi's fluid, allowed to act for half-an-hour, and followed by ascending alcohols. This method preserves the eggs well, but is not so serviceable as the preceding, as it does not produce so great a whitening effect on the protoplasm of the blastodisc.

3. The eggs were treated with osmic acid, followed by Merkel's fluid, as used by Agassiz and Whitman in their studies on pelagic fish-eggs. This method is of very great value in differentiating the periblast and the periblast cells from the other elements.

General Features of the Egg of Chilobranchus.

The eggs are very small, being only 1·2mm. in long diameter. They are nearly always of oval shape (though a few spherical examples were found), and the short diameter is 1mm. The egg is cemented down by one side; the blastodisc is sub-polar in position, but nearly always inclined towards the upper side of the egg (*i.e.*, that side cemented to the surface of the stone); its position would therefore seem to be a polar one, slightly modified by the action of gravity. In a small percentage of cases, however, the blastodisc was found to be situated in the middle of one side of the egg, which brought about marked changes in the general form in certain stages, as will be afterwards noticed. A few abnormalities were observed, of which the most interesting were two cases, in each of which there were *two* two-cell stages close together. It is very likely that these were not natural, but resulted from mechanical action during the removal of the eggs from the stone. There were a good many eggs, however, in which development seemed to have been arrested, there being only an abnormal blastodisc with a softened yolk. Such were probably eggs that had accidentally escaped impregnation.

Circumstances were not favourable for investigating the history of the egg previous to the beginning of the process of segmentation, and what slight observations I have been able to make on this stage may be reserved till I have had the opportunity of a more thorough study. As in some other teleosteans, the germinal disc is formed as a result of impregnation, and an unimpregnated ovum presents no trace of such a structure.

The Blastodisc and the Process of Segmentation.

The blastodisc makes its appearance a little on one side (the upper) of the future ectodermal pole of the egg. When fully formed, and before segmentation has commenced (a phase which, judging from its rarity in preserved specimens, must be of very brief duration), it is a small circular disc, around which is gathered a narrow zone of periblastic protoplasm. From the periblastic zone there radiate outwards a number of branching protoplasmic threads, which soon become lost in the yolk and in the thin investing layer of periblast. The plane of the first cleavage is vertical to the surface of the blastodisc, and is inclined at an angle to the plane passing through the long axis of the egg. In the next stage, of which many specimens were obtained, there are four symmetrically-arranged blastomeres forming a quadrilateral blastodisc with rounded angles. The next change brings about a disturbance of the symmetry, for two of the four cells subdivide in such a way as to give rise at once to the appearance of a long and a short axis in the blastodisc, which now consists of three pairs of cells, arranged right and left on either side of a median line—the future long axis of the embryo. Of these, the middle pair are larger than the others, and each of them very soon becomes divided into two by a transverse fissure. Thus is reached the stage of eight cells, in which four pairs of cells are arranged symmetrically on either side of the middle line. During those phases of segmentation the blastoderm has undergone some increase in size, probably at the expense of the periblastic material, which has become much less evident, the radiating threads having disappeared altogether shortly after the beginning of segmentation.

The next stages are marked by the considerable increase in thickness of the blastoderm, which soon projects prominently from the surface of the egg, and by the appearance of a ring of marginal cells differing to a marked extent from those of the remainder of the blastoderm. This ring first appears in the 32-cell stage, when it consists of ten rather narrow cells encircling the remainder. At first it is on a level with the rest of the blastodisc, but while the latter bulges more and more the marginal cells remain nearly on a level with the surface of the vitellus, eventually becoming tucked in beneath the steep edge of the central part of the blastodisc.

In the meantime the blastodisc has become (after the 32-cell stage) two layers thick in its central portion. It lies directly on a thin layer of non-nucleated periblastic material, which extends round the whole vitellus. There is at this stage no trace of a segmentation cavity. The blastoderm now spreads out as a very thin layer over the ectodermal extremity of the egg. The thick blastoderm of 16 cells becomes converted in eighteen hours into a thin cap of very numerous small cells, covering about a quarter of the yolk. This cap is at first perfectly uniform, but soon changes appear, by which it is marked out into an embryonic (posterior) and a non-embryonic (anterior) portion.

The first of those changes, which becomes marked when the blastoderm extends over about a third of the yolk, is the formation of a thickened rim, having the appearance of being produced by a bending inwards of the edge. About this time also a cavity (segmentation cavity) appears underneath the anterior (non-embryonic) part of the blastoderm. This cavity has a very short duration, soon becoming obliterated. It intervenes between the blastoderm proper and a thin layer of periblast, with scattered nuclei, which forms its floor. A depression then appears just within the anterior border of the ring, bounded behind by two rounded elevations. The depression, which is of small extent, is the non-embryonic part of the blastoderm, the rest, ending in front in two convexities separated by a median notch, is the embryonic shield. As the blastoderm extends further over the yolk, both the embryonic and the non-embryonic portions are increased in size. The two convexities of the anterior border of the embryonic shield coalesce to form one median prominence, which marks the position of the anterior border of the head of the embryo. When the blastoderm has passed the equator of the egg an axial thickening, at first very narrow, appears, running from the posterior border to near the anterior margin of the embryonic shield. Its direction of growth seems to be from behind forwards, and it probably begins at the thickened posterior border, into which its posterior extremity passes out laterally. In some instances there is a slight break or notch in the thickened border of the blastoderm at the end of the axial thickening; but this does not seem to be of constant occurrence.

When the blastoderm covers three-quarters of the surface of the egg the axial thickening has become somewhat broader and is growing downwards into the yolk as a keel-like ridge. This keel is much more strongly developed in its anterior half; behind it decreases greatly in size.

Sections through embryos with the keel in various stages of development show that epiblast and mesoblast are completely fused in the whole length of the keel. This is entirely at variance with what has been observed in other fishes. Goette, for example, states that in the trout there is no coalescence of the layers along the line of the median keel at any stage, and figures them as clearly distinguishable from one another.

It is some time before the blastoderm has quite covered the yolk that the earliest rudiments of the optic vesicles become visible. First the anterior end of the epiblast layer of the keel, which may be termed medullary cords, shows a rounded enlargement in front. Then in this there become distinguishable an axial portion, which is the anterior end of the medullary cord, and two lateral parts, which soon become distinctly separated from the former. When they first become distinguishable these lateral parts of the anterior enlargement extend to the extreme front end of the latter; but very soon they appear to retreat backwards—their anterior ends falling short, by a little distance, of the end of the axial cord. This appears to be due to the anterior part thinning out, while the posterior part becomes thickened and more strongly defined. These lateral parts of the anterior enlargement are the equivalents of what Goette * terms the sensory plate (Sinnesplatte). The thickened posterior part forms the optic "vesicle."

That these optic rudiments arise from the same stratum of cells as the medullary cord is evident enough, but from the way in which they make their appearance at the sides they would rather seem to be thickenings of the surface stratum of epiblast than outgrowths from the medullary cord. The latter, it has also to be noted, at the time when the bodies in question are distinctly formed is scarcely yet a definite structure, but is really nothing more than the more superficial cells of the blastodermic ridge or keel, which are not yet definitely marked off from those below, destined to form the notochord and the mesoblast.

Up to this point there is not the least appearance of a groove or cleft on the surface of the medullary cord, which is an undivided axial thickening of the epiblast not projecting very prominently on the surface. It is only after the establishment of the optic "vesicles" that the medullary cord becomes separated from the cells lying below it, and becomes marked out by a faint longitudinal fissure into two lateral halves. A little later a pair of thickenings appear behind the optic rudiments at the sides of that part of the embryonic cerebro-spinal axis destined to form the hind-brain. These when first they become evident are elongate thickenings running parallel with the medullary cord. The middle part of each gives rise to the rudiment of the auditory labyrinth, which makes its appearance later in the form of a rounded sac.

The first trace of the *brain* is the appearance of a slight swelling just behind the optic vesicles. From this there become constricted off behind a pair of inconspicuous swellings, which

* "Beiträge zur Entwickelungsgeschichte der Wirbelthiere, IV., Ueber die Sinnesplatte der Teleostier." Arch. f. Miker. Anat.

subsequently give rise to the cerebellum. The front part—corresponding to both fore and mid brain—long remains undivided, but subsequently a slight dilatation of the median longitudinal fissure appears opposite the anterior ends of the optic vesicles; this is the third ventricle, and the small segment of the brain at the sides of and in front of it represents the fore-brain. When the rudiment of the third ventricle has made its appearance, the hind-brain has become plainly marked into cerebellum and medulla oblongata.

The lens-involution first appears before the brain shows any definite signs of division into parts; it has the form at first of an irregularly-shaped plug of cells, which does not lose its connection with the surface epiblast till after the fore-brain has become differentiated. It grows into a depression of the optic "vesicle" formed to receive it; the "vesicle" long remains a solid structure, the wall of the optic cup only presenting a division into two layers at a comparatively late period.

The nasal pits appear after both eye and ear rudiments have become well formed; they appear as depressions in little three-cornered masses of cells between the anterior end of the cerebro-spinal nervous axis and the rudimentary eyes.

The proto-vertebræ appear at about the time when the first swelling indicating the brain has become apparent. They are remarkable for their small size and their number. They are formed as a result of the segmentation of two narrow bands of mesoblast lying at the sides of the cerebro-spinal axis.

5.—NOTES ON THE MUSCULAR FIBRES OF PERIPATUS.

By William A. Haswell, M.A., D.Sc., Professor of Biology, University of Sydney.

In Hatchett-Jackson's revised edition of Rolleston's "Forms of Animal Life," there is the following statement with reference to *Peripatus capensis* (p. 320):—"The muscles, with the exception of those attached to the jaws, are unstriped." I have been unable to find in any of the original papers* on *Peripatus* the statement that the muscles attached to the jaws are striped, and I do not know on what authority Hatchett-Jackson rests in making the statement. Owing, however, to the peculiar interest which the subjects presents from the point of view of the evolution of striated muscle, I made a very careful examination of the muscular fibres of the New South Wales species of *Peripatus*

* I refer to the well-known papers on the subject by Mosely, Balfour and others. It is possible that there may be some statement of this kind in Sanger's paper, which I am unable to read.

(P. leuckartii), both in the fresh condition and when treated by the gold method, with the result that the fibres of the jaw muscles are entirely unstriated, like the muscles of the rest of the body, though a peculiar transversely-striped appearance is imparted to those muscles by the arrangement of a number of the finest branches of the tracheæ.

If the statement made by Hatchett-Jackson should prove to be correct—that in *P. capensis* the jaw muscles alone are striated—then one would be tempted to think that we have in the muscular fibres of the appendages of *Peripatus* an example of *degenerate compound fibres*, in which the striation has become lost, save in one set of muscles, since the ordinary fibres of the muscles of the limbs are of compound character, and resemble some varieties of muscular fibres found in other Arthropods in all respects save in the absence of striations. This does not, however, in view of what we know of the rest of the organisation of *Peripatus*, seem very probable, and it appears more likely that a mis-statement has crept into a work otherwise remarkable for its accuracy.

6.—DESCRIPTIONS OF NEW VICTORIAN ALGÆ.

Translated by J. Bracebridge Wilson, M.A., F.L.S., from Till Algernes Systematik nya bidrag af J. G. Agardh.

Siphoneæ.

Bryopsis clavæformis.—Group of plants somewhat pyramidally tufted. Fronds bristle-shaped, about half an inch in height, radiating upwards from a radical plexus, simple or sparingly dichotomous below, cylindrical, gradually thickening upwards into a club shape, bearing spherical conceptacles below the blunt apex.

B. baculifera.—Group of plants somewhat pyramidally tufted. Fronds bristle-shaped, four to five inches long, radiating upwards from a radical plexus; dichotomous below, branches distant, narrowed at the base, finally cylindrical, apices blunt.

B. gemellipara.—Fronds more or less erect, generally simple; each plumula at the lower part of its contour lanceolate, apparently distichous. The branchlets springing on each side duplicated in two ranks, each forming several series of twin branchlets, above the middle simple, with a very short imbricated featherlike tip.

Avrainvillea obscura.—Frond rising with a short flattened stem from a swollen base. Upper portion passing into a wide wedge-shaped expansion, thick, dark in colour, ragged along the terminal margin. (Note.—It is not unlikely that, when more perfect specimens are obtained, our Victorian plant will prove to be *Avrainvillea lætevirens* of Crouan.—J. B. W.)

Callipsygma wilsonis.—Frond expanded on each side above the stem, which is apparently rough below and slightly encrusted, extending in two directions, sparingly, sub-pinnately, branched from the margins. The whole frond is flattened, each branch passing into a terminal fan-shaped expansion, at length plumose by the lengthening of its own rachis. The lower filaments of each expansion somewhat separate, and rapidly passing into fresh branches. The filaments composing the whole frond constricted, so as to form oblong articulations The filaments of the laminæ proceeding from the margin of the rachis repeatedly dichotomous, placed close together, united laterally. Those of the stipes for some distance wavy, alternately superimposed, fastened together, thicker near the medial line.

Udotea peltata.—Frond expanded, slightly funnel-shaped, peltately attached upon a very short simple stipes, the lamina of the flabellate expansion generally somewhat rounded, but inequilateral. Margin ragged, or irregularly lobed. Plant green, filaments of the flabellum covered by a cortical stratum, conspicuous along the margin, rather distant, lower down united, the cross filaments passing transversely to the surface of the fronds, uncinate and peltate, forming the cortical stratum of the surface.

Caulerpa alternifolia.—Fronds from a surculum, erect, slender, filiform, repeatedly dichotomous, pinnate along their whole length. Pinnæ subulate, mucronate, attenuated from a somewhat thicker base, lower pinnæ generally regularly alternate, spreading, distichous, slightly curved inwards, many times exceeding in their length the breadth of the rachis; the upper pinnæ approaching nearer to one another, less regularly alternate.

FLORIDEÆ.

Thamnocarpus glomuliferus.—Frond filiform, elongated, upper portion with long branches, branchlets in the form of glomeruli, alternately arranged like knots along the branches. Stem and branches very distinctly articulated, cortical stratum dense, articulations two and a half times their diameter, separated by the darker line of the nodes. Ramelli situated at the nodes much branched, articulated, the young ramelli rather soft, the older somewhat rigid, furnished with a spinelet at the apex and at the upper nodes.

Fructification as yet unknown.

Cryptonemia wilsoni.—Stipitate membranaceous, nearly a foot in length, fronds elongated, lanceolate or linear, from the usually entire margin scattered proliferous processes, sometimes pinnate, at others terminal, digitately spreading from the upper margin of a frond apparently injured. Young proliferous leaflets obovate lingulate, older ones linear.

Fructification as yet unknown. The older fronds often marked with scattered stains. Frond bright red, without any indication of ribs. Cortical stratum comprises 3 to 4 series of cells, the innermost the larger, occasionally somewhat elongated vertically, very many globose, the cortical cells conspicuously smaller than the others.

Stenogramma leptophyllum.—Fronds arranged in a hemispherical group, mostly very narrow, linear, apparently arranged dichotomously, the older segments alternating on the rachis, sub-pinnate, as it were primary and exceeding the rest. Apices obtuse, very slightly narrowed. Antheridia in blotches in longitudinal series along the middle of the frond. In colour and substance resembling *Stenogramma interruptum.*

Horea wilsonis.—Frond flat, distichously decompound, pinnate, the larger pinnæ compound and intermixed with minute pinnules proceeding from the margin. Pinnæ somewhat erect, sub-obtuse, pinnules very spreading, subulate and delta-shaped. Cystocarps almost intramarginal, topped with a very short crown of spines.

Rhodymenia stenoglossa.—Stems from a radical plexus, numerous, somewhat erect, filiform at the base, soon becoming flat with a slight groove, passing into a flat, very narrow, linear frond. Young frond simple, or sparingly dichotomous, segments slightly attenuated at the base. The older frond beset with marginal processes, by degrees growing out into lingulate pinnæ, subfiliform at the base.

Fructification as yet unknown.

Glaphyrymenia pustulosa.—Plant about a foot in diameter, sometimes also with laciniæ of equal dimensions. Stem sometimes hardly perceptible, almost sessile, sometimes more conspicuous, rounded below, soon flattened into a wedge shape, and then widened into a flat membranous expansion, somewhat thicker near the base and thinner above. Membranous expansion widely expanded, sometimes rounded oblong with a continuous margin, or at times more or less divided into very large lobes, with the margin either even or folded. Surface smooth, or at length pustulate, more or less perforated by scattered foramina. Margins of the foramina and laciniæ often recurved, bearing cystocarps within the margins. Colour and habit resembling those of *Kallymenia reniformis.* Adheres very closely to paper.

(Note.—In the living state this alga is peculiarly soft, velvety, and clinging, quite unlike in consistence any other I have handled.—J. B. W.)

Delesseria heterocystidea.—Frond with cortex ribbed, prolifications appearing from the midrib, generally in a single row, rarely branched, folioles somewhat erect, very slender, lanceolate, acuminate, occasionally blunt, without veins, margin slightly wavy, minutely denticulate.

Sori unknown as yet.

Scinaia moniliformis. — Frond membranaceous, cylindrical, flattened, extremely constricted at the joints, dichotomously decompound, with prolifications appearing below the upper part of the articulations. Articulations united by a very narrow neck, the lowermost obconical, the middle ovate-oblong, the uppermost lately formed sub-rotund.

Chondriopsis foliifera.—Plant nearly pyramidal, with branches alternately pinnate with great regularity. Pinnæ springing from the margin, or within the margin of the rachis, spreading both ways, linear, lanceolate. Simple, or beset with an additional series of similar pinnules; all, on both sides, extremely slender, the last fruit-bearing. Sphærospores rather irregularly arranged on the upper part of the pinnules, marginal keramidia on the pinnules either solitary or few in number. Cortical cells angular, a little longer than their own diameter.

Polysiphonia sphacelarioides.—Stem spread out in every direction, loosely entwined among other algæ, with long, curved, hair-like threads rooting here and there. Articulate, devoid of cortex, distantly branched with dense ramelli. Rachis often extending beyond the branchlets, ramelli subvertical, chiefly secund, younger ones slender to a distance from the base, older branchlets flexible. Articulations of the older branchlets 7-siphoned, mostly 2 to 3 times as long as their diameter. The final ramelli about equal to their diameter.

Cliftonæa pectinata.—The cystocarps in Cliftonæa pectinata (observes Agardh) were first discovered by J. Bracebridge Wilson. In the fruit-bearing specimens sent to me I have seen cystocarps of considerable size, sub-globose, arranged in a row along the midrib, between the laciniæ, produced upon the older parts of the plant; protected, as it seemed to me, by the sterile laciniæ encompassing them from the side of the phyllodes. In a transverse section I observed the pericarp to be formed of two strata, that is, of exterior cells closely packed together, and inner ones more loosely arranged, as though meeting one another only at scattered points; in the lower part of the pericarp more extended longitudinally.

In the lower part of the cystocarp there is a placenta, from which large pear-shaped spores proceed, supported on long stalks, collected into several tufts, such as are normally present in the *Rhodomela* group. On the lowermost part of the placenta I noted a cell of greater size, as though primary, filled with a quantity of granular matter. This cell is joined by other smaller cells, loosely arranged, touching it round about in places, from the upper part of which the spores at length proceed.

7.—NOTES ON THE ZOOLOGY OF HOUTMAN'S ABROLHOS.

By A. J. Campbell, F.L.S.

My visit to these most interesting islands was from 7th to 23rd December, 1889. To Messrs. Broadhurst and McNeil I am indebted for passages to and from different islands, as well as for much open-handed hospitality, while Mr. F. C. Broadhurst, Mr. G. K. Beddoes, C.E. (manager), and other employés of the firm, have furnished me with many valuable notes gathered of late years upon the groups, and which were impossible for me to personally make during my limited sojourn.

Houtman's Abrolhos are certainly the greatest "rookery" for sea birds in Australia, and by reason of their geographical position in the sub-tropics, perhaps afford suitable breeding grounds for a greater number of species than any other distinct or limited spot in the world. That the groups have been resorted to for untold ages by the birds is evinced by the rich deposits of guano—notably upon Rat and Pelsart Islands. Rat Island may be said to be fairly alive with feathers. There were birds breeding upon the bushes, birds breeding under the bushes, and birds breeding in the ground underneath. Rat Island approximately contains 350 acres. Deducting, say 50 acres, for the guano station and cleared ground, and taking one bird for every square yard (there could not be less, probably more, when young and eggs are taken into consideration) the 300 acres would give 1,452,000 birds upon one island alone. With fair success I took instantaneous photographs of some of the flights, but could not take the birds when thickest, namely, at early morn and late evening, the sun being unfavourable or the camera. Of the wonderful flights of noddy and sooty terns I need not speak, but can fully substantiate Gilbert's accurate descriptions as given in Gould.

Mammalia.

Halmaturus derbianus, Grey (Derby's wallaby). Found on the East and West Wallaby Islands (northern group) only.

Euotaria —— ? (seal). Principally found on Easter and Pelsart groups, but now getting scarce.

Mus —— (rat). I was unable to procure a specimen for identification, which may probably prove to be the common European rat introduced by some shipwreck.

Aves.

Haliaetus leucogaster, Gm. (White-bellied sea-eagle). Not common. Eyries are established on Wallaby (Pigeon Island)

and Pelsart groups. The noddy tern constitutes a portion of this eagle's prey. Breeds beginning September. Young do not assume adult plumage until second or third year.

Pandion leucocephalus, Gould (White-headed osprey). More common than the preceding species. One day, as the barque *Capella* was riding at anchor in Good Friday Bay each of the mast heads was occupied by one of these noble birds. In addition to fish, the osprey is very partial to the little white-faced storm petrel and a rough-tailed lizard (*Egernia stokesi*) common upon Rat Island. Lay in September.

Hirundo neoxena, Gould (Welcome swallow). Noticed flying over Pelsart Island.

Sericornis maculatus, Gould (Spotted scrub-tit). Found only on Wallaby group.

Zosterops gouldii, Bp. (Green-backed white-eye). Found in pairs throughout the groups.

Phaps chalcoptera, Lath. (Bronzewing pigeon). Wallaby group.

Turnix scintillans, Gould (Speckled turnix-quail). Wallaby group.

Hæmatopus longirostris, Vieill. (White-breasted oyster-catcher). Few pairs throughout groups.

Hæmatopus unicolor, Wagl. (Sooty oyster-catcher). Seen occasionally.

Ægialitis ruficapilla, Temm. (Red-capped dottrel). A few always upon the islands where they breed.

Tringa albescens, Temm. (Little sandpiper). In small flocks about the beaches. Retire inland to roost at evening, when they often co-mingle with the former species.

Tringa subarquata, Gmel. (Curlew sandpiper). Singly or in twos or threes about the shores. But none observed in full plumage.

Strepsilas interpres, Linn. (Turnstone). This cosmopolitan was observed in flocks of six or seven about the reefs at low water, but scarcely in adult plumage.

Numenius cyanopus, Vieill. (Australian curlew). Noted at Wallaby group.

Numenius uropygialis, Gould (Wimbrel). Small flock seen at the mangrove swamp, Pelsart Island, 23rd December.

Demiegretta sacra, Gmel. (Reef-heron). Both the blue variety and the white found throughout the groups. Breed November.

Hypotænidia philipensis, Linn. (Pectoral rail). Seen upon Rat and Pelsart Islands. Known to breed upon latter.

Porzana tabuensis, Gmel. (Tabuan crake). Pelsart Island, about the mangrove swamp.

Anas castanea, Eyton (Australian teal). Wallaby group.

Larus pacificus, Lath. (Pacific gull). Odd couples breed throughout all groups. Laying commences early September.

Larus longirostris, Masters (Long-billed gull). Common. Breeds in September. Have been witnessed plundering the noddies of their eggs, especially if nearly incubated. The gulls also rob these peaceful birds of the contents of their stomachs when spread out for their mates or young.

Sterna caspia, Pall. (Caspian tern). Seen in small companies about the reefs or singly diving for fish about the harbours. Fledglings seen 15th December, also fresh egg taken same date. Young in down white underneath, mottled with black and brown above.

Sterna bergii, Licht. (Common tern). A few breed upon Pelsart Island. Young in down similar to Caspian tern.

Sterna dougalli, Mont. (Graceful tern). Nesting in scores upon the dead coral ridges in the narrowest part of Pelsart Island. December appears to be the laying month. Young in down under surface white, wings white, and rest of upper surface mottled black and white, with slight brownish tinge. Feet and bill light pink.

Sterna anæstheta, Scop. (Panayan tern). In small companies of ten or twelve, or in pairs, breeding under shelving limestones, sometimes under bushes, chiefly on isolated rocks.

Sterna fuliginosa, Gm. (Sooty tern). The "wide-awakes" first appear in the beginning of September upon Rat and Pelsart Islands, when they come in vast numbers for about a fortnight. When the young are reared, all depart about April. Their call-note sounds like "wide-awake;" hence their vernacular name. A long guttural scream appears to be the alarm note, while "squak" like notes are uttered in anger. Young in down, underneath parts (except throat) whitish, all the rest of the surface mottled with black, brown and white. Feet and bill dark-coloured.

Sternula nereis, Gould. (Little tern). A few couples found breeding upon dead coral on Pelsart Island, in close proximity to the graceful terns. Young in down dull or yellowish white. Bill and feet light yellow.

Sternula inconspicua, Masters. A pair noticed in company with little and Caspian terns near Rat Island. A skin was obtained, which appears to correspond with Masters' description, although some authorities believe it to be a different stage of plumage of the little tern. But this can hardly be, seeing the young of the little tern from the time they are hatched possess yellowish-white bill and feet, whereas Masters' tern has dark-coloured bill and feet.

Anous stolidus, Linn. (Noddy tern). Records kept upon Rat Island show that these birds first appeared for the breeding season 14th August, 1888, and 16th August, 1889, respectively. They are usually first heard at night, and then appear gradually for a few days before they arrive in great crowds. The earliest eggs are deposited about the beginning of October, but laying continues for the two or three following months. About the break-up of the weather in April all the noddies with their young depart. Not a solitary bird remains. A week or two prior to the final exodus the birds leave the island daily, but return at night. This may be a method of exercising the young before the last great flight. There is a curious incident of all these birds having suddenly left Rat Island for about a fortnight during the month of October when a cold rain set in, leaving eggs and young to perish. Upon slight showers of rain falling, the birds clear out to the shoals upon the reefs, and skim over the water in a remarkable manner, as if fishing. The call-note of the noddy is a coarse, gull-like bark. Young in down vary in colour from light to dark sooty brown, with the upper portion of the head mouldy white. Bill and feet black.

Anous tenuirostris, Temm. (Lesser noddy.) As its name implies, it is similar in appearance but smaller than the noddy, yet in one or two points of its natural history differs much. Unlike the noddy, which nests upon low bushes or upon the ground, the lesser noddy seeks the mangrove trees, and then only upon one island (Pelsart) out of all the groups, although mangroves exist elsewhere. Then, again, the lesser noddy remains throughout the year, whereas the noddies' visits are periodical. The first eggs may be observed the beginning of September, but the climax of the breeding season is not reached till December. Young in down, sooty black, upper part of head mouldy white. Bill and feet black.

Now that a successful guano depôt has been established upon Pelsart Island, no doubt in time the limited supply of mangrove trees will be used for fuel. What then will become of the extraordinary flights of the lesser noddies as they go to and from their fishing grounds? I trust the photographs I took may not soon be the "light of other days."

Puffinus nugax (?). Sol. (Allied petrel.) I am not quite satisfied about the identity of this petrel, although it closely resembles *P. nugax*. Professor McCoy, to whom I submitted a skin, shares my doubt. If it be *P. nugax*, then it has never been reported from the western side of Australia, nor has it been recorded nocturnal, as the Abrolhos bird certainly is. I took my specimen flying about Rat Island the midnight of 9th December. They have also been known, attracted by the light, to fall into the fires of persons camping upon the islands. They breed in underground burrows in July, and appear to rear their young and depart in time to accommodate the following species.

Puffinus sphenurus, Gould. (Wedge-tailed petrel.) It has never been hitherto published that this petrel is also nocturnal in its habits. It is somewhat extraordinary that such a peculiar trait in the bird's character should have escaped Gilbert's notice.

About half an hour after sundown they commence moaning and get uneasy in their burrows, and shortly afterwards birds may be seen swiftly cutting the air in many directions. The moaning and infant-like cries of the wedge-tailed petrel are a curious experience. After a ramble, one quiet night, I noted in my pocket-book next morning that "the whole island seemed groaning and travailling in pain with the noise of mutton birds." Sometimes the roofs of the guano station are struck with terrible force by the birds during flight. About half an hour before sunrise they disappear underground, when all is quiet as far as they are concerned. The attitude of this petrel upon the ground resembles a duck upon water, a squatting posture. When walking they are assisted by their wings, which gives the bird a waddling or lame gait. The burrows generally extended two or three feet in an oblique direction, rarely more than five feet. Sometimes they deposit their single egg in holes or fissures of rock, while more than once eggs have been taken from under bushes. The eggs, like those of the noddies and other birds, are excellent eating, not at all fishy in flavour as may be supposed.

Procellaria fregata, Linn. (White-faced storm-petrel.) 15th December, found young about ten days old in burrows upon Beacon Rock, near Rat Island. They were clothed in long bluish-grey down, with dark naked head and bill; feet also dark-coloured, with webs yellowish-white. After death an amber-coloured oil exudes freely from the beak.

Phaëton candidus, Briss. (White-tailed tropic-bird.) An occasional visitor.

Phaëton rubricauda, Bodd. (Red-tailed tropic-bird.) Seen occasionally on Rat Island during calm weather.

Graculus varius, Gm. (Pied cormorant.) Frequent the bays and breed in numbers upon isolated rocks.

Pelecanus conspicillatus, Temm. (Australian pelican.) Have been known to breed upon Pigeon Island (Wallaby group) during September.

Reptilia.

Morelia variegata (?) (Carpet snake.) Found only on Wallaby group. Said to be a darker variety than that found on the mainland, and not so lively in movements. Maximum length about nine feet. Supposed to be non-venomous.

Egernia kingi, Gr. During the season these lizards devour many of the eggs and young of the noddy and sooty terns, when their skin assumes a darker hue; but whether this be from the change of food or merely a summer coat remains to be proved.

Egernia stokesi, Gr.

Lygosoma lesueuri, D. and B. (variety).

Lygosoma præpeditum, Blg.

8.—A COMPLETE CENSUS OF THE FLORA OF THE GRAMPIANS AND PYRENEES.

By D. Sullivan, F.L.S.

In presenting this compilation to the Society, I beg to state that my sole aim and object is to encourage others to attempt similar productions in their respective districts. By such efforts amateur botanists could at once see which districts were explored and where to go to make their labours both pleasant and profitable. The present enumeration is the result of eighteen years' research, and little remains to be accomplished by future explorers within the area included in the "census" now presented. Sir Thomas Mitchell, Baron von Mueller, Dalachy, and others have been over the district, so that in the way of actual discovery there was little left for me to accomplish; still I have added, as shown, not less than thirty-six plants new to science. It is quite possible that many mosses and lichens, and perhaps orchids, remain still to be discovered in the deep umbrageous gorges of the Grampians. The district, concerning which these pages are written, extends from Stawell to the Hopkins and the Ararat and Hamilton railway on the one hand, and from the Grampians, Serra, and Victoria Ranges on the other, or about forty miles each way, which gives an area of 1600 square miles. The country lying between these boundaries is beautifully diversified with hill and dale, having a most charming effect, especially in the spring, when the grass and crops are green.

The principal trees scattered over this area are *Eucalyptus rostrata*, *viminalis*, *stuartiana*, *obliqua*, *leucoxylon*, *gunnii* and *goniocalyx*, *Acacia decurrens*, *melanoxylon* and *pycnantha*. For a time the wholesale destruction of these useful trees was ruthlessly carried on for the sake of their bark, but, I am happy to say, since the appointment of foresters in the district, one seldom sees saplings denuded of their bark. The native cherry, *Exocarpus cupressiformis*, at one time very plentiful, is totally disappearing. The sheoaks, too, are becoming scarce.

With regard to the vegetation of the Pyrenees, it is neither varied nor remarkable. I have found no plants that could be said to be absolutely restricted to these ranges. The eucalypts already mentioned, together with *Prostanthera rotundifolia*, *Correa æmula*, *Kunzea pomifera*, and a few acacias, form the leading features. *Bursaria spinosa* attains here the dimensions of a middle-sized tree. The most elevated peaks of the Pyrenees are Langi Ghiran, 3200, and Ben Nevis, 3000 feet above the level of the sea. The native plants are destined in time to become extinct, owing to bush fires and the vast number of sheep depasturing on the slopes, and, in fact, to the very summits of the ranges. Taking leave of the Pyrenees, and turning our attention to the beautiful Grampians—"the garden of Victoria"—one feels like a weary traveller coming upon an oasis after traversing the dreary desert, that is, from a botanist's point of view.

The Grampians (in 1871, when I first commenced their exploration) were very different indeed from what they are at present. They were then a perfect floral paradise. Bush fires and sheep have made sad havoc within the last ten or twelve years. The *Epacrideæ* abound everywhere on the heath-grounds. The incomparable *Epacris impressa*—the queen of native flowers—here exhibits its endless variety of colour through all shades, from dark-red to the purest white. Contrasted with this, the bright-red of *Styphelia sonderi*, the white and pink of *Styphelia ericoides*, the greenish yellow of *Styphelia adscendens*, the delicate white of *Styphelia glacialis*, the fiery-red flowers of *Daviesia brevifolia*, the tall white-flowered spikes of the grass-tree (*Xanthorrhœa australis*), with the fine glossy foliage of the young trees of *Eucalyptus robusta*, and you have before you a picture that, to be appreciated, must be seen. Crossing the creeks at the foot of the mountains, the explorer tears his way through a maze of Melaleucas, Leptospermum, Acacias, Pultenæas, Sprengelias, and species of Myrtaceæ, with charming festoons of the white-flowered *Clematis aristata*, the pretty blue-flowered *Comesperma volubile*, and the rare yellow-flowered *Marianthus bignoniaceus*. Then, tired from his late exertion, he sits probably on a rock, taking in at one view the splendour and variety that nature has lavished upon this highly-favoured locality. The prevailing plants close to the mountains are *Conospermum mitchelli*, with immense corymbs of white flowers, the white-flowered Brachylomas, *Kennedya monophylla* (native sarsaparilla), grass-trees, Correas, Hakeas, Dillwynias, and the Styphelias already alluded to Advancing up the stony ridges, the scented Boronias, Eriostemons, myrtaceous plants, Pultenæas, Bossiæas, and the large white-flowered *Leptospermum lanigerum* are met with everywhere.

After about three hours' struggling, the summit of the highest peak—Mount William—is reached. The height of Mount William is variously recorded at from 4000 to 5200 feet, the latter being probably nearest the truth.

The scenery is, indeed, sublime. To the north-west, forming a curved line, are the Grampians, and farther still the dark outline of the Black Range, towards the South Australian borders. To the north-east is to be seen the bold granitic peaks of the other Black Range, in the vicinity of Stawell. Mount Ararat, standing boldly out from the group of granite hills by which it is surrounded, presents the appearance of a volcanic cone. Farther to the east, Mount Cole, Langi Ghiran, and Ben Nevis, the culminating points of the Pyrenees, form a conspicuous feature in the landscape. Moyston, Stawell, and Dunkeld are the only towns visible from Mount William. To the south, the vast and fertile plains of the Hopkins, dotted over with small lakes, resembling sparkling stars, in the far distance, give a momentary relief from the contemplation of apparently interminable mountain scenery. Descending one of the deep gorges or gullies of the mountain, the traveller finds himself in the midst of a dense, luxuriant growth of fern-trees, Lomarias, Gleicheneas, &c., their ample fronds completely canopying the mountain streams. As he advances downwards the gorge widens, and now, indeed, he is in the "The Garden of Victoria." The walks, however, are badly kept, for one has to labour through the dense entangled mass of vegetation with the utmost difficulty. Pultenæas, Coprosmas, Daviesias, Pomaderris, Baueras, Hoveas, Melaleucas, Eriostemons, Correas, Sprengelias, Clematis, Billardieras, and hundreds of others too numerous to mention, mingle their brilliant red, yellow, blue, pink, and scarlet flowers in such profusion as to fairly dazzle the eyes of the spectator.

DICOTYLEDONEÆ. Ray.

Choripetaleæ Hypogynæ. F. v. M.

RANUNCULACEÆ. B. de Jussieu.

Clematis. l'Ecluse.

Clematis aristata. R. Brown. Grampians.
Clematis microphylla. Candolle. Grampians.

Myosurus. L'Obel.

Myosurus minimus. Linné. Grampians, Saline Flats.

Ranunculus. Tournefort.

Ranunculus aquatilis. Dodonæus. Grampians.
Ranunculus lappaceus. Smith. Grampians and Pyrenees.
Ranunculus rivularis. Banks and Solander. Grampians and Pyrenees.
Ranunculus hirtus. Banks and Solander. Pyrenees.
Ranunculus parviflorus. Linné. Grampians and Pyrenees.

DILLENIACEÆ. Salisbury.

Hibbertia. Andrews.

Hibbertia densiflora. F. v. M. Grampians.
Hibbertia stricta. R. Brown. Grampians and Pyrenees.
Hibbertia humifusa. F. v. M. Grampians.
Hibbertia billardieri. F. v. M. Grampians.
Hibbertia fasciculata. R. Brown. Grampians.
Hibbertia virgata. R. Brown. Grampians, Serra, and Victorian Ranges.
Hibbertia diffusa. R. Brown. Grampians, Serra, and Victorian Ranges.
Hibbertia acicularis. F. v. M. Grampians.

MAGNOLIACEÆ. St. Hilaire.

Drimys. Forster.

Drimys aromatica. F. v. M.

LAURACEÆ. Ventenat.

Cassytha. Osbeck.

Cassytha glabella. R. Brown. Grampians.
Cassytha pubescens. R. Brown. Grampians.
Cassytha melantha. R. Brown. Grampians.

CRUCIFERÆ. B. de Jussieu.

Nasturtium. Linné.

Nasturtium terrestre. R. Brown. Grampians.

Cardamine. l'Ecluse.

Cardamine dictyosperma. Hooker. Grampians.
Cardamine laciniata. F. v. M. Grampians and Pyrenees.
Cardamine hirsuta. Linné. Grampians.
Cardamine hirsuta, var. glabra. Grampians.

Sisymbrium. Tournefort.

Sisymbrium cardaminoides. F. v. M. Grampians.

Capsella. Medicus.

Capsella elliptica. C. A. Meyer. Grampians and Pyrenees.

Lepidium. Dioscorides.

Lepidium ruderale. Linné. Grampians and Pyrenees.

VIOLACEÆ. De Candolle.

Viola. Plinius.

Viola betonicifolia. Smith. Grampians and Pyrenees.
Viola hederacea. Labillardière. Grampians and Pyrenees.

Hymenanthera. R. Brown.

Hymenanthera banksii. F. v. Mueller. Pyrenees.

PITTOSPOREÆ. R. Brown.

Bursaria. Cavanilles.

Bursaria spinosa. Cavanilles. Grampians and Pyrenees.

Marianthus. Huegel.

Marianthus procumbens. Bentham. Grampians.
Marianthus bignoniaceus. F. v. M. Grampians.

Billardiera. Smith.

Billardiera scandens. Smith. Grampians.
Billardiera cymosa. F. v. M. Grampians and Pyrenees.

DROSERACEÆ. Salisbury.

Drosera. Linné.

Drosera spathulata. Labillardière. Grampians and Pyrenees.
Drosera whittakerii. Planchon. Grampians and Pyrenees.
Drosera pygmæa. De Candolle. Grampians.
Drosera glanduligera. Lehmann. Grampians and Pyrenees.
Drosera peltata. Smith. Grampians and Pyrenees.
Drosera auriculata. Backhouse. Grampians.
Drosera menziesii. R. Brown. Grampians and Pyrenees.
Drosera binata. Labillardière. Grampians.

HYPERICINÆ. St. Hilaire.

Hypericum. Plinius.

Hypericum japonicum. Thunberg.

POLYGALEÆ. Jussieu.

Comesperma. Labillardière.

Comesperma retusum. Labillardière. Grampians.
Comesperma volubile. Labillardière. Grampians.
Comesperma calymega. Labillardière. Grampians
Comesperma defoliatum. F. v. M. Grampians.
Comesperma polygaloides. F. v. M. Grampians.

TREMANDREÆ. R. Brown.

Tetratheca. Smith.

Tetratheca ciliata. Lindley. Grampians and Pyrenees.
Tetratheca ericifolia. Smith. Grampians.

RUTACEÆ. Jussieu.

Boronia. Smith.

Boronia polygalifolia. Smith. Grampians.
Boronia pilosa. Labillardière. Grampians.
Boronia pinnata. Smith. Grampians.

Eriostemon. Smith.

Eriostemon obovalis. Cunningham. Grampians.
Eriostemon pleurandroides. F. v. M. Serra Range.
Eriostemon hillebrandi. F. v. M. Grampians.
Eriostemon pungens. Lindley. Grampians.

Correa. Smith.

Correa speciosa. Andrews. Grampians and Pyrenees.
Correa lawrenciana. Hooker. Grampians.
Correa æmula. F. v. M. Grampians and Pyrenees.

LINEÆ. De Candolle.

Linum. Theophrastos.

Linum marginale. Cunningham. Grampians and Pyrenees.

GERANIACEÆ. Jussieu.

Geranium. Dioscorides.

Geranium carolinanum. Linné. Grampians and Pyrenees.
Geranium sessiliflorum. Cavanilles. Grampians and Pyrenees.

Erodium. l'Héritier.

Erodium cygnorum. Nees. Pyrenees.

Pelargonium, l'Héritier.

Pelargonium australe. Willdenow. Grampians and Pyrenees.
Parlargonium rodneyanum. Mitchell. Pyrenees.

Oxalis. Plinius.

Oxalis corniculata. Linné. Grampians and Pyrenees.

STERCULIACEÆ. Ventenat.

Lasiopetalum. Smith.

Lasiopetalum dasyphyllum. Sieber. Grampians.

EUPHORBIACEÆ. Jussieu.

Poranthera. Rudge.

Poranthera microphylla. Brongniart. Grampians.

Pseudanthus. Sieber.

Pseudanthus ovalifolius. F. v. M. Grampians.

Beyeria. Miquel.

Beyeria viscosa. Miquel. Grampians.
Beyeria opaca. F. v. M. Grampians.

Amperea. Jussieu.

Amperea spartioides. Brongniart. Grampians.

Phyllanthus. Commelin.

Phyllanthus thymoides. Sieber. Grampians.

URTICEÆ. Ventenat.

Parietaria. C. Bauhin.

Parietaria debilis. G. Foster. Grampians.

Urtica. Plinius.

Urtica incisa, Poiret. Grampians.

CASUARINEÆ. Mirbel.

Casuarina. Rumphius.

Casuarina quadrivalvis. Labillardière. Pyrenees.
Casuarina distyla. Ventenat. Grampians.

SAPINDACEÆ. Jussieu.

Dodonæa. Linne.

Dodonæa viscosa. Linné. Grampians.
Dodonæa bursarifolia. Behr and F. v. M. Grampians.
Dodonæa boronifolia. G. Don. Pyrenees.

STACKHOUSIEÆ. R. Brown.

Stackhousia. Smith.

Stackhousia linarifolia. Cunningham. Grampians and Pyrenees.
Stackhousia viminea. Smith. Grampians.

PORTULACEÆ. Jussieu.

Claytonia. Gronovius.

Claytonia pygmæa. F. v. M. Grampians and Pyrenees.
Claytonia australasica. Hooker. Grampians and Pyrenees.
Claytonia calyptrata. F. v. M. Grampians and Pyrenees.

CARYOPHYLLEÆ.

Stellaria. Linné.

Stellaria pungens. Brongniart. Grampians and Pyrenees.
Stellaria glauca. Withering. Pyrenees.
Stellaria flaccida. Hooker. Grampians.
Stellaria multiflora. Hooker.

Spergularia, Persoon.

Spergularia rubra. Cambessèdes, Grampians.

Polycarpon. Loefling.

Polycarpon tetraphyllum. Loefling. Grampians.

AMARANTACEÆ. Jussieu.

Alternanthera. Forskael.

Alternanthera triandra. Lamarck. Pyrenees.

Ptilotus. R. Brown.

Ptilotus alopecuroideus. F. v. M. Grampians.
Ptilotus erubescens. Schlechtendal. Pyrenees.
Ptilotus spathulatus. Poiret. Pyrenees.
Ptilotus macrocephalus. Poiret. Grampians.

SALSOLACEÆ. Linne.

Rhagodia. R. Brown.

Rhagodia billardieri. R. Brown. Pyrenees.

Chenopodium. Tournefort.

Chenopodium carinatum. R. Brown. Grampians.

Dysphania. R. Brown.

Dysphania myriocephalia. Bentham. Pyrenees.

FICOIDEÆ.

Mesembrianthemum. Breyne.

Mesembrianthemum aequilaterale. Haworth. Pyrenees.
Mesembrianthemum australe. Solander. Pyrenees.

POLYGONACEÆ. Jussieu.

Rumex. Plinius.

Rumex brownii. Campdera. Grampians.
Rumex bidens. R. Brown. Pyrenees.

Polygonum. Dioscorides.

Polygonum strigosum. R. Brown. Grampians and Pyrenees.
Polygonum prostratum. R. Brown. Grampians and Pyrenees.
Polygonum hydropiper. Linné. Grampians and Pyrenees.
Polygonum minus. Hudson. Grampians.
Polygonum lapathifolium. Linné. Grampians.

Muehlenbeckia. Meissner.

Muehlenbeckia cunninghamii. F. v. M. Pyrenees.

Summary of the Choripetaleæ Hypogynæ :—

Natural Orders	24
Genera	52
Species	112

Choripetaleæ Perigynæ.

LEGUMINOSÆ. Haller.

Gompholobium. Smith.

Gompholobium huegelii. Bentham.

Sphærolobium. Smith.

Sphærolobium vimineum. Smith. Grampians.

Viminaria. Smith.

Viminaria denudata. Smith. Grampians.

Daviesia. Smith.

Daviesia corymbosa. Smith. Grampians.
Daviesia brevifolia. Lindley. Grampians.
Daviesia ulicina. Smith. Grampians.

Aotus. Smith.

Aotus villosa. Smith. Grampians.

Pultenæa. Smith.

Pultenæa rosea. F. v. M. Grampians.
Pultenæa gunnii. Bentham. Pyrenees.
Pultenæa daphnoides. Wendland. Grampians.
Pultenæa scabra. R. Brown. Grampians.
Pultenæa pedunculata. Hooker. Grampians.
Pultenæa subumbellata. Hooker. Grampians.
Pultenæa dentata. Labillardière Grampians.

Pultenæa mollis. Lindley. Grampians.
Pultenæa viscosa. R. Brown. Grampians.
Pultenæa juniperina. Labillardière. Grampians.
Pultenæa villosa. Willdenow. Grampians.
Pultenæa villifera. Sieber. Grampians.
Pultenæa styphelioides. Cunningham. Grampians.
Pultenæa laxiflora. Bentham. Grampians.

Eutaxia. R. Brown.

Eutaxia empetrifolia. Schlechtendal. Grampians.

Dillwynia. Smith.

Dillwynia floribunda. Smith. Grampians.
Dillwynia hispida. Lindley. Grampians.
Dillwynia ericifolia. Smith. Grampians.

Platylobium. Smith.

Platylobium alternifolium. F. v. M. Grampians.
Platylobium obtusangulum. Hooker. Grampians and Pyrenees.
Platylobium formosum. Smith. Grampians.
Platylobium triangulare. R. Brown. Grampians.

Bossiæa. Ventenat.

Bossiæa cinerea. R. Brown. Grampians.
Bossiæa riparia. Cunningham. Grampians.
Bossiæa prostrata. R. Brown. Grampians.

Templetonia. R. Brown.

Templetonia muelleri. Bentham. Grampians.

Hovea. R. Brown.

Hovea longifolia. R. Brown. Grampians.
Hovea heterophylla. Cunningham. Grampians.

Goodia. Salisbury.

Goodia lotifolia. Salisbury. Grampians.
Goodia medicaginea. F. v. M. Grampians.

Indigofera. Linné.

Indigofera australis. Willdenow.

Swainsonia. Salisbury.

Swainsonia procumbens. F. v. M. Grampians.
Swainsonia lessertiifolia. Candolle. Grampians.

Glycine. Linné.

Glycine clandestina. Wendland. Grampians and Pyrenees.
Glycine latrobeana. Bentham. Grampians and Pyrenees.

Kennedya. Ventenat.

Kennedya prostrata. R. Brown. Grampians and Pyrenees.
Kennedya monophylla. Ventenat. Grampians and Pyrenees.

ACACIA. Dioscorides.

I.—Pungentes.

Acacia juniperina. Willdenow. Grampians and Pyrenees.

II.—UNINERVES.

Acacia aspera. Lindley. Grampians.
Acacia armata. R. Brown. Grampians and Pyrenees.
Acacia vomeriformes. Cunningham. Grampians and Pyrenees.
Acacia retinodes. Schlechtendal. Grampians.
Acacia pycnantha. Bentham. Grampians and Pyrenees.
Acacia myrtifolia. Willdenow. Grampians.

III.—PLURINERVES.

Acacia whanii. F. v. M. Grampians.
Acacia melanoxylon. R. Brown. Grampians and Pyrenees.

IV.—JULIFERÆ.

Acacia oxycedrus. Sieber. Grampians.
Acacia verticillata. Willdenow. Grampians and Pyrenees.
Acacia longifolia. Willdenow. Grampians

V.—BIPINNATÆ.

Acacia mitchelli. Bentham. Grampians.
Acacia decurrens. Willdenow. Grampians and Pyrenees.

ROSACEÆ. Jussieu.

RUBUS. Plinius.

Rubus parvifolius. Linné. Grampians and Pyrenees.

ALCHEMILLA. Brunfels.

Alchemilla vulgaris. Bauhin. Grampians and Pyrenees.

ACÆNA. Mutis.

Acæna ovina. Cunningham. Grampians.
Acæna sanguisorbæ. Vahl. Grampians and Pyrenees.

SAXIFRAGEÆ. Ventenat.

BAUERÆ. Banks and Kennedy.

Bauera sessiliflora. F. v. M. Grampians.
Bauera rubioides. Andrews. Grampians.

CRASSULACEÆ. De Candolle.

TILLÆA. Michelli.

Tillæa verticillaris. Candolle. Grampians and Pyrenees.
Tillæa purpurata. Hooker. Grampians and Pyrenees.
Tillæa macrantha. Hooker. Grampians and Pyrenees.
Tillæa recurva. Hooker. Grampians and Pyrenees.

ONAGREÆ. Jussieu.

EPILOBIUM. Gesner.

Epilobium tetragonum. Linné. Grampians and Pyrenees.

SALICARIEÆ. Jussieu.

LYTHRUM. Linne.

Lythrum salicaria. Linné. Grampians and Pyrenees.
Lythrum hyssopifolia. Linné. Grampians and Pyrenees.

HALORAGEÆ. R. Brown.

Haloragis. R. and G. Forster.

Haloragis elata. Cunningham. Grampians and Pyrenees.
Haloragis micrantha. R. Brown. Grampians and Pyrenees.
Haloragis ceratophylla. Zahlbruckner. Grampians and Pyrenees.
Haloragis tetragyna. R. Brown. Grampians and Pyrenees.
Haloragis teucrioides. Schlechtendal. Grampians and Pyrenees.

Myriophyllum. Dioscorides.

Myriophyllum variifolium. Hooker. Grampians and Pyrenees.
Myriophyllum integrifolium. Hooker. Hopkins River.

CALLITRICHINÆ.

Callitriche. Linné.

Callitriche verna. Linné. Pyrenees.

MYRTACEÆ. Jussieu.

Calycothrix. Labillardière.

Calycothrix tetragona. Labillardière. Grampians.
Calycothrix sullivani. F. v. M. Grampians (new).

Lhotzkya. Schauer.

Lhotzkya genetylloides. F. v. M. Grampians.

Thryptomene. Endlicher.

Thryptomene mitchelliana. F. v. M. Grampians.
Thryptomene ericæa. F. v. M. Pyrenees.
Thryptomene ciliata. F. v. M. Grampians.

Bæckea. Linné.

Bæckea diffusa. Sieber. Grampians.

Leptospermum. R. and G. Foster.

Leptospermum scoparium. Foster. Grampians.
Leptospermum myrsinoides. Schlechtendal. Grampians.
Leptospermum lanigerum. Smith. Grampians.
Leptospermum flavescens. Smith. Grampians.

Kunzea. Reichenbach.

Kunzea pomifera. F. v. M. Grampians and Pyrenees.

Callistemon. R. Brown.

Callistemon coccineus. F. v. M. Grampians.

Melaleuca. Linné.

Melaleuca gibbosa. Labillardière. Grampians.
Melaleuca decussata. R. Brown. Grampians.
Melaleuca squarossa. Donn. Grampians.
Melaleuca squamea. Labillardière. Grampians.

Eucalyptus. l'Heritier.

Eucalyptus pauciflora. Sieber. Grampians.
Eucalyptus amygdalina (var.). Labillardière, Grampians.

Eucalyptus obliqua. l'Heritier.
Eucalyptus capitellata. Smith. Grampians.
Eucalyptus leucoxylon. F. v. M. (var.). Pyrenees.
Eucalyptus melliodora. Cunningham. Grampians and Pyrenees.
Eucalyptus alpina. Lindley. Grampians.
Eucalyptus goniocalyx. F. v. M. Pyrenees and Grampians.
Eucalyptus gunii. Hooker. Grampians.
Eucalyptus stuartiana. F. v. M. Grampians and Pyrenees.
Eucalyptus viminalis. Labillardière. Grampians and Pyrenees.
Eucalyptus rostrata. Schlechtendal. Grampians and Pyrenees.
Eucalyptus macrorrhyncha. F. v. M. Grampians.

RHAMNACEÆ. Jussieu.

POMADERRIS. Labillardiere.

Pomaderris apetala. Labillardière. Grampians.
Pomaderris elliptica. Labillardière. Grampians.
Pomaderris elachophylla. F. v. M. Grampians and Pyrenees.
Pomaderris vacciniifolia. Reisseck and F. v. M. Grampians.

CRYPTANDRA. Smith.

Cryptandra amara Smith. Grampians.

ARALIACEÆ. Ventenat.

ASTROTRICHA. Candolle.

Astrotricha ledifolia. Candolle. Grampians.

UMBELLIFERÆ. Morison.

HYDROCOTYLE. Tournefort.

Hydrocotyle laxiflora. Candolle. Grampians and Pyrenees.
Hydrocotyle callicarpa. Bunge. Grampians and Pyrenees.
Hydrocotyle capillaris. F. v. M. Grampians and Pyrenees.

DIDISCUS. Candolle.

Didiscus pusillus. F. v. M. Grampians.

TRACHYMENE. Rudge.

Tractyme heterophylla. F. v. M. Grampians.

ERYNGIUM. Theophrastos.

Eryngium vesiculosum. Labillardière. Grampians and Pyrenees.

APIUM. Tournefort.

Apium prostratum. Labillardière. Grampians.

DAUCUS. l'Ecluse.

Daucus brachiatus. Sieber. Grampians and Pyrenees.

OREOMYRRHIS. Endlicher.

Oreomyrrhis andicola. Enlicher. Grampians.

Summary of the Choripetaleæ Perigynæ :—

Natural Orders	11
Genera	47
Species	124

Synpetaleæ Perigynæ.

SANTALACÆ. R. Brown.

Leptomeria. R. Brown.

Leptomeria aphylla. R. Brown. Grampians.

Exocarpos. Labillardière.

Exocarpos cupressiformis. Labillardière. Grampians and Pyrenees.
Exocarpos stricta. R. Brown. Grampians.

LORANTHACEÆ. Jussieu.

Loranthus. Linné.

Loranthus pendulus. Sieber. Grampians and Pyrenees.
Loranthus celastroides. Sieber. Grampians.
Loranthus exocarpi. Behr. Grampians.

PROTEACEÆ. Jussieu.

Isopogon. R. Brown.

Isopogon ceratophyllus. R. Brown. Grampians and Pyrenees.

Adenanthos. Labillardiere.

Adenanthos terminalis. R. Brown. Grampians.

Conospermum. Smith.

Conospermum mitchellii. Meissner. Grampians.
Conospermum patens. Schlechtendal. Grampians.

Persoonia. Smith.

Persoonia rigida. R. Brown. Grampians.
Persoonia juniperina. Labillardière. Grampians.

Grevillia. R. Brown.

Grevillia aquifolium. Lindley. Grampians.
Grevillia ilicifolia. R. Brown. Grampians.
Grevillia alpina. Lindley. Grampians.
Grevillia confertifolia. F. v. M.
Grevillia australis. R. Brown. Grampians.

Hakea. Schrader.

Hakea rostrata. F. v. M. Grampians.
Hakea acicularis. R. Brown. Grampians.
Hakea ulicina. R. Brown. Grampians and Pyrenees.
Hakea dactyloides. Cavanilles. Grampians.

Banksia. Linné.

Banksia marginata. Cavanilles. Grampians and Pyrenees.
Banksia ornata. F. v. M. Grampians.

THYMELEÆ. Jussieu.

Pimelea. Banks and Solander.

Pimelia curviflora. R. Brown. Grampians.
Pimelia phylicoides. Meissner. Grampians.

Pimelia flava. R. Brown. Grampians.
Pimelia axiflora. F. v. M. Pyrenees.
Pimelia linifolia. Smith. Grampians.
Pimelia humilis. R. Brown. Grampians and Pyrenees.
Pimelia spathulata. Labillardière. Grampians.

RUBIACEÆ. Jussieu.

Coprosma. R. and G. Foster.

Coprosma hirtella. Labillardière. Grampians.
Coprosma billardieri. Hooker. Grampians and Pyrenees.

Opercularia. Gaertner.

Opercularia varia. Hooker. Grampians.
Opercularia ovata. Hooker. Grampians.

Galium. Dioscorides.

Galium umbrosum. Solander. Grampians and Pyrenees.
Galium australe. Candolle. Grampians and Pyrenees.

Asperula. Dalechamps.

Asperula oligantha. F. v. M. Grampians and Pyrenees.

COMPOSITÆ. Vaillant.

Lagenophora. Cassini.

Lagenophora billardieri. Cassini. Grampians and Pyrenees.
Lagenophora huegelii. Bentham. Grampians and Pyrenees.
Lagenophora emphysopus. Hooker. Grampians and Pyrenees.

Brachycome. Cassini.

Brachycome diversifolia. Fischer and Meyer. Grampians and Pyrenees.
Brachycome graminea. F. v. M. Grampians and Pyrenees.
Brachycome exilis. Sonder. Grampians and Pyrenees.
Brachycome scapiformis. Candolle. Grampians.
Brachycome multifida. Candolle. Grampians and Pyrenees.
Brachycome collina. Bentham. Grampians and Pyrenees.

Calotis. R. Brown.

Calotis anthemoides. F. v. M. Grampians.

Aster. Dioscorides.

Aster myrsinoides. Labillardière. Grampians.
Aster stellulatus. Labillardière. Grampians.
Aster asterotrichus. F. v. M. Grampians and Pyrenees.
Aster glandulosus. Labillardière. Grampians.
Aster huegelii. F. v. M. Grampians.
Aster aculeatus. — Grampians.

Vittadinia. Ach. Richard.

Vittadinia australis. A. Richard. Grampians and Pyrenees.

Stuartina. Sonder.

Stuartina muelleri. Sonder. Grampians and Pyrenees.

GNAPHALIUM. Bauhin.

Gnaphalium luteo-album. Linné. Grampians and Pyrenees.
Gnaphalium japonicum. Thunberg. Grampians and Pyrenees.
Gnaphalium indutum. Hooker. Grampians.

PODOLEPIS. Labillardière.

Podolepis acuminata. R. Brown. Grampians and Pyrenees.

LEPTORRHYNCHOS. Lessing.

Leptorrhynchus squamatus. Lessing. Grampians and Pyrenees.
Leptorrhynchus tenuifolius. F. v. M. Grampians.
Leptorrhynchus elongatus. Candolle. Grampians.
Leptorrhynchus medius. Cunningham. Grampians.

HELIPTERUM. Candolle.

Helipterum incanum. Candolle. Pyrenees.
Helipterum cotula. Candolle. Pyrenees.
Helipterum corymbiflorum. Schlechtendal. Grampians.
Helipterum exiguum. F. v. M. Grampians and Pyrenees.
Helipterum dimorpholepis. Bentham. Grampians and Pyrenees.

HELICHRYSUM. Theophrastos and Dioscorides.

Helichrysum blandowskianum. Steetz. Grampians.
Helichrysum apiculatum. Candolle. Grampians and Pyrenees.
Helichrysum semipapposum. Candolle. Grampians and Pyrenees.
Helichrysum baxteri. Cunningham. Grampians and Pyrenees.
Helichrysum scorpioides. Labillardière. Grampians and Pyrenees.
Helichrysum obtusifolium. Sonder and F. v. M. Grampians.
Helichrysum ferrugineum. Lessing. Grampians and Pyrenees.
Helichrysum obcordatum. F. v. M. Grampians.
Helichrysum bracteolatum. Bentham. Grampians.

CASSINIA. R. Brown.

Cassinia aculeata. R. Brown.

HUMEA. Smith.

Humea elegans. Smith. Grampians.

RUTIDOSIS. Candolle.

Rutidosis pumilo. Bentham. Grampians and Pyrenees.

IXODIA. R. Brown.

Ixodia achilleoides. R. Brown. Grampians.

MILLOTIA. Cassini.

Millotia tenuifolia. Cassini. Grampians and Pyrenees.

ANGIANTHUS. Wendland.

Angianthus tomentosus. Wendland. Grampians.

CALOCEPHALUS. R. Brown.

Calocephalus lacteus. Lessing. Grampians and Pyrenees.
Calocephalus citreus. Lessing. Grampians and Pyrenees.

SIEGESBECKIA. Linné.

Siegesbeckia orientalis. Linné. Grampians.

COTULA. Linné.

Cotula filifolia. Thunberg. Grampians.
Cotula coronopifolia. Linné. Grampians and Pyrenees.
Cotula australis. Hooker. Grampians and Pyrenees.

CENTIPEDA. Loureiro.

Centipeda cunninghami. F. v. M. Grampians and Pyrenees.
Centipeda orbicularis. Loureiro. Grampians.

ISOETOPSIS. Turczaninow.

Isoetopsis graminifolia. Turczaninow. Grampians.

SENECIO. Plinius.

Senecio lautus. Solander. Grampians.
Senecio vagus. F. v. M. Grampians and Pyrenees.
Senecio velleioides. Cunningham. Grampians.

ERECHTITES. Rafinesque.

Erechtites quadridentata. Candolle. Pyrenees.

CYMBONOTUS. Cassini.

Cymbonotus lawsonianus. Gaudichaud. Pyrenees.

MICROSERIS. D. Don.

Microseris fosteri. Hooker. Grampians and Pyrenees.

CAMPANULACEÆ. Jussieu.

LOBELIA. Linné.

Lobelia simplicicaulis. R. Brown. Grampians and Pyrenees.
Lobelia rhombifolia. De Vriese. Grampians.
Lobelia anceps. Thunberg. Grampians and Pyrenees.
Lobelia pratioides. Bentham. Grampians and Pyrenees.
Lobelia concolor. R. Brown. Grampians and Pyrenees.

ISOTOMA. R. Brown.

Isotoma fluviatilis. F. v. M. Grampians and Pyrenees.

WAHLENBERGIA. Schrader.

Wahlenbergia gracilis. Candolle. Grampians and Pyrenees.

CANDOLLEACEÆ. F. v. M.

CANDOLLEA. Labillardière.

Candollea sobolifera. F. v. M. Grampians.
Candollea calcarata. F. v. M. Grampians.
Candollea despecta. R. Brown. Grampians.

LEEWENHOEKIA. R. Brown.

Leewenhoekia dubia. Sonder. Grampians and Pyrenees.

GOODENIACEÆ. R. Brown.

BRUNONIA. Smith.

Brunonia australis. Smith. Grampians and Pyrenees.

SCÆVOLA. Linné.

Scævola æmula. R. Brown. Grampians.

GOODENIA. Smith.

Goodenia ovata. Smith. Grampians and Pyrenees.
Goodenia geniculata. R. Brown. Grampians and Pyrenees.
Goodenia elongata. Labillardière. Grampians.
Goodenia pinnatifida. Schlechtendal. Grampians and Pyrenees.
Goodenia humilis. R. Brown. Grampians.

VELLEYA. Smith.

Velleya paradoxa. R. Brown. Grampians.

SELLIERA. Cavanilles.

Selliera radicans. Cavanilles. Grampians and Pyrenees.

Summary of the Synpetaleæ Perigynæ :—

Natural Orders	9
Genera	50
Species	118

SYNPETALEÆ HYPOGYNÆ.

GENTIANEÆ. Jussieu.

SEBÆA. Solander.

Sebæa ovata. R. Brown. Grampians and Pyrenees.
Sebæa albidiflora. F. v. M. Grampians (Wannon R.).

ERYTHRÆA. Reneaulme.

Erythræa australis. R. Brown. Grampians.

LOGANIACEÆ. R. Brown.

MITRASACME. Labillardière.

Mitrasacme paradoxa. R. Brown. Grampians.
Mitrasacme distylis. F. v. M. Grampians.

PLANTAGINEÆ. Jussieu.

PLANTAGO. l'Ecluse.

Plantago varia. R. Brown. Grampians and Pyrenees.

PRIMULACEÆ. Ventenat.

SAMOLUS. Tournefort.

Samolus repens. Persoon. Grampians and Pyrenees.

CONVOLVULACEÆ. Jussieu.

CONVOLVULUS. W. Turner.

Convolvulus erubescens. Sims. Grampians and Pyrenees.

DICHONDRA. Forster.

Dichondra repens. Forster. Pyrenees.

SOLANACEÆ. Haller.

Solanum. Tournefort.

Solanum nigrum. Linne. Grampians and Pyrenees.

SCROPHULARINÆ. Mirbel.

Mimulus. Linné.

Mimulus repens. R. Brown. Grampians.
Mimulus gracilis. R. Brown. Grampians.

Gratiola. Dodoens.

Gratiola pedunculata. R. Brown. Grampians and Pyrenees.
Gratiola peruviana. Linné. Grampians and Pyrenees.

Limosella. Lindern.

Limosella aquatica. Linné. Grampians and Pyrenees.

Veronica. Fuchs.

Veronica derwentia. Littlejohn. Grampians and Pyrenees.
Veronica gracilis. R. Brown. Grampians and Pyrenees.
Veronica calycina. R. Brown. Grampians.
Veronica peregrina. Linné. Grampians and Pyrenees.

Euphrasia. Matthaeus.

Euphrasia brownii. F. v. M. Grampians.
Euphrasia scabra. R. Brown. Grampians and Pyrenees.

LENTIBULARINEÆ. Richard.

Utricularia. Linné.

Utricularia dichotoma. Labillardière. Grampians and Pyrenees.
Utricularia lateriflora. R. Brown. Grampians.

Polypompholyx. Lehmann.

Polypompholyx tenella. Lehmann. Grampians.

ASPERIFOLIÆ. Haller.

Myosotis. Dioscorides.

Myosotis australe. R. Brown. Grampians and Pyrenees.

Eritrichum. Schrader.

Eritrichum australasicum. Candolle. Pyrenees.

Cynoglossum. Dioscorides.

Cynoglossum suaveolens. R. Brown. Grampians and Pyrenees.
Cynoglossum australe. R. Brown. Grampians.

LABIATÆ. Jussieu.

Mentha. Hippocrates.

Mentha laxiflora. Bentham. Grampians.
Mentha australis. R. Brown. Grampians and Pyrenees.
Mentha gracilis. R. Brown. Grampians.
Mentha saturejoides. R. Brown. Grampians.

LYCOPUS. Plinius.

Lycopus australis. R. Brown. Grampians.

BRUNELLA. Brunfels.

Brunella vulgaris. Candolle. Grampians.

PROSTANTHERA. Labillardière.

Prostanthera rotundifolia, R. Brown. Grampians and Pyrenees.
Prostanthera lasiantha. Labillardière. Grampians.
Prostanthera hirtula. F. v. M. Grampians.
Prostanthera spinosa. F. v. M. Grampians.
Prostanthera debilis. F. v. M. Grampians (new).

AJUGA. Scribonius.

Ajuga australis. R. Brown. Grampians and Pyrenees.

TEUCRIUM. Dioscorides.

Teucrium corymbosum. R. Brown. Pyrenees.

VERBENACEÆ. Jussieu.

VERBENA. l'Ecluse.

Verbena officinalis. Linné. Grampians.

MYOPORINÆ. R. Brown.

MYOPORUM. Banks and Solander.

Myoporum viscosum. R. Brown. Pyrenees.

EPACRIDEÆ. R. Brown.

STYPHELIA. Solander.

Styphelia Sonderi. F. v. M. Grampians and Pyrenees.
Styphelia adscendens. R. Brown. Grampians.
Styphelia humifusa. Persoon. Grampians and Pyrenees.
Styphelia thymifolia. F. v. M. Grampians.
Styphelia strigosa. Smith. Grampians and Pyrenees.
Styphelia pinifolia. F. v. M. Grampians.
Styphelia glacialis. F. v. M. Grampians.
Styphelia ericoides. Smith. Grampians.
Styphelia rufa. F. v. M. Grampians.
Styphelia scoparia. Smith. Grampians.

BRACHYLOMA. Sonder.

Brachyloma daphnoides. Bentham. Grampians.
Brachyloma ciliatum. Bentham. Grampians.
Brachyloma depressum. Bentham. Grampians.

EPACRIS. Cavanilles.

Epacris impressa. Labillardière. Grampians.
Epacris obtusifolia. Smith. Grampians.

Summary of the Synpetaleæ Hypogynæ:—

Natural Orders	13
Genera	28
Species	58

Apetaleæ Gymnospermeæ.

CONIFERÆ. Haller.

Callitris. Ventenat.

Callitris pyramidalis. Ventenat. Grampians.

Summary of Dicotyledoneæ.

Orders, 58; genera, 178; Species, 413.

Monocotyledoneæ.

Calyceæ Perigynæ. F. v. M.

ORCHIDEÆ. Haller.

Dipodium. R. Brown.

Dipodium punctatum. R. Brown. Grampians.

Gastrodia. R. Brown.

Gastrodia sesamoides. R. Brown. Grampians.

Thelymitra. Forster.

Thelymitra ixioides. Swartz. Grampians and Pyrenees.
Thelymitra longifolia. Forster. Grampians.
Thelymitra carnea. R. Brown. Grampians.
Thelymitra antennifera. Hooker. Grampians.
Thelymitra macmillani. F. v. M. Grampians.

Diuris. Smith.

Diuris palustris. Lindley. Grampians.
Diuris pedunculata. R. Brown. Grampians and Pyrenees.
Diuris sulphurea. R. Brown. Grampians.
Diuris longifolia. R. Brown. Grampians.

Calochilus. R. Brown.

Calochilus campestris. Grampians.

Prasophyllum. R. Brown.

Prasophyllum patens. R. Brown. Grampians.
Prasophyllum elatum. R. Brown. Grampians.
Prasophyllum

Microtis. R. Brown.

Microtis porrifolia. R. Brown. Grampians and Pyrenees.
Microtis atrata. Lindley. Grampians.

Corysanthes. R. Brown.

Corysanthes pruinosa. R. Brown. Grampians.

Pterostylis. R. Brown.

Pterostylis concinna. R. Brown. Grampians and Pyrenees.
Pterostylis curta. R. Brown. Grampians.
Pterostylis nutans. R. Brown. Grampians and Pyrenees.
Pterostylis nana. R. Brown. Grampians.

Pterostylis barbata. Lindley. Grampians.
Pterostylis mutica. R. Brown. Grampians and Pyrenees.
Pterostylis rufa. R. Brown. Grampians.
Pterostylis longifolia. R. Brown. Grampians.

CALEYA. R. Brown.

Caleya major. R. Brown. Grampians.
Caleya sullivani. F. v. M. Grampians (new).

ACIANTHUS. R. Brown.

Acianthus caudatus. R. Brown. Grampians.

CYRTOSTYLIS. R. Brown.

Cyrtostylis reniformis. R. Brown. Grampians and Pyrenees.

LYPERANTHUS. R. Brown.

Lyperanthus nigricans. R. Brown. Grampians.

ERIOCHILUS. R. Brown.

Eriochilus autumnalis. R. Brown. Grampians.

CALADENIA. R. Brown.

Caladenia menziesii. R. Brown. Grampians.
Caladenia latifolia. R. Brown. Grampians.
Caladenia carnea. R. Brown. Grampians.
Caladenia deformis. R. Brown. Grampians and Pyrenees.

CHILOGLOTTIS. R. Brown.

Chiloglottis gunnii. Lindley. Grampians.

GLOSSODIA. R. Brown.

Glossodia major. R. Brown. Grampians.

IRIDEÆ. Ventenat.

PATERSONIA. R. Brown.

Patersonia glauca. R. Brown. Grampians.
Patersonia longiscapa. Sweet. Grampians.

HYDROCHARIDEÆ. Lamarck

OTTELIA. Persoon.

Ottelia ovalifolia. Richard. Grampians and Pyrenees.

AMARYLLIDEÆ. St. Hilaire.

HYPOXIS. Linné.

Hypoxis glabella. R. Brown. Grampians and Pyrenees.
Hypoxis hygrometrica. Labillardière. Grampians and Pyrenees.

CALYCEÆ HYPOGYNÆ. F. v. M.

LILIACEÆ. Haller.

DRYMOPHILA. R. Brown

Drymophila cyanocarpa. R. Brown. Grampians.

DIANELLA. Lamarck.

Dianella revoluta. R. Brown. Grampians.
Dianella longifolia. R. Brown. Grampians.
Dianella tasmanica. Hooker. Grampians.

WURMBEA. Thunberg.

Wurmbea (Anguillaria) disica. F. v. M. Grampians and Pyrenees.

BURCHARDIA. R. Brown.

Burchardia umbellata. R. Brown. Grampians and Pyrenees.

BULBINE. Linné.

Bulbine bulbosa. Haworth. Grampians and Pyrenees.
Bulbine semi-barbata. Haworth. Grampians and Pyrenees.

THYSANOTUS. R. Brown.

Thysanotus tuberosus. R. Brown. Grampians and Pyrenees.
Thysanotus patersoni. R. Brown. Grampians and Pyrenees.

CÆSIA. R. Brown.

Cæsia vittata. R. Brown. Grampians.
Cæsia parviflora. R. Brown. Grampians.

CHAMÆSCILLA. F. v. M.

Chamæscilla corymbosa. F. v. M. Grampians and Pyrenees.

TRICHORYNE. R. Brown.

Trichoryne elatior. R. Brown. Grampians and Pyrenees.

STYPANDRA. R. Brown.

Stypandra glauca. R. Brown. Grampians.
Stypandra cæspitosa. R. Brown. Grampians.

ARTHROPODIUM. R. Brown.

Arthropodium minus. R. Brown. Grampians and Pyrenees.
Arthropodium strictum. R. Brown. Grampians and Pyrenees

CALECTASIA. R. Brown.

Calectasia cyanea. R. Brown. Grampians.

XEROTES. R. Brown.

Xerotes longifolia. R. Brown. Grampians and Pyrenees.
Xerotes brownii. F. v. M. Grampians.
Xerotes micrantha. Endlicher. Grampians.
Xerotes thunbergii. F. v. M. Grampians.
Xerotes glauca. R. Brown. Grampians.

XANTHORRHŒA. Smith.

Xanthorrhœa australis. R. Brown. Grampians.
Xanthorrhœa minor. R. Brown. Grampians.

TYPHACEÆ. Jussieu.

TYPHA. Tournefort.

Typha angustifolia. Linné.

FLUVIALES. Ventenat.

Triglochin. Dalechamps.

Triglochin procera. R. Brown. Grampians and Pyrenees.
Triglochin striata. Ruiz and Pavon. Grampians and Pyrenees.
Triglochin nana. — Grampians aud Pyrenees.

Potamogeton. Fuchs.

Potamogeton natans. Linné. Grampians and Pyrenees.

XYRIDEÆ. Salisbury.

Xyris. Gronovius.

Xyris gracilis. R. Brown. Grampians.

JUNCEÆ. R. Brown.

Luzula. Candolle.

Luzula campestris. Candolle. Grampians and Pyrenees.

Juncus. Camerarius.

Juncus bufonius. Linné. Grampians and Pyrenees.
Juncus brownii. F. v. M. Grampians.
Juncus planifolius. R. Brown. Grampians and Pyrenees.
Juncus communis. Meyer. Grampians and Pyrenees.
Juncus pauciflorus. R. Brown. Grampians and Pyrenees.
Juncus pallidus. R. Brown. Grampians and Pyrenees.
Juncus maritimus. Lamarck. Grampians and Pyrenees.
Juncus prismatocarpus. R. Brown. Grampians and Pyrenees.

RESTIACEÆ. R. Brown.

Trithuria. Hooker.

Trithuria submersa. Hooker. Grampians.

Aphelia. R. Rrown.

Aphelia gracilis. Sonder. Grampians and Pyrenees.
Aphelia pumilio. F. v. M. Grampians and Pyrenees.

Centrolepis. Labillardière.

Centrolepis polygyna. Hieronymus. Grampians.
Centrolepis aristata. Roemer and Schultes. Grampians and Pyrenees.

Lepyrodia. R. Brown.

Lepyrodia interrupta. F. v. M. Grampians.

Restio. Linné.

Restio complanatus. R. Brown. Grampians.
Restio tetraphyllus. Labillardière. Grampians.

Calostrophus. Labillardière.

Calostrophus lateriflorus. F. v. M. Grampians.
Calostrophus fastigiatus. F. v. M. Grampians.

Lepidobolus. Nees.

Lepidobolus drapetocoleus. F. v. M. Grampians.

GRAMINEÆ. Haller.

Neurachne. R. Brown.

Neurachne alopecuroides. R. Brown. Grampians.

Lepturus. R. Brown.

Lepturus incurvatus. Trinius. Grampians.

Anthistiria. Linné (fil.).

Anthistiria ciliata. Linné (fil.). Grampians and Pyrenees.

Erharta. Thunberg.

Ehrharta stipoides. Labillardière. Grampians.

Stipa. Linné.

Stipa semibarbata. R. Brown. Grampians and Pyrenees.
Stipa pubescens. R. Brown. Grampians and Pyrenees.
Stipa scabra. Lindley. Grampians and Pyrenees.

Dichelachne. Endlicher.

Dichelachne crinita. Hooker. Grampians.
Dichelachne sciurea. Hooker. Grampians.

Pentapogon. R. Brown.

Pentapogon billardièri. R. Brown. Grampians.

Echinopogon. Palisot.

Echinopogon ovatus. Palisot. Pyrenees.

Amphipogon. R. Brown.

Amphipogon strictus. R. Brown. Grampians.

Agrostis. Linné.

Agrostis solandri. F. v. M. Grampians.

Aira. Linné.

Aira cæspitosa. Linné. Grampians and Pyrenees.

Danthonia. Candolle.

Danthonia penicillata. F. v. M. Grampians and Pyrenees.
Danthonia nervosa. Hooker. Grampians and Pyrenees.

Poa. Linné.

Poa cæspitosa. Forster. Grampians and Pyrenees.

Festuca. Dillenius.

Festuca distichophylla. Grampians.

Triodia. R. Brown.

Triodia irritans. R. Brown. Grampians.

Eragrostris. Palisot.

Eragrostis brownii. Nees. Grampians.

Agropyron. Gaertner

Agropyron scabrum. Palisot. Grampians.

ARUNDO. Varro.

Arundo phragmites. Dodoens. Grampians and Pyrenees.

ACALYCEÆ HYPOGYNÆ. F. v. M.

CYPERACEÆ. Haller.

CYPERUS. Tournefort.

Cyperus difformis. Linné. Grampians.
Cyperus lucidus. R. Brown. Grampians and Pyrenees.

HELEOCHARIS. R. Brown.

Heleocharis sphacelata. R. Brown. Grampians.
Heleocharis acuta. R. Brown. Grampians and Pyrenees.

SCIRPUS. Terentius.

Scirpus fluitans. Linné. Grampians.
Scirpus cartilagineus. Sprengel. Grampians and Pyrenees.
Scirpus nodosus. Rottboel. Grampians and Pyrenees.

SCHOENUS. Linné.

Schoenus imberbis. Hooker. Grampians.
Schoenus axillaris. Poiret. Grampians.

LEPIDOSPERMA. Labillardière.

Lepidosperma semiteres. F. v. M. Grampians.
Lepidosperma filiforme. Labillardière. Grampians.

CLADIUM. P. Browne.

Cladium mariscus. R. Brown. Grampians and Pyrenees.

CAUSTIS. R. Brown.

Caustis flexuosa. R. Brown. Grampians.

CAREX. Ruppius.

Carex tereticaulis. F. v. M. Grampians.
Carex appressa. — Grampians.

Summary of Monocotyledoneæ.

Orders, 12; genera, 73; species, 132.

ACOTYLEDONEÆ.

ACOTYLEDONEÆ VASCULARES.

LYCOPODINEÆ. Swartz.

LYCOPODIUM. Ruppius.

Lycopodium densum. Labillardière. Grampians.
Lycopodium laterale. R. Brown. Grampians.

SELAGINELLA. Palisot.

Selaginella preissiana. Sprengel. Grampians.
Selaginella uliginosa. Sprengel. Grampians.

Phylloglosum. Kunze.

Phylloglosum drummondii. Kunze. Grampians.

FILICES. Linné.

Ophioglossum. Tournefort.

Ophioglossum vulgatum. Bauhin. Grampians.

Schizæa. Smith.

Schizæa fistulosa. Labillardière. Grampians.
Schizæa dichotoma. Smith. Grampians.

Gleichenia. Smith.

Gleichenia circinata. Swartz. Grampians and Pyrenees.
Gleichenia dicarpa. R. Brown. Grampians.
Gleichenia flabellata. R. Brown. Grampians.

Osmunda. Tournefort.

Osmunda barbara. Thunberg. Grampians.

Alsophila. R. Brown.

Alsophila australis. R. Brown. Grampians.

Dicksonia. l'Heritier.

Dicksonia antarctica. Grampians and Pyrenees.
Dicksonia davallioides. R. Brown. Grampians.

Davallia. Smith.

Davallia pyxidata. Cavanilles. Grampians.
Davallia dubia. R. Brown. Grampians.

Lindsaya. Lindsaya.

Lindsaya linearis. Swartz. Grampians.

Adiantum. Tournefort.

Adiantum æthiopicum. Linné. Grampians and Pyrenees.

Cheilanthes. Swartz.

Cheilanthes tenuifolia. Swartz. Grampians and Pyrenees.

Pteris. Linné.

Pteris falcata. R. Brown. Grampians.
Pteris aquilina. Linné. Grampians and Pyrenees.
Pteris incisa. Thunberg. Grampians.

Lomaria. Willdenow.

Lomaria discolor. Willdenow. Grampians and Pyrenees.
Lomaria capensis. Willdenow. Grampians.
Lomaria procera. Grampians and Pyrenees.

Asplenium. Linné.

Asplenium flabellifolium. Cavanilles. Grampians and Pyrenees.
Asplenium bulbiferum. Forster. Grampians.

Aspidium. Swartz.

Aspidium aculeatum. Swartz. Grampians.
Aspidium decompositum. Swartz. Grampians.

Polypodium. Tournefort.

Polypodium grammatidis. R. Brown. Grampians.
Polypodium pustulatum. Forster. Grampians.
Polypodium scandens. Forster. Grampians.
Polypodium punctatum. Thunberg. Grampians.

Grammitis. Swartz.

Grammitis rutifolia. R Brown. Grampians and Pyrenees.
Grammitis leptophylla. Swartz. Grampians.

Acotyledoneæ Vasculares.

Orders, 2; genera, 19; species, 36.

MUSCI: MOSSES.

Dicraneæ.

Ditrichium muelleri. Hampe. Grampians and Pyrenees.
Ditrichium affine. C. Mueller. Pyrenees.
Dicranella paucifolia. C. Mueller. Grampians (new).
Dicranum sullivani. C. Mueller. Grampians (new).
Dicranum dicarpum. C. Mueller. Grampians.
Dicranum polychætum. Hampe. Grampians.
Dicranum angustinervis. Mitten. Grampians.
Dicranum subpungens. Hampe. Grampians.
Ceratodon purpureus. Bridel. Grampians and Pyrenees.
Campylopus tasmanicus. Grampians and Pyrenees.
Campylopus depilosus. C. Mueller. Grampians (new).

Grimmieæ.

Grimmia basaltica. Grampians.
Grimmia subcallosa. C. Mueller. Grampians and Pyrenees (new).
Grimmia leiocarpa. Taylor. Pyrenees.
Grimmia cylindropsis. C. Mueller. Grampians (new).
Grimmia sullivani. C. Mueller. Pyrenees (new).
Grimmia cygnicolla. Taylor. Pyrenees and Grampians.

Tortuleæ.

Acaulon sullivani. C. Mueller. Pyrenees (new).
Tortula panduræfolia. C. Mueller. Pyrenees.
Tortula vesiculosa. C. Mueller. Grampians and Pyrenees (new).
Tortula breviseta. C. Mueller. Pyrenees.
Tortula propinqua. C. Mueller. Pyrenees (new).
Tortula calycina. Schwaegrichen. Grampians and Pyrenees.
Tortula sullivani. C. Mueller. Grampians and Pyrenees (new).
Tortula lamellosa. C. Mueller. Grampians (new).
Tortula geminata. C. Mueller. Grampians (new).
Tortula acrophylla. C. Mueller. Grampians and Pyrenees (new).
Astomum kanseanum. Grampians and Pyrenees.
Eucalypta tasmanica. Hampe and C. Mueller. Pyrenees.
Phascum disrumpens. C. Mueller. Pyrenees (new).
Phascum sullivani. C. Mueller. Pyrenees and Grampians (new).
Pottia brachyphylla. Pyrenees and Grampians.
Weissia nudiflora. C. Mueller. Grampians and Pyrenees.
Weissia sullivani. C. Mueller. Grampians (new).

Orthotricheæ.

Orthotrichum eucalyptaceum. C. Mueller. Grampians (new).
Orthotrichum sullivani. C. Mueller. Grampians (new).
Zygodon brownii. Schwaegrichen. Pyrenees and Grampians.
Zygodon scaber. C. Mueller. Grampians and Pyrenees (new).

Funarieæ.

Funaria hygrometrica. Linné. Grampians and Pyrences.
Funaria pulchidens. C. Mueller. Pyrenees (new).
Leptangium repens. Hooker. Pyrenees and Grampians.
Entosthodon sullivani. C. Mueller. Grampians and Pyrenees (new).
Entosthodon minuticaulis. C. Mueller. Pyrenees (new).
Entosthodon dissodontoides. C. Mueller. Grampians (new).

Hookerieæ.

Orthodontium zetterstedtii. C. Mueller. Grampians.

Bartramieæ.

Bartramia erecta. Hampe. Grampians and Pyrenees (new).
Bartramia austro-pyrenaica. C. Mueller. Pyrenees (new).
Bartramia pygmæa. C. Mueller. Grampians and Pyrenees (new).
Bartramia commutata. Hampe. Pyrenees and Grampians.

Bryeæ.

Bryum mielichhoferia. C. Mueller. Grampians (new).
Bryum leucothecium. C. Mueller. Pyrenees (new).
Bryum austro-nutans. C. Mueller. Grampians (new).
Bryum pyrothecium. C. Mueller. Grampians.
Bryum subrotundifolium. Hampe. Pyrenees (new).
Bryum pohliopsis. C. Mueller. Grampians (new).
Bryum altisetum. C. Mueller. Grampians (new).
Bryum pumilisetum. C. Mueller. Grampians (new).
Bryum pachypyxis. Hampe. Pyrenees (new).
Bryum breviramulosum. Hampe. Pyrenees (new).
Bryum sullivani. C. Mueller. Pyrenees (new).
Bryum gambierense. C. Mueller. Pyrenees.
Bryum inæquale. Taylor. Pyrenees.
Bryum nutans. Schreber. Grampians.
Mielichhoferia sullivani. C. Mueller. Grampians (new).
Leptostomum flexipile. C. Mueller. Grampians and Pyrenees.

Neckereæ.

Neckera hymenondonta. C. Mueller. Grampians.
Meteorium molle. Hooker (fil.) et Wilson. Grampians.
Hedwigia ciliata. Ehrhart. Grampians.
Rhacocarpus humboldtii. Hooker. Grampians.
Hedwigidium emersa. Hampe and C. Mueller. Grampians.

Hypneæ.

Rhynchostegium patulum. Hampe. Grampians.
Rhynchostegium trachychætum. F. v. M. Grampians.
Hypnum stenangium. C. Mueller. Grampians (new).
Thuidium plumiforme. Hampe. Grampians.
Thuidium pinnatum. Grampians.

SKITOPHYLLEÆ.

Fissideus sullivani. C. Mueller. Grampians.

POLYTRICHEÆ.

Polytrichum juniperinum. Hedwig. Grampians and Pyrenees.
Polytrichum sullivani. Mitten. Grampians.

ANDREÆ.

Andreæa subulata. Harvey. Grampians.
Andræa acuminata. Mitten. Grampians.

LICHENES.

Parmelia perforata. — Grampians.
Parmelia placorrhodioides. Nylander. Grampians.
Parmelia physodes. Acharius. Grampians.
Parmelia conspersa. Acharius. Pyrenees and Grampians.
Parmelia anthomelana. J. Muller. Pyrenees.
Parmelia imitatrix. Taylor. Pyrenees.
Parmelia æneofusca. J. Muller. Pyrenees.
Parmelia tenuisima. Taylor. Grampians.
Parmelia pertusa. — Grampians.
Cladonia verticillata. Floerke. Grampians and Pyrenees.
Cladonia ochrochlora. Floerke. Grampians.
Cladonia macileuta. Nylander. Pyrenees.
Cladonia corallifera. Nylander. Pyrenees and Grampians.
Cladonia pyxidata. Hoffmann. Pyrenees.
Cladonia costata. Floerke. Grampians.
Cladonia furcata. — Pyrenees.
Pertusaria glebosa. J. Muller. Grampians.
Urceolaria scruposa. Acharius. Grampians.
Placodium xanthophanum. Nylander. Grampians.
Callopisma aurantiacum. Nylander. Pyrenees.
Lecanora vitellina. Nylander. Grampians.
Lecanora effusa. Fries. Grampians.
Lecanora hoffmannia. Acharius. Pyrenees.
Lecanora sordida. Fries. Pyrenees and Grampians.
Lecanora atra. Acharius. Pyrenees.
Rhizocarpon geographicum. Kirb. Pyrenees and Grampians.
Lecidea confluens. Fries. Pyrenees.
Theloschistes parietinus. Norm. Pyrenees.
Ramalina levidea. — Pyrenees.
Usnea barbata. — Pyrenees.
Usnea dasypogoides. Nylander. Pyrenees.
Clathrina (Cladonia) sullivani. Pyrenees (new).
Stereocaulon proximum. Nylander. Grampians.
Knightiella leucocarpa. J. Muller. Pyrenees.
Squamaria gelida. — Grampians and Pyrenees.
Physcia speciosa. — Pyrenees.
Peltigera polydactyla. — Grampians.
Peltigera pulverulenta. — Grampians.
Stictina fragellima. — Grampians.
Stictina gilva. — Grampians.
Sticta freycinettii. — Grampians.
Sticta fasciculata. — Grampians.
Biatora lucida. — Grampians.

Total species	708
New species discovered by the writer	36

9.—NOTES ON THE KNOWN DIPTEROUS FAUNA OF AUSTRALIA.

By Frederick A. A. Skuse.

The Diptera, or two-winged flies, constitute a very considerable section of our fauna; indeed, it would be strange if they did not, for throughout the world this order is known to be one of the most richly represented of the great insect class.

Our Lepidoptera and Coleoptera have been assiduously collected and studied, but the Diptera, which are probably as numerous as either of these orders, have been sadly neglected by both collectors and describers.

The total number of described Australian Diptera cannot be precisely stated, but it does not exceed 1392. Even this small total is undoubtedly above the mark, being for the most part merely an enumeration of the published descriptions. On close examination, many cases will be found where descriptions of the same species are twice and thrice presented by one or more authors, under not only different specific and perhaps generic names, but in some instances placed in wrong families. Many unavoidable cases of describing the same species twice over must necessarily be found among the numerous publications of Walker and Macquart between 1848 and 1856; also, between those of Dr. Schiner ("Novara" Exp.) and Thomson ("Eugenia" Exp.), both appearing in the year 1868, and each containing about fifty descriptions of new species of Diptera found in the neighbourhood of Sydney.

In the following pages, under the different family headings, arranged in systematic order, I have enumerated all the genera (with the number of species) recorded from Australia, or known to occur here.

The families Cecidomyidæ, Sciaridæ, Mycetophilidæ, Simulidæ, Bibionidæ, Culicidæ, Chironomidæ, and the Tipulidæ brevipalpi have been reviewed by myself in the proceedings of the Linnean Society of New South Wales (1888-89), and a fair number of species have been described. All the species of the rest of the families have been described by European authors, chiefly by Walker and Macquart, in the *Diptères Exotiques* and *British Museum Catalogue* respectively; and very little indeed has been done among the Australian Diptera during the last twenty years. Dr. Schiner (V.z.-b.G. Wien, 1866) reviewed the Asilidæ of the world, with the advantage of a large number of types, so that our knowledge of the described Australian species is fairly complete; Dr. Gerstaecker (Ent. Zeit. Stett., 1868) overhauled the Midaidæ; and Bigot (Ann. Soc. Ent. Fr. 1874) partially reviewed the Dexidæ. Of few of the other families is our knowledge reliable, except where the genera are readily understood, and limited in described species.

Our described species are referred to rather more than 300 genera, of which about 80, or a little more than one-fourth, are regarded as endemic; but these numbers will doubtless be somewhat modified on a careful investigation of the species themselves.

This essay can only be a very incomplete sketch of the Australian Diptera, but at any rate it serves to show the present unsatisfactory state of our knowledge of this most prolific and interesting portion of our fauna; and may prove of assistance to entomologists who may be induced to come forward and devote some attention to one or more of the neglected families. There is an abundance of unnamed material in collections, and a plentiful harvest yet to be gathered.

Section I.—DIPTERA ORTHORHAPHA.

Division I.—Nematocera.

The families falling under this division are probably as richly represented in Australia as in any other part of the world. Very little is known of the species occurring outside New South Wales, and the majority of them have been described from specimens obtained in the vicinity of Sydney. The Blepharoceridæ and Orphnephilidæ are the only families at present unknown.

Fam. 1. Cecidomyidæ.

Ninety-five species referred to fourteen genera have been described from Australia, or, more correctly, exclusively from New South Wales. *Heteropeza*, Winn., one; *Miastor*, Mein., two; *Gonioclema*, Sk., one; *Cecidomyia*, Loew, seven; *Diplosis*, Loew, forty-eight; *Asphondylia*, Loew, two; *Hormomyia*, Loew, one; *Necrophlebia*, Sk., one; *Chastomera*, Sk., one; *Colpodia*, Winn., one; *Epidosis*, Loew, ten; *Asynapta*, Loew, three; *Lasioptera*, Meig., seven; and *Campylomyza*, Meig., ten. Most of these genera are of world-wide distribution; and some of them occur in a fossil state in amber. *Necrophlebia*, *Chastomera*, and *Gonioclema* have hitherto been found only in Australia. I know several undescribed species, belonging to four or five genera, among which is a species of *Lestremia*. I am also imperfectly acquainted with the life-histories of several species, some of which form galls on the leaves and twigs of the *Eucalypti*. This family seems to be very abundant in Australia.

For descriptions of the Australian species see Proc. Linn. Soc. New South Wales, vol. iii. (Ser. 2nd), 1888, pp. 17-144, pl. 2-3. Descriptions of all the known genera, and references to the most important papers treating on this group are given.

Fam. 2. Sciaridæ.

The typical genus *Sciara*, Meig., is represented by forty-two described species, and *Trichosia*, Winn., by one species, nearly all from New South Wales. Several species of *Sciara* and one or two of *Zygoneura*, Meig., are known to me, but not yet characterised. *Sciara* seems to be generally diffused throughout all regions of the earth's surface; *Zyoneura* and *Trichosia* have been recorded from Europe and America.

Undoubtedly this family is abundantly represented in Australia, but scarcely anything is known of the species outside New South Wales. See Proc. Linn. Soc. New South Wales, vol. iii. (Ser. 2nd), 1888, pp. 657-724, pl. 11.

Fam. 3. Mycetophilidæ.

The hitherto described species number thirty-five species apportioned to no less than sixteen genera. *Macrocera*, Meig., three; *Ceroplatus*, Bosc, one; *Heteropterna*, Sk., one; *Platyura*, Meig., eight; *Pseudoplatyura*, Sk., one; *Antriadophila*, Sk., four; *Sciophila*, Meig., one; *Homaspis*, Sk., one; *Acrodicrania*, Sk., three; *Leia*, Meig., one; *Ateleia*, Sk., one; *Trizygia*, Sk., one; *Aphelomera*, Sk., one; *Trichonta*, Winn., two; *Mycetophila*, Meig., two; and *Brachydicrania*, Sk., four. Of these, nine generic names, *Heteropterna*, *Pseudoplatyura*, *Antriadophila*, *Homaspis*, *Acrodicrania*, *Ateleia*, *Trizygia*, *Aphelomera*, and *Brachydicrania* have been proposed for peculiar Australian forms; the other genera are of more or less world-wide distribution.

Since enumerating the species last year (Proc. Linn. Soc. New South Wales, vol. iii. (Ser. 2nd), 1888, pp. 1123-1220, pl. 31 and 32), I have discovered several additional species. No estimate can be taken of the number of species inhabiting Australia, but the number must be very considerable. Very little is known of the species occurring outside New South Wales.

Fam. 4. Simulidæ.

This family, containing only a single known genus of universal distribution, is represented in New South Wales by only a single described species, *S. molestum*, Sk. No others have been yet discovered.

Fam. 5. Bibionidæ.

Australia does not appear to be rich in Bibionidæ. Nine species of *Bibio*, Geoff., are ascribed to this country, one of which is *Bibio marci*, Geoff., known commonly in Europe. I have only seen one species, *B. imitator*, Walk., with which *B. fulvipennis* and *B. ruficoxis*, Macq., and *B. helioscops*, Sch. are synonymous.

Plecia, Wied., common to America, Asia and the Eastern Isles, is known in Australia by four well-marked species. *Dilophus*, Meig., of almost world-wide distribution, has two species; and *Scatopse*, Geoff., also occurring almost everywhere, is represented here by two species, one of which, *S. notata*, Linn., originally a native of Europe, is now known from several parts of the world, having been introduced into other countries through the medium of shipping. See Proc. Linn. Soc. New South Wales, vol. iii. (2nd series), 1888, pp. 1363-1386, pl. 39.

Fam. 6. BLEPHAROCERIDÆ.

No representative of this group has been yet discovered in Australia.

Fam. 7. CULICIDÆ.

The genus *Megarrhina*, Desv., recorded from America, West Indies, Asia and the Eastern Isles, is known in this country by one species. The cosmopolitan genus *Culex*, Linn., seems abundantly represented, twenty-one species having been already described; one of these, *C. ciliaris* (? var.) Linn., has been introduced from Europe, and is the great nocturnal pest of all the colonies. *Anopheles*, Meig., has five, and *Ædes*, Meig., one described example. I am also in the position to record the occurrence of *Corethra*, Meig., having recently taken specimens at Wagga Wagga, New South Wales. For descriptions of our species see Proc. Linn. Soc. New South Wales, vol. iii. (2nd series), 1888, pp. 1717-1764, pl. 40.

Fam. 8. CHIRONOMIDÆ.

This family, rich in North American and European species, seems also abundant in Australia. Eleven genera and seventy-two species have been already recorded. *Chironomus*, Meig., twenty-eight; *Orthocladius*, v. d. Wulp, five; *Camptocladius*, v. d. Wulp, five; *Doloplastus*, Sk., one; *Tanytarsus*, v. d. Wulp, seven; *Metriocnemus*, v. d. Wulp, one; *Tanypus*, Meig., one; *Isoplastus*, Sk., three; *Procladius*, Sk., two; *Leptoconops*, Sk., one; and *Ceratopogon*, Meig., seventeen. *Doloplastus*, *Isoplastus*, *Procladius*, and *Leptoconops* have been adopted for what appear to be endemic forms. Most if not all of the other genera are probably universally represented, but owing to the insignificant size of these insects, and the difficulties which attend their collection and study, very few have been described, except from Europe and America. The Australian species are described in the Proc. Linn. Soc. New South Wales, vol. iv. (2nd series), 1889, pp. 215-311, pl. 11-14.

Fam. 9. ORPHNEPHILIDÆ.

None known.

Fam. 10. Psychodidæ.

Several examples are known to me, but none have been described.

Fam. 11. Tipulidæ.

This group is probably as richly represented in this country as it is known to be in Europe and America. The Tipulidæ brevipalpi have received the most attention, with the result that almost one hundred species belonging to twenty-five genera are now known, as follows:—Limnobina, *Dicranomyia*, Steph., fourteen; *Thrypticomyia*, Sk., one; *Geranomyia*, Hal., four; *Limnobia*, Meig., one; *Trochobola*, O. Sack., one; *Libnotes*, Westw., one; Limnobina anomala, *Rhamphidia*, Meig., four; *Orimarga*, O. Sack., two; *Leiponeura*, Sk., two; *Teucholabis*, O. Sack, one; Eriopterina, *Rhypholophus*, Kol., two; *Molophilus*, Curt., sixteen; *Tasiocera*, Sk., two; *Erioptera*, Meig., one; *Trimicra*, O. Sack, two; *Gnophomyia*, O. Sack., one; *Goniomyia*, Meig., one; *Rhabdomastix*, Sk., one; *Lechria*, Sk., one; *Trentepohlia*, Bigot., one; *Conosia*, v. d. Wulp, one; Limnophilina *Limnophila*, Macq., sixteen; *Gynoplistia*, Westw., eighteen; *Cerozodia*. Westw., one; and Amalopina, *Amalopis*, Hal., two. The genera *Thrypticomyia*, *Leiponeura*, *Tasiocera*, *Rhabdomastix* and *Lechria* have been erected for Australian species. The second great division, Tipulidæ longipalpi, is also well represented, but the described genera and species must undergo a thorough revision before the genera can be clearly defined and located. Altogether, something like twenty-two species have been described, eleven of which are vaguely described under the name *Tipula*. Several species belong to *Macromastix*, O. Sack., a genus which also occurs in New Zealand and South America. The genera *Leptotarsus*, Guérin, *Semnotes*, Westw., and *Ptilogyna*, Westw., are peculiar Australian forms.

Several undescribed species of Tipulidæ are known to me, including a species belonging to the section Cylindrotomina.

Fam. 12. Dixidæ.

No species yet recorded from Australia; I am, however, acquainted with three species occurring in N.S.W. *Dixa*, Meig. (the only genus included in this family), is known by several species in Europe and America.

Fam. 13. Rhyphidæ.

This family, represented throughout the world by the genus *Rhyphus*, Latr., the species of which bear a remarkable similarity, is known by one described species, *R. brevis*, Wlk., from Tasmania. This and another species seem to be found all over New South Wales.

Division II.—Brachycera.

The Asilidæ and Bombylidæ have received a considerable amount of attention, from their being conspicuous and for the most part large insects. No species belonging to Acanthomeridæ and Senopinidæ yet recorded.

Fam. 14. Xylophagidæ.

Of this small family two Australian examples of both *Xylophagus*, Meig., and *Agapophytus*, Guérin, have been described. *Agapophytus* is endemic, while the other genus is represented in Europe and America.

Fam 15. Cœnomyidæ.

This family seems to be of rare occurrence everywhere, as far as the number of species is concerned. Three Australian species, belonging to the genus *Chiromyza*, have been described; one of these by Macquart under the name *Xenomorpha australis.*

Fam 16. Stratiomyidæ.

Thirty-eight species, referred to nine genera. From this it appears that this family, which is so richly represented in other countries, is but poorly so in Australia. Of the more or less cosmopolitan genera, *Odontomyia*, Meig., is known by seventeen described examples; *Beris*, Latr., seven; *Stratiomyia*, Geoff., eight; *Sargus*, Fabr., *Oxycera*, Meig., *Clitellaria*, Meig., *Metoponia*, Macq., and *Ephippium*, Latr., by one each. *Anacanthella*, Macq., the only known genus which seems peculiar to this country, has also a single described species.

Fam. 17. Acanthomeridæ.

No examples yet described from Australia, nor have any, as far as I am aware, been yet discovered here.

Fam. 18. Tabanidæ.

One hundred species, arranged under eight genera, have been recorded. The cosmopolitan genera, *Pangonia*, Latr., *Chrysops*, Meig., *Silvius*, Meig., and *Tabanus*, Linn., are represented by forty-seven, two, four, and forty-three species respectively; the other four genera, *Apocampta*, Sch., *Cænopnyga*, Thoms., *Dasybasis*, Macq., and *Palecorhynchus*, Macq., are endemic, and each contains only a single described species. Possibly *Apocampta* and *Cænopnyga* are identical. *Tabanus* and *Pangonia* are numerous all over the country. The number of Australian species belonging to the section Pangonina is considered very large, and, according to the list, only exceeded by the American species.

Fam. 19. Leptidæ.

Only four species stand recorded. Three belong to *Chrysopila*, Macq., and the fourth to *Leptis*, Fab., both well-known genera in Europe and America.

Fam. 20. Asilidæ.

Of this family one hundred and thirty-four species and thirty genera are recorded for Australia. The Dasypogonina are represented by forty-eight species, twenty-one of which are distributed as follows:—*Bathypogon*, three; *Brachyrhopala*, two; *Cabasa*, two; *Codula*, two; *Damalis*, one; *Dioctria*, one; *Leptogaster*, three; *Microstylum*, one; *Phellus*, one; *Saropogon*, two; *Stenopogon*, one; *Plesiomma*, one; and *Laparus*, one. The remaining twenty-six species doubtfully occupy their correct genera. The Laphrinæ only fifteen species—*Andrenosoma*, one; *Dasyllis*, one; *Lampria*, one; *Laphria*, four; *Thereutria*, four; *Tapinocera*, one; and three doubtful species. The Asilinæ number the most, with seventy-one species and eleven genera—*Asilus* three, *Cerdistus* one, *Craspedia* two, *Erax* six, *Glaphyropyga* one, *Itamus* six, *Ommatius* five, *Philodicus* two, *Proctacanthus* three, *Promachus* two, *Psecas* one, and thirty-nine species of uncertain position. Seven of the genera, *Brachyropala*, *Cabasa*, *Codula*, *Craspedia*, *Phellus*, *Psecas*, and *Tapinocera* are endemic; two, *Bathypogon* and *Glaphyropyga*, are only found elsewhere in South America, while *Thereutria* is only otherwise known by an oceanic species. The rest of the genera are more or less completely universal in their distribution. See V. z.-b. G., Wien, xvi., pp. 649-722, 1866, by Dr. J. R. Schiner.

Although the Asilidæ have been largely collected, being for the most part conspicuous insects, they are so numerous in this country that it is probable only a small proportion of the existing species are yet described. The family is richly represented in the Macleay collection.

Fam. 21. Midaidæ.

The Australian species of this family occupy exclusively endemic genera. Dr. A. Gerstaecker (Ent. Zeit. Stett, 1868, pp. 65-103) reviewed the Midaidæ of the world, and placed all the known Australian species under three new generic names. Thomson (Eugenies Resa, p. 463) in the same year proposed the name *Harmophana* for two species, one of which, described by Macquart, Gerstaecker simultaneously placed in his own new genus *Triclonus*. *Diochlistis* contains one, *Triclonus* four, and *Miltinus* ten species. The Australian genus *Pomacera*, Macq., with a single species, may also be provisionally retained in this family. The Midaidæ are generally distributed over the country, but several of them have been described from Western Australia.

Fam. 22. Nemestrinidæ.

This apparently limited family is, according to descriptions, more numerous in Australia than in any other country, the total of our species amounting to twenty-five. The African and South American faunas are each credited with about twenty species; these belong to the genera to which the majority of the Australian forms are referred. *Trichophthalma*, Westw., has nineteen, *Hirmoneura*, Meig., four, and *Trichopsidea*, Westw., and *Exeretoneura*, Macq., a single species each. The two last-mentioned genera are known only from this country; *Exeretoneura* is recorded only from Tasmania.

Fam. 23. Bombylidæ.

This family is richly represented. One hundred and twenty-three species, referable to eleven genera, have been characterised; no species, falling under the section Toxophorinæ are yet known here. Anthracinæ has fifty nine species, nine of which belong to *Exoprosopa*, Macq., and the remainder to *Anthrax*, Scop; Lomatinæ includes sixteen species, one belonging to *Lomatia*, Meig., five to *Neuria*, Newm., and ten to *Comptosia*, Macq.; and Bombylinæ is represented by six genera and forty-eight species, two species belong to *Geron*, Meig., the same number to *Phthiria*, Meig., one each to *Dischistus*, Loew, and *Lomatia*, Meig., two to *Acreotrichus*, Macq., and forty to the typical genus *Bombylius*. Only one genus, *Acreotrichus*, Macq., is yet recorded as peculiar to Australia; several of the others are cosmopolitan.

Fam. 24. Therevidæ.

Thirty-three species, belonging to five genera, have been described. *Anabarhynchus*, Macq., peculiar to Australia, has eleven described species; *Dimassus*, Walk., has one species occurring in New South Wales and two others of doubtful locality. *Thereva*, Latr., a cosmopolitan genus, is, according to descriptions, represented throughout the country by at least seventeen species. The genus *Phycus*, Wlk., is known by only two species, one of which has been described from New South Wales, the other from Bengal. *Ectinorhynchus*, Macq., only known from Sydney, South Australia and Tasmania, seems to be limited to three or four species.

Fam. 25. Scenopinidæ.

No Australian species have been yet recorded, and I do not yet know of the occurrence of any.

Fam. 26. Cyrtidæ.

Represented here by six genera, three of which are endemic; these latter, *Epicerina*, Macq., and *Leucopsina* and *Nothra*, Westw., each contains only a single described example. *Oncodes*, Latr., of world-wide distribution, has five Australian representatives; while *Pterodontia*, Gray, and *Panops*, Latr., have each three species (see Trans. Ent. Soc., Lond., 1876, pp. 507-518). The genus *Oncodes* occurs all over the country; Thomson's species described (*Eugenies Resa*, 1868, p. 475) under the name of *Mesophysa*, from Sydney, belongs to *Oncodes*.

Fam. 27. Empidæ.

This family, so numerously represented in Europe and America, seems to be only sparingly so in Australia; the cosmopolitan genera, *Hybos*, *Hilara*, and *Empis*, Meig., are indicated by one, two, and three species respectively. The two species of *Hilara* belong to Tasmania; *Empis* occurs in New South Wales and Tasmania; the single species of *Hybos* is only known in New South Wales. There are some undescribed species known to me in collections.

Fam. 28. Dolichopodidæ.

The Dolichopodidæ seem numerous in both genera and species, but only twenty-one species have been described; all but one have been characterised under the generic title *Psilopus*, Meig.; the odd one is a *Hydrophorus*, from Tasmania. Doubtless many of those described by Walker and others as *Psilopus* will eventually be found to really belong to different genera; some names, I believe to be synonyms. Loew (Mon. Dipt., N. Amer. II., 1864) has written an important work on the North American species.

Fam. 29. Lonchopteridæ.

No species have yet been recorded, though the family, which is throughout the world represented by only a single known genus, occurs in Australia.

Section II.—DIPTERA CYCLORHAPHA.

Division I.—Proboscidea.

Except among the Syrphidæ, Tachinidæ, Dexidæ, Muscidæ, and Anthomyidæ, very little is known of the Australian species belonging to the numerous families included in this division. The Cordyluridæ, Lonchæidæ, Heteroneuridæ, Sepsidæ, Diopsidæ, and Asteidæ are unknown.

Fam. 30. Syrphidæ.

Twenty-three genera of this extensive family are known in this country; the widely-scattered genera *Syrphus*, Fab., and

Eristalis, Latr., are put down as numbering fifteen and eleven species respectively; the remaining genera, *Brachyopa*, Meig., *Ceria*, Fabr. *Cheilosia*, Meig., *Chrysogaster*, Meig., *Chrysotoxum*, Meig., *Coiloprosopa*, Macq., *Criorrhina*, Macq., *Cyphipelta*, Bigot, *Deineches*, Wlk., *Eumerus*, Meig., *Helophilus*, Meig., *Hemilampra*, Macq., *Melanostoma*, Sch., *Merodon*, Latr., *Mesembrius*, Rond., *Microdon*, Meig., *Mixogaster*, Macq., *Orthoprosopa*, Macq., *Psilota*, Meig., *Sphærophoria*, St. Farq., and *Xylota*, Meig., have mostly only one, but never more than three, species described as Australian. The genera *Coiloprosopa*, *Cyphipelta*,, *Deineches*, *Hemilampra*, and *Orthoprosopa* seem peculiar to Australia, none having been yet recorded from other countries.

The total number of species on paper is sixty-one, though it is scarcely probable that they are all tenable; Schiner, in 1868, put the Australian species down at 53, and even this includes the New Zealand species.

The Syrphidæ are numerous all over Australia, and doubtless there is a large number of unknown forms; there is a considerable number of undescribed species in the Macleay collection.

The cosmopolitan species, *Eristalis tenax*, Linn., occurs in Australia and New Zealand.

Dr. Williston (Bull. U.S. Nat. Mus. No. 31, Washington, 1886) has monographed the North American species, and compiled a complete list of all known genera, with synonyms.

Fam. 31. Conopidæ.

The universal genus *Conops*, Linn., is credited with twelve Australian species. The only other genus known here is the endemic *Pleurocerina*, Macq., of which a single example is recorded. *Conops* occurs throughout the continent.

Fam. 32. Pipunculidæ.

No species have been hitherto described from Australia. There are specimens belonging to the well-known genus *Pipunculus*, Latr., in the Macleay collection.

Fam. 33. Platypezidæ.

None yet recorded. I know one or two species of *Platypeza* Meig., or an allied genus.

Fam. 34. Œstridæ.

No Australian examples hitherto recorded. Sir William Macleay informs me that a fly which may belong to this family attacks the natives of northern Australia. *Œstrus ovis*, Linn., is said to have been introduced into this country (Proc. Roy. Soc. Tasm., 1884, p. 258, by A. Morton)

Fam. 35. Tachinidæ.

The recorded species amount to eighty-six, referred to twenty-eight genera. *Hyalomyia*, R. Desv., one; *Gymnosoma*, Meig., one; *Ocyptera*, Latr., four; *Jurinia*, R. Desv., one; *Echinomyia*, Dumer., one; *Micropalpus*, Macq., nine; *Gonia*, Meig., two; *Exorista*, Meig., seven; *Tachina*, Meig., twelve; *Masicera*, Macq., twelve; *Phorocera*, R. Desv., fourteen; *Belvoisia*, R. Desv., one; *Blepharopeza*, Macq., one; *Eurygaster*, Macq., two; *Degeeria*, Meig., one; *Chrysosoma*, Macq., one; *Myobia*, Macq., one; *Tritaxys*, Macq., one; *Aprotheca*, Macq., one; *Chlorogaster*, Macq., one; *Exechopalpus*, Macq., one; *Heterometopia*, Macq., three; *Platytainia*, Macq., one; *Polychæta*, Macq., one; *Sumpigaster*, Macq., one; *Teretrophora*, Macq., one; *Toxocnemus*, Macq., one; and *Trichostylum*, Macq., one. The ten last-named genera are regarded as endemic forms; the remainder are found either in Europe or America, or in both, &c. Four species of *Micropalpus* have been described under the name *Nemoræa*, R. Desv.

Fam. 36. Dexidæ.

Twelve genera, with about ninety-four species, are ascribed to this family. Some of the genera and species require a critical revision; this has been partly effected by Bigot (Ann. Soc. Ent. Fr., Ser. V., 4, 1874, pp. 451-460). *Dexia*, Meig., seventeen; *Prosena*, St. Farq., six; *Rutilia*, R. Desv., thirty-three, two of them doubtfully Australian; *Formosia*, Guérin, seventeen; *Microtopeza* (?=*Rutilia*), Macq., two; *Omalogaster*, Macq., three; *Amphibolia*, Macq., three, one of which is possibly merely a synonym; *Senostoma*, Macq., two; *Diaphania*, Macq., three; *Amenia*, R. Desv., five; and *Chetogaster* and *Graphystylum*, Macq., one each. Three species described as *Rutilia* belong to *Amphibolia*, fourteen to *Formosia*, and one to *Diaphania*. Eleven species described by Walker under *Dexia* are placed in *Rutilia*, another in *Formosia*. The genera *Chetogaster*, *Diaphania*, and *Graphostylum* are endemic, and closely allied to *Rutilia*; the latter seems peculiar to Australia, New Guinea, and the Eastern Islands, New Zealand, and India. *Amphibolia* and *Senostoma* are also endemic. *Amenia* occurs also in New Zealand, one species, *A. leonina*, being common to that country and Australia; *Microtopeza sinuata* and *Rutilia pellucens* are also found in both countries. *Formosia* is represented also in the Eastern Archipelago and in New Zealand; *Dexia* and *Prosena* occur in Europe and America.

Fam. 37. Sarcophagidæ.

Nine species, belonging to the wide-spread genus *Sarcophaga* Meig., have been described.

Fam. 38. MUSCIDÆ.

Fourteen genera, with sixty-seven species distributed among them, have been recorded, as follows :—*Stomoxys*, Geoff., one; *Idia*, Meig., two; *Calliphora*, R. Desv., thirteen; *Pollenia*, R. Desv., four; *Lucilia*, R. Desv., five; *Somomyia*, Rond., three; *Pyrellia*, R. Desv., six; *Orimia*, R. Desv., seven; *Musca*, Linn., fifteen; *Cyrtoneura*, Macq., four; *Rhynchomyia*, R. Desv., four; *Onesia*, R. Desv., one; *Glossina*, Wied., one; and *Apatemyia*, Macq., one. The latter genus is apparently endemic, all the others have a more or less universal dispersion.

This family is most abundantly represented in Australia; there must be many undescribed forms in collections.

Musca domestica, Linn., the common house-fly, now known almost throughout the world, is only too numerous.

Fam. 39. ANTHOMYIDÆ.

Eleven genera and thirty-five species are recorded, but this total cannot be regarded as representative. *Anthomyia*, Meig., well known all over the world, is credited with only thirteen species; *Aricia*, R. Desv., with eight species, one of which has been described by Bigot under the name *Yetodesia; Ophyra*, R. Desv., three; *Hydrotaœ* and *Limnophora*, R. Desv., and *Spilogaster*, Macq., two each; and *Coenosia*, Meig., *Lispe*, Latr., *Pygophora*, Sch., *Duomyia*, Walk., and *Macrochœta*, Macq., a single representative each. The three last-named genera are regarded as endemic. Undescribed species of *Gonia*, Meig., or an allied genus, are in the Macleay collection.

Fam. 40. CORDYLURIDÆ.

The family is represented, but no species have been yet described.

Fam. 41. HELOMYZIDÆ.

Five specimens of the typical genus *Helomyza*, Fall., have been described, four of them from Tasmania and one from New South Wales. The genus appears to be of world-wide distribution. *Heteromyza*, Fall., also apparently universal, has two species described from Tasmania.

Fam. 42. SCIOMYZIDÆ.

Four genera with seventeen species are distributed as follows :—*Sciomyza*, Fall., eleven, *Tetanocera*, Latr., two, *Dryomyza*, Fall., three, and *Tapeigaster*, Macq., one. Only the last-named is endemic. There are undescribed species belonging to this group in the Macleay collection.

Fam. 43. Psilidæ.

None yet described. There are specimens of *Loxocera* or an allied genus in the Macleay collection.

Fam. 44. Micropezidæ.

Five indigenous species of *Calobata*, Meig., only have been described. This genus is distributed throughout the globe. Macquart (Dipt. Exot. II., part 3rd, 1843, p. 245) seems to believe that Wiedemann's *Calobata albitarsis*, described in 1830, from Java, is identical with a species found at Cuba, Philadelphia, and (Port Jackson) Sydney; if so, his *C. albimana*, from Java, is the same species.

Calobata occurs throughout Australia and at Lord Howe Island.

Fam. 45. Ortalidæ.

Twenty-two species, referred to seven genera, are recorded. *Lamprogaster*, Macq., found also in the Phillipine Islands, Java, the South Sea Islands, and New Zealand, is represented in Australia by about eight or nine described examples; one of which, *Lamprogaster strigipennis*, described by Macquart as a *Tephritis* (= *Trypeta*), is according to Schiner found in New Zealand. Walker has described several of our species under the generic title *Chromatomyia*, proposed six years after Macquart's name. *Stenopterina*, Macq., has five recorded species, mostly Tasmanian; this genus also occurs in America, Java, etc. *Herina*, R. Desv., which is widely distributed, has a single species from Tasmania (described by Thomson as *Hernia*). The typical genus *Ortalis*, Fall., is according to our list represented in Australia by four species; probably not one of them is an *Ortalis*. Besides these four genera, the three following, with one species each, are regarded as endemic, *Campigaster*, *Epicerella*, and *Toxura*, Macq.

Fam. 46. Trypetidæ.

Thirty-two species and three or four genera are doubtfully ascribed to Australia. Various authors have characterised species which apparently belong to *Trypeta*, under no less than four generic names (*i.e.*, *Acinia*, *Tephritis*, *Trupanea*, and *Urophora*), hence no doubt the same species have in several instances been described under different names. The species described by Macquart as *Platystoma*, Meig., and his genus *Euprosopia* (peculiar to Australia) also cannot be trusted. Macquart and Guérin describe each a new genus (*Cardiacera* and *Bactrocera* respectively) for Australian insects, which probably belong to *Dacus*, Meig.; a third species has been described by Walker under the name *Dacus*.

The above-mentioned species and genera require a thorough overhauling before any can be satisfactorily admitted. See Loew's papers on the North American Trypetidæ (Mon. Dipt., N. Amer., I. & III., 1862-1873).

Fam. 47. LONCHÆIDÆ.

No Australian species have been yet identified.

Fam. 48. SAPROMYZIDÆ.

Eight species of *Sapromyza*, Fall., and two of *Lauxania*, Latr., both world-wide genera, have been described from New South Wales and Tasmania. *Celyphus inæqualis*, Costa, dubiously Anstralian, should perhaps be referred to this family.

Fam. 49. PHYCODROMIDÆ.

One species each of *Phycodroma*, Stenh., and *Cœlopa*, Meig., are recorded.

Fam. 50. HETERONEURIDÆ.

No species of this family have yet been recorded from Australia.

Fam. 51. OPOMYZIDÆ.

One species of the universally-distributed genus, *Opomyza*, Fall., described from Tasmania.

Fam. 52. SEPSIDÆ.

None recorded.

Fam. 53. PIOPHILIDÆ.

None recorded; the well-known *Piophila casei*, Linn., of course occurs in Australia.

Fam. 54. DIOPSIDÆ.

None known to occur.

Fam. 55. EPHYDRIDÆ.

One species of *Ephydra*, Fall., a widely-distributed genus, and one of *Ectropa*, Sch., an endemic form, have been characterised.

Fam. 56. DROSOPHILIDÆ.

One species of the cosmopolitan genus, *Drosophila*, Fall., described from New South Wales. Several others are known in collections.

Fam. 57. Oscinidæ.

Two species each of the wide-spread genera *Oscinis*, Latr., and *Chlorops*, Meig., stand recorded. Several undescribed species occur in collections, from all parts of Australia. The genus *Batrachomyia*, Kr., proposed for two species parasitic upon Australian frogs, and *Lestophonus*, Will., containing also two species, parasitic upon Australian Coccididæ, seem peculiar to this country. The latter two species have been artificially introduced into America.

Fam. 58. Agromyzidæ.

A single species of *Oxyrhina*, Zett., has been described by Thomson from Sydney.

Fam. 59. Phytomyzidæ.

The genus *Phytomyza* is numerously represented, but no species have yet been described.

Fam. 60. Asteidæ.

Not known as yet in Australia.

Fam. 61. Borboridæ.

Some species of *Borborus*, Meig., or allied genus, are in the Macleay collection. None yet described.

Fam. 62. Phoridæ.

The genus *Phora*, Latr., is numerous. Only one species has been described, *Phora nebulosa*, Wlk., from Tasmania.

Division II.—Eproboscidea.

Fam. 63. Hippoboscidæ.

The cosmopolitan genera *Hippobosca*, Linn., and *Ornithomyia*, Latr., have respectively two and four described species. Several other species are known in collections. *Olfersia*, Wied., is credited with a single species. *Melophagus ovinus*, Linn., which is known now almost throughout the civilised world, is found in Australia.

Fam. 64. Nycteribidæ.

I know a number of species in collections, but hitherto none have been described from this country.

10.—ON THE EXPERIMENTAL CULTIVATION OF THE MOTHER-OF-PEARL SHELL *MELEAGRINA MARGARITIFERA* IN QUEENSLAND.

By W. Saville-Kent, F.L.S., F.Z.S., Commissioner of Fisheries and P.R.S., Queensland.

The pearl and pearl-shell fisheries of Queensland and West Australia occupy a prominent position among the most valuable natural products of the Australian continent. Collectively, within the past few years, they have represented an average annual export value of over £200,000. This estimated value was, however, in previous years considerably exceeded, the falling-off, which has been most marked with relation to the Queensland output, being due mainly to the exhaustion of the home and inshore fishing-grounds, the pearl-shelling vessels having consequently to go much further afield and to expend much more time and labour than formerly in securing their harvest. In the earlier years of the Australian pearl-shelling industry fine shell was abundant so close in shore that it might be collected by wading at low spring tides. Examples are even yet to be occasionally obtained, and have been so collected by myself under these conditions. The greater bulk of the shell is at the present date obtained with diving apparatus from an average depth of seven or eight fathoms, while the very largest shell now procurable, and coming from near the coast of New Guinea, is brought up from a depth of close upon twenty fathoms. But few divers, however, can endure the strain of long-continued labour under such a superincumbent weight of water. A second cause which has contributed very extensively towards the exhaustion of the more accessible fishing-grounds has been the wholesale collection of the young, miniature shell, now being left to arrive at maturity to replenish the exhausted waters. This minature shell cannot be utilised for the same purposes as the mature shell, and there is no demand for it in the English market.

Recognising the necessity of instituting regulations that shall act as a check upon the unrestricted destruction of the young shell, and the desirability of inaugurating any other measures that might contribute towards the improvement and further development of this important industry, I have been recently deputed by the Queensland Government to make an exhaustive inquiry into and draw up a report upon the entire subject. For this purpose I have spent some two months in the Torres Straits district, making Thursday Island my head-quarters, and from thence visiting all the more important stations and shelling-grounds. Full details of the evidence collected and recommendations of regulations suggested for the better conservation and development of the fishery are embodied in the desired report. Apart from the matters entailing ordinary official attention, advantage was taken of the opportunities afforded me during my visit to Torres Straits to initiate a series of experiments in the direction of ascertaining the possibility of bringing the living pearl-shell in alive from the more remote fishing-grounds, and of laying it down and cultivating it in the readily accessible inshore waters. The results obtained in connection with these investigations were of so satisfactory a nature, and are, if ultimately followed up, calculated to exert so far-reaching an influence upon the future development of the pearl and pearl-shell fisheries of the Australian continent, that I have considered a brief account of them, together with an enumeration of the means and methods employed in their realisation, might form an appropriate contribution to the Proceedings of the Australian Association for the Advancement of Science. With the sanction of the Queensland Government, they are accordingly submitted.

It may be mentioned, in the first place, that previous to the date of these investigations the most contrary views were prevalent among those engaged in the shelling industry concerning the life-history and natural habits of the mother-of-pearl shell, *Meleagrina margaritifera*, whilst little or no credence was attached by them to the possibility of bringing the shell in alive and cultivating it artificially. By way of illustrating the variety of opinions that were upheld, it was affirmed by many of the pearl-shell divers that the mollusc remained permanently fixed in its ocean bed throughout every phase of its existence. By others it was asserted that the shell had no means of attaching itself, but that at the same time it remained perfectly quiescent in its selected habitat. By yet a third section it was as strenuously maintained that the pearl shell was a migratory animal, that was constantly moving from place to place. Had this last-named theory proved to be the correct one, all attempts at artificial cultivation would have necessarily proved abortive, the impounded shells being liable, after the manner of scallops (genus *Pecten*), *Lima*, and other allied types, to take unto themselves wings and fly away. As the experiments demonstrated, however, neither of the three theories propounded were in precise accord with the actual facts.

By a fortunate coincidence I arrived at Thursday Island at a period that enabled me almost immediately to acquire some important information concerning the life habits of this shell-fish. A few weeks only prior to my arrival, 10th August, a diver, who had been employed to examine the bottom of the storage hulk, the *Star of Peace*, for the purpose of repairs, found growing upon it a quantity of shells, which were pronounced by some to be the young of the true pearl-shell. No attempt was made to keep these shells alive. They were merely dried and cleaned, and in that condition were submitted to me for examination and identification by the hon. John Douglas, the Government resident at Thursday Island. The majority of the examples gathered were evidently the young of the *Meleagrina margaritifera*. Mixed with them were, however, the young of the smaller black-lipped species usually identified with *Meleagrina cumingii*, and also those of a third non-commercial species not yet precisely determined, but apparently corresponding with *Meleagrina muricata*. These shells, gathered from the *Star of Peace*, varied in size from one to three inches in diameter. Within the next few days, while exploring the coral reefs in the immediate neighbourhood of Thursday Island at low spring tide, I had the good fortune to find several similar young living examples of the true mother-of-pearl shell, *M. margaritifera*. The smallest of these measured no more than one quarter of an inch, and the largest about two inches in diameter. These shells were, in all cases, attached to the under surface of loose coral rocks by a cable or byssus, consisting of a bundle of tough green threads. By severing this byssus carefully with a knife, the shells were secured without the slightest injury, and were brought in and kept alive for the purpose of studying their habits. Efficient aquaria for their conservation were extemporised out of a couple of huge clam shells, *Tridacna gigas*, each having a capacity of several gallons, that ornamented the lawn of the Government Residency. Sea-water was brought up in buckets from the shore, and renewed to them every day, the little pearl-shells adapting themselves with remarkable alacrity to their novel surroundings. About a dozen individuals, to which others were subsequently added, were maintained in health for several weeks under the conditions just described, and afforded the opportunity of observing and recording many important data.

It was first observed that these young pearl-shells possessed the capacity of ejecting the portion of the byssus remaining imbedded in their tissues after they were separated from their primary attachment, and of secreting a new byssus, by which they affixed themselves to the nearest available anchorage. This was represented, in association with the specimens under observation, by the interior surface of the clam-shells in which they were confined. In all instances, with rare exceptions, the re-attachment of the shells was effected on the immediate spot upon which they were placed when brought in from the sea, and to which anchorage they remained firmly fixed throughout the period of their confinement. The exceptions referred to were furnished by certain of the smallest-sized shells, one or two of which crept from the upper and re-attached themselves to the shaded under-surface of an empty oyster-shell, upon which they had been placed. A specimen in another instance moved for the space of a few inches before re-attaching itself by its new byssus. Two of the smallest examples, about one-quarter inch in diameter, which were temporarily kept in a wide-mouthed bottle, were observed to creep, with the aid of their slender protrusible foot, a little distance up the side of the bottle, and to which they then made themselves secure by the secretion of a new byssus. This byssus, or anchoring cable, is secreted a thread at a time; during its exudation it is of the consistency of liquid glue, but rapidly hardens in the water. The byssus of living examples of the true pearl-shell, *Meleagrina margaritifera*, was in all cases observed, whether young or old, of a glassy sea-green hue, and the number of threads or strands of which the entire cable is composed usually averages from thirty to forty. It may be mentioned here that the extemporised aquaria, represented by two large clam-shells, in which the young pearl-shells were confined, were left exposed on the hillside in front of the Residency, and fully open to the action of the south-east monsoon, which, at the period of the experiments conducted, August and September, blew strongly and continuously, and thus received the thorough re-oxygenisation of the water in which the shells were kept. The only additional precaution taken for their welfare was the placing of a board over the top of the clam-shells to screen the water with its living contents from the direct rays of the tropical midday sun.

The facts that were determined in association with the experimental culture of the young shells, as just described, may be thus summarized:—1. It was conclusively demonstrated that the pearl-shell, in its young condition at least, firmly attaches itself to submarine objects by means of a so-called byssus, or anchoring cable. 2. That in the event of injury, the primary byssus can be ejected and a new one secreted. This fact carried with it the demonstration that the animal was capable at will of separating itself from its original fulcrum, and of re-attaching itself elsewhere. 3. While the young animals were found to possess the capacity of locomotion, such locomotion was shown to be of a feeble character and rarely exercised. In this respect the habits of the pearl-shell were found to coincide to a considerable extent with those that have been observed of ordinary mussels, genus *Mytilus*, and the wing-shells, genus *Avicula*. Active locomotive functions similar to those of the scallop-shells, genus *Pecten*, and an allied type, genus *Lima*—both of which can transport themselves to considerable distances by the opening and closing of their valves—are certainly not possessed by the pearl-shell, *Meleagrina margaritifera*, and have been incorrectly ascribed to it by many of the divers and owners of shelling-boats.

The information gathered concerning the life habits of the young pearl-shell was next extended to that of the more matured and adult individuals. This was accomplished chiefly through the acquirement of materials obtained in an excursion made in the G.S. *Albatross* to one of the most prolific shelling-grounds in

Torres Straits, lying west from Bado or Mulgrave Island, and familiarly known to the fishermen as the "Old ground." Some forty vessels, luggers of ten or eleven tons burden, were then engaged in shelling operations in the area traversed by the *Albatross.* The majority of these were boarded, the manner of working observed, materials collected, and much practical information elicited from the divers. It was found in this connection that all the medium-sized pearl-shells, up to a diameter of seven or eight inches, were attached, in a similar manner as the young ones already described, by a strong byssus, or anchoring cable, to a supporting fulcrum, which consisted chiefly of the fragments of coral and shell, of which the sea bottom in this district is composed. The shells of larger size, nine or ten inches in diameter and of considerable weight, 5 or 6 lbs., were in all examples I examined devoid of a byssus, and rested simply on their ocean bed. A similar condition was observed, also, of several shells of the same size I personally collected at extreme low tide, on the Warrior and other outlying coral reefs. Such adult shells evidently require no cable to keep them anchored in the tideway, their own weight insuring their stability, which is in most instances further secured by the luxuriant growth upon their exposed upper shells, usually the right valve, of heavy madrepores and other corals, such as the well-known cup coral, *Turbinaria peltata*, and innumerable varieties of sponges, shells, sea-weeds, and other organic growths. Under such a combined weight it would be altogether impossible for the animal to move, and the question of their migratory habits previously suggested may, in face of the practical evidence now adduced, be most distinctly answered in the negative. Many young shells, corresponding in every essential point with those referred to as having been obtained from the bottom of the *Star of Peace*, were also found adhering to the adult individuals. These were saved alive, in company with a series of matured specimens, to form the subject of further investigation.

One of the most important objects of the expedition was to ascertain by direct experiment if it was possible to bring the pearl-shells in alive from the outer fishing-grounds, and to relay and cultivate them in the shallower inshore waters. The evidence hitherto adduced was not favourable to this proposed scheme, the majority of the witnesses interrogated maintaining that the shells would not survive removal from their native habitat, and that all attempts previously made to transport the shell had failed. In order to thoroughly test the matter, several distinct methods were now resorted to. Some fifty examples, varying in dimension from five or six to as much as ten inches in diameter, were placed at my disposal by the different boats. The majority of these specimens were immersed in two tubs of sea water on board the *Albatross*, the water being run off and renewed in them every three or four hours. At night, when the ship was usually at anchor, these shells were taken out of the tubs and placed in specially-constructed cages composed of wired netting stretched over rhomboidal wooden frames, this shape offering the least resistance to the current. The frames, with their contents, were then lowered overboard, and secured by a rope till the morning. A small number of specimens, some half a dozen only, were simply placed in a shady place on deck, sea water being thrown over them at intervals. With a third equally small series an experiment was put in practice, and identical with the method recently reported to have been attended with remarkable success in connection with the conservation of the American oyster for long periods out of water. This method, known as "muzzling," consists of fastening the shells so tightly together with wire that the contained liquids cannot escape. Thus treated, the oysters are said to survive several weeks' isolation from their native element. All the pearl-shells treated in the several manners described were brought into Thursday Island on the second day after their collection. Of the examples confined in tubs of sea water, renewed at intervals throughout the day and lowered overboard in frames at night, every specimen was preserved in health. Of the number simply placed in the shade on deck, sea water being occasionally thrown over them, one half only arrived in good condition, while the remaining half, being too exhausted to recover, fell a prey to crabs and predatory molluscs. A like untimely end befell all those examples on which the "muzzling" process had been practised. A subsequent study of the case last recorded showed that the mortality was brought about through the liquid draining away entirely from the animals through the byssal or pedal cleft, which retains its full development even in the adult shells in which a byssus is no longer present. A like explanation applies also, though in a less marked degree, to the specimens left on deck, and over which water was thrown at occasional intervals. The results of the foregoing experiments clearly demonstrate that the mother-of-pearl shell, while of a much more delicate constitution than the ordinary oyster, and very impatient of prolonged removal from its native element, might, with due care and under conditions corresponding with those to which the bulk of the specimens were submitted, viz., continued immersion in sea water, be easily transported in a living state from the outer fishing-grounds to any desired locality.

The next step taken was to ascertain the practicability of cultivating the pearl-shell brought from the outer fishing-grounds, having a depth of seven or eight fathoms, in the comparatively shallow inshore waters. With this object, some favourable-looking pools in the fringing coral reef, off Vivian Point, and immediately beneath the Government residence at Thursday Island, were selected. These pools, which were only exposed for a few hours during the lowest ebb of the spring tides, proved to be admirably adapted for the purpose. At all other times a strong current, which is one of the most essential elements of their healthy growth, swept over them. Corals of the genus *Madrepora*, which will flourish in the purest and swiftly-circulating water only, were growing freely in these pools, and the conditions generally coincided closely with those under which the pearl-shell was in former times abundantly and may even yet be occasionally gathered in its adult state. For greater security, and in order that they might be more readily accessible for examination at all tides, the forty adult and about an equal number of young specimens that had been brought in by the *Albatross* were placed in wire netting-covered frames, closely resembling those that have for some years been successfully employed by me for the culture of ordinary oysters. In these frames the shells were raised slightly from the surface of the ground, and at the same time remained covered by a few inches of water at even the lowest ebb of the tide. Examined at short intervals during the remaining period of my stay at Thursday Island, about six weeks, all the specimens were found not only to be doing well, but to be growing rapidly. By the end of this relatively short period some of the examples had added as much as half an inch to the free border of their shells, and in almost all instances lappet-like prolongations of new shell were produced throughout this region. A corresponding rapidity of growth was also observed of the young shells having a diameter of two or three inches only, and including both those acquired in connection with the *Albatross* expedition and the specimens previously obtained from the adjacent coral reef.

Several examples from the stock of pearl-shell accumulated were dissected for the purpose of preparing illustrations of the animal's anatomy, and others were sacrificed with the object of ascertaining the capacity possessed by the living animals of repairing their shells, and the time occupied in such process. The results obtained in these several directions tended to show that the growth and maturation of the pearl-shell is effected within a much shorter interval than has been hitherto suspected. By many of those practically associated with the pearl-shell fisheries a period of from ten to fifteen years has been variously assigned to the mollusc as the time required for the growth of its shell to a marketable condition. Until the species has been under cultivation or direct observation for a number of years, it will be impossible to accurately determine this important point. From the investigations recently conducted, and evidence otherwise collected, I am, however, inclined to anticipate that, under favourable conditions, a period not exceeding three years suffices for the shell to attain to the marketable size of eight or nine inches diameter, and that heavy shells of five or six pounds weight per pair may be the product of five years' growth. In connection with the experiments initiated in the direction of the artificial cultivation of the pearl-shell, it was my desire to make myself acquainted with the reproductive phenomena of the species, and of which up to that time no accurate information was available. In none of the specimens dissected, or in the more numerous examples opened in my presence on the shelling-grounds, however, were the reproductive organs in a mature state of development. From this circumstance, I am disposed to conjecture that the principle spawning season of the mollusc occurs at a time of the year differing from that of my recent visit to the Torres Straits, and most probably during the hotter season of the north-west monsoon. As evidence in support of this conclusion, it may be stated that some few of the specimens examined immediately before my return to Brisbane were found on dissection to have their reproductive organs in a more advanced condition of development than those investigated at an earlier date.

As a general result of the experiments and investigation so far conducted, added to the satisfactory intelligence recently received (December, 1889) concerning the condition of the pearl-shell that has been under cultivation at Thursday Island for over three months, the practicability of artificially transporting and cultivating this valuable mollusc is, I consider, fully assured. Suitable facilities being granted, in the form of leases of fore-shores and water areas similar to those conceded for the purposes of ordinary oyster culture, there is no reason, indeed, why all the available areas of the intertropical Australian coastline should not be utilised for the development of the newly-indicated branch of this pearl and pearl-shelling industry. The archipelago of islands in Torres Straits, with its numerous sheltered intervening channels, and including Thursday Island as a central station, no doubt offers the most favourable field for the prosecution of this industry. The neighbourhoods of Port Essington and Port Darwin, falling within the jurisdiction of South Australia, with which I am personally acquainted, are also eminently suited for pearl-shell cultivation. And the same may be said of the more sheltered areas of the north-western coastline of West Australia, a district which is already notable for its valuable pearl and pearl-shell fisheries.

It may be argued, in conclusion, that a scientifically-conducted system of artificial cultivation offers, as is the case with ordinary oysters, the only sure remedy against the reckless practice of over-fishing, and which has, not only in Australian waters, but in other quarters of the globe, ruined what were formerly the most prolific fisheries almost beyond redemption. Should the series of experiments and investigation recorded in this paper lead to the inauguration of the more scientific and permanently profitable development of the Australian pearl and pearl-shell fisheries, herein suggested, the author's object will have been accomplished.

11.—AN APPARENTLY NEW TYPE OF CESTODE SCOLEX.

By Professor W. A. Haswell, M.A., D.Sc.

12.—THE CLAIMS OF ARBORICULTURE AS A SCIENCE IN AUSTRALIA.

By W. Brown.

13.—AUSTRALIAN LICHENOLOGY.

By Rev. F. R. M. Wilson.

[*Abstract.*]

Australian lichenology begins with this century.

In 1791 M. Labillardiere accompanied Amiral d'Entrecasteaux in his expedition in search of La Pérouse, and, on returning to France, he published the results of his collection in his "Novæ Hollandiæ Plantarum Specimen," 1804. He gives description and drawings of one lichen from Cape Van Diemen, New Holland, which he named *Bæomyces reteporus*. Acharius calls it *Cenomyce retipora*, Syn. Meth., 1814. Acharius mentions only another lichen from New Holland, *Collema tremelloides*, var. *pichneum*, sent to him by Thunberg.

In 1802 Mr. Robert Brown accompanied Captain Flinders in his investigation of the coasts of New Holland; and of the lichens collected by him he gives a list of 58 species common to Australia and Europe, in Appendix 3 to "Flinders' Voyage to Terra Australis," 1814. Brown's collection lay in the British Museum for nearly 80 years, until Rev. Mr. Crombie revised it, and published the names of 73 lichens, inclusive of 12 new species described by him.—*Journ. Lin. Soc.*, Lond., 1880.

In 1817 M. Gaudichaud accompanied Amiral Freycinet in his expedition to the South Seas, and on returning to France published the results of his collection in the botanical part of Freycinet's "Voyage Autour du Monde." The lichens were determined by Persoon, and 4 of them were gathered in Australia.

In 1827 Sprengel's "Systema Vegetarum" mentions only 2 Australian lichens.

In 1838 Herr Ludovic Preiss, visiting Swan River, met there a botanical resident, James Drummond, who took Preiss through the neighbouring country. When he returned to Europe he submitted the lichens of his collection to Elias Fries, who enumerated, in the "Planta Preissianæ, or Enumeratio Plantarum," edited in 1847 by Christian Lehman, 23 lichens, inclusive of 2 described as new.

In 1839 Mr. Joseph D. Hooker accompanied Sir Jas. Clark Ross in his Antarctic expedition. On returning to England he drew up an account of the botany of the voyage. The 3rd and 4th vols. contain the "Flora Tasmaniæ," 1847, in which Messrs. Babington and Mitten enumerate 92 lichens, inclusive of 2 described as new. Mr. Hooker was assisted in the collection of these by seven persons, whose names he gives.

After Hooker's visit to Australia, Mr. Drummond sent to him from the Swan River, among other plants, a number of lichens, which were submitted to Messrs. Taylor, Montague, and Berkeley, and the names and descriptions were published in the *London Journal of Botany*, 1844-47.

In 1847 Dr. Ferd. Mueller, now Baron v. Mueller, came to Adelaide, and made collections in South Australia till 1852 and in Victoria during 1848. The lichens were sent to Dr. Hampe, who published their names and descriptions in Schechtendal's *Linnæa*. In 1852 Dr. Mueller was made Government Botanist in Victoria; and in his reports to the Victorian Council in 1854, and to the Assembly in 1858, he transcribed from the *Linnæa* a list of 31 Victorian lichens, and a list of 15.

Baron v. Mueller informs me that M. Verreaux, mentioned by Nylander as an Australian collector, came out to New South Wales at the expense of the Paris Museum, and that Mrs. Dietrich came to the same colony at the expense of Godefroy, of Hamburg, as a collector for his herbarium. Ludwig Leichardt collected a few lichens in New South Wales for the Melbourne Bot. Mus.

In 1858-1860 Nylander published his *Syn. Meth. Lich.*, in which he notices 77 Australian lichens. His works have revolutionised the study of lichenology, and necessitate revision of all lichens previously named.

In New South Wales Rev. Dr. W. Wools published, in 1867, in his "Contribution to the Flora of Australia," the names of fourteen lichens collected by him in New South Wales, chiefly near Parramatta. The names are not reliable.

"Der Reise der Oesterreichischen Fregatte *Novara*" was published at Vienna, 1870, in which Dr. Krempelhuber records four lichens collected by the *Novara* expedition from 1857 to 1860.

Dr. Chas. Knight, having made a collection of 52 lichens in the neighbourhood of Sydney, published their names, including descriptions of 40 new species, in the Trans. Lin. Soc., Lond., 1882. This is a most valuable contribution to the lichenology of New South Wales.

Specimens collected in the same colony by Messrs. Kirton, Wilcox, Bauerlen and White, and Mrs. Hodgkinson, for the Victorian Botanical Department, have been named by European specialists, and preserved in the Melbourne Bot. Mus. A few collected by myself, near Sydney and in the Blue Mountains, are enumerated in the Proc. Roy. Soc., Queensland, vol. vi. I have also named a few for Mr. A. G. Hamilton, of Mount Kembla, New South Wales.

In VICTORIA collections by Messrs. R. Wilhelmi, D. Sullivan, C. Walther, Merral, C. French, and Mrs. McCann, have been forwarded by B. v. Mueller to Europe, the earlier collections to Dr. Krempelhuber, who published the names of 122 in "Der Verhanlungen des Kais. Kæn. Zool. Botan. Gesellsch," Wien, 1880, whence a list of the names has been transcribed into *Frag. Phyt. Austral.*, xi. supplement; the later collections to Professor Jean Mueller, who revised Krempelhuber's determinations in the Ratisbon Flora, or Botanische Zeitung, 1887, and published the names of others, including descriptions of new species in the same journal, whence a list of the names has been transcribed into the *Victorian Naturalist*, 1887. J. Mueller's determinations are the most reliable and complete that we have of Australian lichens. Some Victorian lichens, collected by Mr. Hugh Paton, from Glasgow, along with some from Ball's herbarium, collected at the Macquarrie, were named by Dr. Stirton, and published in Proc. Roy. Soc. Vic., September, 1880. Collections by Miss F. M. Campbell, now Mrs. Martin, by Mr. F. Reader, and by myself, were determined by Dr. Chas. Knight. Latterly I have taken it upon me to name and describe a few out of the large number collected by myself; and lists of 237 species, with descriptions of 43 new ones, have been published in the *Victorian Naturalist*, October, 1887, June, 1888, August and September, 1889.

In SOUTH AUSTRALIA a few specimens are recorded in Fraser's *Phytologia Australiensis.* Messrs. J. G. O. Tepper, Batt, and Oliver have collected a few, the names of which appear in Trans. Roy. Soc. South Australia, vol. iv., v., vi. and ix. A few have been collected also by myself, one of which was new.

In QUEENSLAND Messrs. Hartmann, Sayer, Karston, Pentzke, and Persich gathered a number of lichens, among other plants, for the Victorian Bot. Dept., and they have been determined by Prof. J. Mueller. Mr. F. M. Bailey, the Government Botanist at Brisbane, and Messrs. Bowman, J. Keys, J. Shirley, Cosson and Mrs. Thozet have made collections, which have been examined by Dr. Stirton, Rev. W. Leighton, Dr. C. Knight, or Prof. Mueller. And with the help of my friend J. Shirley I have made a fair collection from the neighbourhood of Brisbane. Stirton's namings appear in the *Scottish Naturalist*, 1878, and in Proc. Roy. Soc. Victoria, 1880, and in Proc. Roy. Soc. Tasmania, 1880, from which latter they have been reprinted in *Frag. Phyt.*

Austral., xi. suppl. Knight's earlier namings appear in Proc. Roy. Soc. Qn., vol. i., in a paper by Mr. Bailey. The later appear in the synopsis of "Queensland Flora" and Sup. i. and ii. All the Queensland lichens hitherto named, numbering 485, are classified and described by Mr. J. Shirley in his "Queensland Flora," which appeared in Proc. Roy. Soc. Qn., vols. v. and vi., and has been lately published by him in a separate form. This is a most useful work, and will be found to be indispensable to the student of Queensland lichenology.

In Western Australia there have been, in late years, three collectors, Messrs. Moore, Webb and A. J. Campbell.

In Tasmania I do not know of any collections made since those of Hooker.

LITERATURE OF AUSTRALIAN LICHENOLOGY.

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P *in Melbourne Public Library.* B *in Brisbane Museum.*
M *in B. v. Mueller's Library.* ! *I have consulted.*

HERBARIA OF AUSTRALIAN LICHENS.

1. In Brown's collection in British Museum.
2. In Preiss' collection.
3. In Hampe's Lichenes Exsiccati.
4. In Melbourne Botan. Museum. !
5. In Krempelhuber's herbarium.
6. In Godefroy's herbarium at Hamburg.
7. In Ball's herbarium.
8. In Dr. Stirton's herbarium, Glasgow.
9. In Dr. Knight's herbarium, Wellington, N.Z.
10. In Prof. Mueller's herbarium, Geneva.
11. In Museum, Brisbane. !
12. In Museum, Paris.
13. Knight's N.S.W. collection in Kew Museum, England.
14. In Leighton's herbarium, Shrewsbury, England.
15. In Museum, Adelaide.
16. In Mrs. Martin's herbarium, Brighton, Vic. !
17. In Mr. Sullivan's herbarium, Moyston, Vic. !
18. In Mr. Hamilton's herbarium, Mount Kembla, N.S.W.
19. In Mr. Shirley's herbarium, S. Brisbane, Q.
20. In Rev. F. R. M. Wilson's herbarium, Kew. Vic. !

14.—DISEASES OF PLANTS.

By Mrs. Wm. Martin.

15.—DEMONSTRATION OF LIGHT PRODUCING BACTERIA WITH EXPLANATORY NOTES AND EXPERIMENTS.

By Oscar Katz, Ph.D.

16.—NOTE ON *DAVIESIA LATIFOLIA.*

By J. Bosisto, C.M.G.

[*Abstract.*]

This plant is a favourite remedy for low fevers and for expelling hydatid cysts among the settlers in those parts of Victoria where it is found growing. The plant, being in bloom during the present month (September), offered a favourable opportunity for examining its characters and constituents.

Daviesia latifolia is indigenous to Victoria; it belongs to the sub-order Papillionaceæ, of the extensive natural order Leguminosæ. It grows about 3 feet high on lands at the foot of the ranges and mountainous districts of Gippsland; the shrub is plentiful. The leaves strongly veined, in length from 1 to 2 inches, rising from the stem by a petiole half an inch long; the penduncles are axillary, solitary, and many-flowered; the latter are very minute, the outer part of the corolla being of a bright golden hue, and the inner part of a dark purple; the legumes are triangular in shape, each containing one or two seeds, bean-shape, small, and spotted purple and brown.

The whole plant is bitter, the leaves especially. On analysis, two active principles are obtained, one a crystalline body, the other an oleo-resin. The crystals now before this section are very bitter (Daviesine), minute and acicular, forming star-like groups; these, together with the oleo-resin, are now being further investigated. These active principles are destroyed if subjected to the temperature of the boiling-point of water.

Under these circumstances, should the therapeutic effect of *D. latifolia* undergo examination, it would be better to employ either the expressed juice of the plant or an infusion made at a temperature not exceeding 180° Fahr.

17.—NOTES ON NEW AND RARE SPECIES OF VICTORIA FUNGI.

By H. T. Tisdall, F.L.S.

18.—SOME NOTES UPON THE RARER SPECIES OF TASMANIAN EUCALYPTS, WITH SPECIAL REFERENCE TO A SUPPOSED NEW SPECIES.

By G. S. Perrin, F.L.S., Conservator of State Forests, Victoria.

[*Abstract.*]

The timber trees of Tasmania, and more particularly the eucalypts, are well and widely known. The famous blue-gum (*E. globulus*) has won the name of anti-fever tree, whilst its merits as an anti-malarial agent upon the Pontine Marshes, in Algiers, and in America are now acknowledged.

The next most important tree is *E. obliqua*, the "stringy-bark," which has outstripped *E. globulus* in commercial value. These two, with *E. amygdalina*, var *regnans*, the swamp-gum, and *E. sieberiana*, vie with each other in the extraordinary girth and height of the trunk.*

If we leave out the timber eucalypts of Tasmania the list of alpine or sub-alpine species becomes very restricted, and consist of the following :—

E. vernicosa.—Sub-alpine, very distinct. Small-leaved species, somewhat similar to the Alpine form of *E. gunnii*, Victoria. The former, however, has thick, fleshy leaves, ovate or semi-orbicular. Timber small, scrubby nature. Mountain tops.

E. cordata.—A somewhat rare and very interesting eucalypt, from the extreme beauty of its foliage and inflorescence. That this tree is not commonly found may be inferred from the fact that, although the author explored the greater portion of Tasmania during a two years' residence, and kept a special look out for this particular tree, he never had the good fortune to come across it. The specimen exhibited was sent from Hobart by Mr. F. Abbott, of the Botanic Gardens. It is, however, fair to state that the writer never visited that particular part of Mount Wellington where Messrs. Stephens and Abbott re-discovered the tree many years after Labillardière first brought it under the notice of the scientific world in 1806. In respect to its isolation and comparative rarity, this species is comparable to *E. alpina* in Victoria, and, like the latter, may doubtless be cultivated, and thus saved from utter extinction, as an ornamental plant for our parks and gardens.

E. cordata is of shrubby growth, its handsome glaucous foliage and rich golden-yellow stamens fringing the edge of the calyces at once arrest the eye, and also the rich colouration of its opposite, sessile, clasping, cordate, and broadly ovate leaves, in conjunction with the size and general beauty of its inflorescence.

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* A blue-gum measured by the author at Geeveston, Huon River, Tasmania, gave the length of 330 feet clear of top branches, having a diameter at the break of 16 inches. This was the highest tree seen and measured by the author in Tasmania.

Baron Sir F. von Mueller has on many occasions pointed out the rapid decadence or approaching extinction of many well-known forms of vegetable life, and in his late admirable presidential address again pointedly brought the subject under notice.

There is no doubt that, had it not been for the two gentlemen named above, *E. cordata* would have become extinct in Tasmania, as it is doubtful if it can now be found in the locality attributed to it by the celebrated botanist, Labillardière, in Recherchè Bay. Mr. Abbott is, however, cultivating the tree in the local Botanic Garden, and will thus save it from extinction and the bush fires, now, alas ! all too numerous upon the slopes of the once densely-timbered Mount Wellington.

E. cordata, in its extreme isolation, is in Tasmania analagous to *E. Alpina*, which is confined to the summit of Mount Williams in Victoria.

E. cordata was originally discovered by Labillardière in Recherchè Bay in 1806, and again, much later, on the banks of the Huon River by Sir J. D. Hooker, also by Robert Brown at the same place. Many years after, Messrs. Stephens and Abbott found it growing at Recherchè, Sandfly, Huon Road, and Norfolk Peninsula. It would appear to grow only in certain localities and its *habitat* is limited to a restricted area. From the fact that I personally never saw the tree growing in Tasmania, though I travelled down both banks of the Huon River for many miles, also down the coast line to the most southern point of Recherchè Bay and also on Norfolk Peninsula, and later on the Sandfly, all the time keeping a watchful eye on the eucalypts of the districts referred to, it seems to me that the tree is exceedingly restricted in the area of its growth, and could only be found by the merest chance. It is, I think, evident that the tree is not as abundant as it was formerly, also that a tree reported to Baron von Mueller by Mr. Coombs as *E. cordata* should more properly be referred to *E. urnigera*, of which a specimen is exhibited. The latter is common, and grows to a large size on Mount Wellington, where I noted it as growing 60 or 70 feet high, with red wood not unlike Jarrah (*E. marginata*). Such an error is quite possible in the face of the fact that Bentham chronicled in *Flora Australiensis*, Oldfield's opinion, that *E. cordata* was the young state of *E. obliqua*. These two trees, we now well know, are quite dissimilar in every way.

E. cordata, it will be noticed, has its leaves sessile, opposite, orbicular, cordate, and slightly crenulated, and *always clasping* at the base. The disposition of the seed vessels is primarily in 3's, rarely in 4's, flowers axillary, sometimes terminal, stalks sometimes angular, stalklets none.

From the Baron's description it will be noted that the leaves of *E. cordata* are *not connate*. This peculiar perfoliate or junction of opposite leaves is not uncommon to several of our eucalypts in the young state, the most important of these being *E. perfoliata* (North-western Australia), *E. risdoni* (Tasmania), *E. sideroxylon* (Ironbark, Victoria), *E. uncinata* and *E. gamophylla* (North and Central Australia). The latter, indeed, somewhat resembles *E. risdoni* in the lanceolar semi-elliptical to half-ovate, or sometimes almost cordate, shape of the leaves.

I have now very much pleasure in directing attention specially to two exhibits. These are—First, *E. risdoni*, a fine specimen, with perfoliate or *connate* leaves; with this specimen I am enabled to point out that *E. risdoni* in its more matured state is *never perfoliate*; its seed vessels are large. Specimen No. 2 is a very singular one, and it is to this that I wish to draw your attention. It is, as you may see, a small sub-alpine eucalypt, with *perfoliate leaves.* These being connate, or joined together, would seem to refer it to *E. risdoni*, but on comparing the two specimens shown it is at once seen that they are not at all allied, even in the young state, *E. risdoni* showing a dark thick leaf, with a strong tendency to become lanceolate. No. 2 specimen, on the other hand, partakes more of the characteristics of *E. cordata*, but differs from it in the fact that the leaves of the latter are distinctly and *invariably* clasping at the base, whereas the former is *always* perfoliate in young or old specimens. *E. risdoni* rarely or never retains the connate character of the leaves in its more advanced state, and herein lies a most important difference, and gives the assumption that the stranger is a new species. The veins are spreading, the marginal vein being removed from the edge, which is slightly crenulated and recurved. It is invariably found in a low, shrubby state, only a few feet high, in wet, marshy table-lands of high altitude. From dried specimens; showing the buds only, the disposition of the seed-vessels are in 3's. The specimen in question was obtained about 10 miles from Parattah, on the main-line railway. It flowers in or about the month of March, and grows readily in water. The specimen in question grew well in the Exhibition Building and flowered there, but, unfortunately, they were destroyed by some passing visitor. The seed vessels are very small, about a line to a line and a half in diameter. From the perfoliate character of the specimen *(E. risdoni)* on the table, it is probably an Alpine form of this well-known tree, so numerous at Risdon, on the Derwent.

The specimen No. 2 is quite distinct from *E. cordata*, in the size of the seed-vessels and also in the shape of them. I regret I have none to show at present, but I saw two on the plant when in the Exhibition. The shape of the leaves is different to that of *E. cordata*, being more orbicular, it differs also in the *connate* character of the foliage, though the venation is somewhat similar.

As I have specimens of all the trees named in this paper, it is easy to note the different characteristics of the specimens shown, and I am of opinion that the new claimant to notice will be found to be a new species.

19.—ON THE PUBLICATION OF A CRITICAL LIST OF THE AUSTRALIAN FAUNA AND FLORA.

By Chas. T. Musson.

20.—VEGETABLE FOOD STUFFS OF THE AUSTRALIAN ABORIGINES.

By J. H. Maiden, F.L.S.

21.—SOME REMARKABLE AGREEMENTS BETWEEN SCIENCE AND AGRICULTURAL PRACTICE.

By G. W. Brown.

22.—THE GEOGRAPHICAL DISTRIBUTION OF LAND AND FRESH WATER VERTEBRATES IN VICTORIA.

By A. H. S. Lucas, M.A., B.Sc.

Section E.

GEOGRAPHY.

President of the Section: W. H. Miskin, Esq., F.E.S.

1.—SOME PHYSICAL PHENOMENA OF THE SOUTH PACIFIC ISLANDS.

By Rev. Samuel Ella.

When asked by your secretary to prepare a paper for the geographical section of your association, I felt some hesitation in undertaking the work, as I can lay no claim to being a geographer, nor, indeed, a scientist that could offer you anything worthy of your acceptance at your annual gathering. Yet, certain physical phenomena which have impressed me during forty years' acquaintance with some of the South Pacific islands, I concluded would not be void of interest to your section; and a narrative of my experience and observation, though failing in a constructive character, might become suggestive or illustrative to some more familiar with theories of physical geography than I am. Geographical science, indeed, is one not founded on theories and hypotheses, but upon established facts, and things as absolutely existing. We are, therefore, dependent on voyagers, travellers, and residents in the Pacific Islands for our knowledge of these regions. In many of these islands, little known to the civilised world, the Christian missionary and intelligent residents can afford much valuable and acceptable information; and it is very desirable that they should recognise this fact, and carefully note and communicate the knowledge they acquire.

For a long period very little was known regarding the Pacific islands, and all correct information to be obtained must have been particularly interesting to Australians. Until a comparatively recent date unaccountable apathy was shown in the matter of maritime surveys in the Pacifie. The famous American Exploring Expedition, under Commodore Wilkes, in 1838-42, was the first extensive effort made for a thorough survey of that part of the ocean which had attracted the enterprise of American whalers. This was followed up by further surveys on the part of the British, by H.M.S. *Herald*, Capt. Denham, in Fiji and the

New Hebrides, and recently these have been succeeded by more effective operations by means of the Australian fleet. Although the French have possessions east and west, very little has been done by them to extend the knowledge already acquired. Only within the last month or two we have received intelligence of the loss of a valuable vessel and cargo near the island of Rakaanga, by running on to a shoal not marked on any existing chart. Some difficulty and confusion have also arisen through various names being given to the same place. Hydrographers and mariners have attached an arbitrary nomenclature of their own, and have not taken any trouble to ascertain the right name, which might have been done by recognising the native name, which is generally euphonious and expressive.

(1).—Volcanoes.

It is generally understood that the origin of many of the Pacific Islands is volcanic; indeed, it is apparent that the coral islands also are constructed on a volcanic base. Darwin affirms, "It is a remarkable fact that all the many small islands lying far from any continent in the Pacific, Indian, and Atlantic Oceans, with the exception of the Seychelles and this little point of rock (St. Paul's), are, I believe, composed either of coral or of erupted matter. The volcanic nature of these oceanic islands is evidently an extension of that law, and the effect of those same causes, whether chemical or mechanical, from which it results that a vast majority of the volcanoes now in action stand either near sea coasts or as islands in the midst of the sea."—*Journal of Researches*, chap. i. On the Sandwich Islands and the New Hebrides Group, in New Zealand, and some other islands, active volcanoes and geysers still exist. In Samoa, some thirty years ago, there still survived old natives who could speak of the volcano they had seen in operation on the large island of Savaii, in a district still bearing the name of *Le Mu* (the burning), in the interior north-west of Savaii. The ground there remains barren, and is covered with lava, tuff, and scoriæ. On the island of Upolu there are two remarkable volcanic mountains, very high and conical. One of these is in the centre of the Aana district, called Tafua, on the top of which is an extinct crater, very deep, and containing a lake, which possesses an underground aqueduct running for three or four miles, and debouching from a cavern about a mile from the shore, and thence flowing in a river to the sea, distinct from two streams, which are fed from the exterior watershed of the mountain, and reach the sea on each side of the Aana district. Massive rocks, volcanic tufa, and ridges of cellular lava along the shore, and in various tracks from the mountain side, show how extensive an eruption must have taken place here. In some parts black, rugged lava rocks form an iron-bound coast and in other places similar hardened lava streams, like molten metal, crop up along the shore, or lie buried in the sand within the lagoon.

The small island of Aporima, situated between Upolu and Savaii, is also an unmistakable crater. It rises precipitously from the sea on three sides, with a narrow chasm on the north side, forming the entrance to the island, very difficult of access, except in favourable weather. At one time Aporima was an impregnable fortress to the people of Manono—an adjacent island—and gave them preponderating influence in time of war; even now it might be converted into a small Gibraltar. It possesses a pleasant spring of water, while Manono, the larger island, is destitute of fresh water. An ancient legend states that this spring formerly existed on Manono, but Mafuïé, the god of earthquakes, being angry with the Manonoans, took it away from them, and transferred it to Aporima. This may indicate an earthquake disturbance at some distant period.

A Submarine Volcano.—On 12th September, 1866, the people of Tau and Olosenga, the eastern islands of Samoa, were alarmed by the appearance of a submarine volcano, which burst forth between the two islands. The Rev. Dr. Turner thus described the event in an article supplied to the *Sydney Morning Herald*:—"On the 7th of September, 1866, the natives of Tau and Olosenga were surprised by an unusual succession of earthquakes. There were three or four in the course of an hour. On the night of the 9th there were 39 shocks in all. The motion at first was but a slight tremulous agitation, but its continuance, and the addition of an unusual 'subterranean groaning,' as the natives called it, alarmed everyone. On the 12th, a little after noon, a commotion was observed in the deep blue sea, about two miles from Olosenga and three from Tau. It appeared like the surf breaking on a sunken rock. Some thought it might be a whale blowing, others that it was a great shoal of fish. This continued all day. By break of day on the 13th volcanic action was unmistakable. At first the eruptions were at intervals of about an hour. They went on increasing till the 15th, when they were fifty in an hour; and then for three days there was one continued succession of outbursts. The natives looked on in amazement at the great jets of mud and dense columns of other volcanic matter rising in terrific grandeur as high, it is said, as Matafao, a mountain of Tutuila. That would be 2000 feet or more. They then branched out into clouds of dust, which blackened the sky, and covered up Olosenga from the sight of the people on Tau. The roar of the eruptions and the collision and crash of the masses of rock, met in their downward course by others flying up, were fearful. Quantities of fused obsidian, too, threw off fragments, which shone and sparkled in the sunshine with indescribable beauty. No flame appeared. Only once or twice was there a gleam of fire in the matter thrown up. The sea was most violently agitated in a great circular basin half a mile in diameter; and after a time there was a slight sulphurous tinge in the ocean for miles away. Heaps of dead fish were washed ashore on Tau and Olosenga, and among them deep sea monsters, six and twelve feet long, which the natives never saw before, and for which they have no name. The sulphurous vapours, heat, smoke, and ashes soon made the settlement in Olosenga unbearable, and the natives fled to a place on the south side of the island. A slight tremulous motion continued to be felt on the land, but no fissures opened, nor did any hot springs make their appearance. The ordinary springs of fresh water were unaffected. After three days the activity of the volcano began to abate, and two months afterwards there were only three or four eruptions in the course of a day, and the height to which the matter was thrown up was reduced to 30 or 40 feet above the level of the sea." The action ceased on 29th November, but burst out again the following January like a great spring of water, accompanied by seismic tremors on the islands. This continued till March, when it ceased altogether. The captain of H.M.S. *Falcon* was directed to survey that part of the ocean. Nothing was apparent to the sight, but, on soundings being taken, a cone was discovered at 91 fathoms, and the surrounding soundings gave 120 fathoms and upwards.

In the New Hebrides Group there are still some active volcanoes. A notable one exists on the island of Tanna. It is described by Captain Cook, who witnessed it in August, 1774. Formerly the eruptions were very powerful, and would vomit forth great stones and masses of scoriæ with loud reports. It has lately become more quiet, and the discharges are much subdued, though continually giving forth columns of smoke and eruptive matter, and emitting a bright light, which may be seen for a considerable distance, and lava flows down its side. In the neighbourhood of this volcano there is a sulphur lake, which once supplied large quantities of crude sulphur to shippers. Around the active crater are found several extinct craters and hot sulphurous springs, very strongly impregnated. These latter are used medicinally by the natives, and sometimes for an evil purpose by the women. Volcanic dust and sulphur are borne in the air for several miles. Obsidian is found near the volcano, and also a stone resembling the nephrite of New Zealand. The soil of Tanna is remarkably rich and fertile, black alluvial, and mixed with decomposed trap. On the island of Ambrym there were till lately two volcanoes, the larger of which is 3500 feet high. It has recently become inactive, while the eruption of the smaller, on the opposite side of the island, has increased in power. The small island of Tangoa, north of Faté, possesses a crater partially extinct. It now emits only hot mud and steam. In some places the ground is hot enough to enable the natives to cook their food, by burying it in the earth. On the small high islands of Lopevi and Paamu* there are active volcanos. In 1881 a submarine volcano broke forth near Traitor's Head, Erromanga.

In the Banks' Islands, north of the New Hebrides, active volcanoes and hot springs and other igneous formations exist.

(2).—Earthquakes.

The South Pacific islands are subject to frequent earthquakes, of more or less magnitude. The oscillations are sometimes very severe, but more generally of slight character. Earthquakes are not confined to the volcanic islands, but are experienced also on islands of coral formation, which have a volcanic base. The seismic wave is seldom vertical, but chiefly horizontal, generally (as far as can be perceived) from north-east to south-west. I have only on one occasion remarked any rumbling sound or other accompanying noise often noticed in many volcanic regions. Where active volcanoes exist the shocks are often accompanied or followed by an increased outburst of the volcano. There is no active volcano now in the Samoan Group, though earthquakes are very frequent. As before remarked, at the early part of the present century there existed a volcano on the northern island of Savaii, which occasionally became eruptive. There are several extinct craters in the mountains of Upolu and Tutuila as well as on Savaii.

The testimony of the old natives is that the shocks of earthquakes were much more severe in olden times. The reason assigned for the present change was that the god of volcanoes and earthquakes, named Mafuïé, had his arm broken in a contest with a young warrior, since which time he has been able to shake the earth with one arm only, and hence the shocks are comparatively light. It may be interesting to the lovers of folk-lore to know the legend as related. It denotes also how the connection of volcanic actions and earthquakes is associated in the minds of the natives. The legend states that a certain chief and warrior, named Talanga, was a favourite of the god Mafuïé, the Samoan Vulcan. This god's abode was in the crater of a volcano. Talanga was admitted to the regions of Mafuïé, and here he worked a valuable plantation of taro (*arum esculentum*), whence Talanga would take home to his family very choice taro, which excited not only the admiration of his family, but also their curiosity to know whence it came. His son, Tiitii, determined to find out the secret, and one day stole quietly after his father when he went to the plantation. He saw him ascend a mountain until he came to a great rock, which seemed to stop further advance; but

* Between Ambrym and Api.

Talanga went up to the rock, and cried, "Rock, rock, divide! I am Talanga, come to work my plantation." Immediately the rock divided in the centre, and Talanga entered. The son, Tiitii, in like manner approached the rock, and feigned his father's voice with the same "Open, sesame," and obtained admittance to the land of Mafuïé. He found his father at work in his secret plantation. His father started up on seeing his son there, and warned him of his proximity to danger, and begged him not to talk aloud, lest Mafuïé should hear him and be angry. Looking around on the new scene before him, Tiitii discovered a column of smoke, and asked his father what it was. His father told him it was the fire of Mafuïé. "I must go and get some," said Tiitii. "Don't," replied Talanga, "he will be angry and devour you." "I am not afraid," said the son; and off he went in wild bravado, singing a war-song, and descended the crater. Mafuïé rushed out upon the young fellow, exclaiming, "Who are you? What do you want here?" "I am Tiitii, son of Talanga, and I am come for some fire to cook our taro." "Take it, and begone," shouted Mafuïé. Highly delighted with the success of his exploit, Tiitii returned to his father with some burning cinders. They then quickly made an oven (an easy matter for natives), and were about to place the taro in it when the oven blew up, put out the fire, and scattered the stones about. Talanga reproved his son for his temerity; but Tiitii, nothing daunted, ran back in a rage to Mafuïé and abused him, exclaiming, "Why have you broken up our oven, and put out the fire?" Mafuïé then flew into a passion, and rushed out upon Tiitii, and wrestled with him.* Tiitii caught Mafuïé by the right arm, and wrenched it off. He then seized the other, and would have twisted it off also, but Mafuïé acknowledged his defeat, and begged Tiitii to spare his left arm. "I need it," he said, "to hold Samoa level. If you leave me my left arm," he promised, "you shall have fire, and you may always enjoy cooked food." This was agreed to, and Mafuïé said, "Go now, you will obtain fire in every wood you cut." Since then, the story adds, the Samoans have readily obtained fire by rubbing one piece of wood against another, and also that Mafuïé has since only been able to give slight shakes to Samoa, by means of a long-handled lever, which he works with one hand in his subterranean regions. This legend exists also in Tonga and Savage Island (Niué) in somewhat modified forms.

Among the records of earthquakes which occurred during my residence in Samoa, the most remarkable are those which took place at the close of 1850, from the 26h September to the 29th December. There were seven shocks during that period. On 26th September, at 9.15 p.m., a single sharp shock, followed by

* Wrestling matches were favourite sports with the natives. I often met a Samoan whose right arm was withered, it having been wrenched from its socket, and the ligature broken in such a bout.

horizontal tremors; 28th October, about noon, a slight single shock; 9th November, at 6.10 p.m., double shock, the second sharper and of longer duration than the first; this was succeeded by another shock, slight, at 11 p.m. 28th December, at midnight, a single sharp shock; 29th December, 7.45 p.m., shock slight, single. These successive visitations are seldom so frequent. An earthquake of more than usual severity in Samoa was experienced on 22nd February, '61, at a quarter to 3 p.m. The shock was double, the second tremor of great force. The following day two shocks were felt: at 2.20 a.m., sharp, severe; 4.15 p.m., slighter.

A peculiarity regarding the recurrence of earthquakes in Samoa is worthy of notice, for it is difficult to assign a reason for the phenomenon; the visitation of an earthquake is often succeeded by another in about a fortnight. The shocks are simultaneous on the islands of Upolu, Savaii, Manono, Aporima, and Tutuila, though these islands lie at some distance from each other. Last September severe seismic tremors were felt in Samoa, causing great alarm. They lasted for three minutes. Buildings trembled violently, and trees swayed as in a gale. Ships at anchor in the harbour of Apia rocked to an alarming extent, and dragged their anchors, although the sea seemed perfectly calm. Since then, news from Apia state that the tremors have been so frequent and forcible that some of the residents were apprehensive that extinct volcanoes were again about to become eruptive.

Earthquakes are experienced on New Caledonia and in the neighbouring Loyalty Group. They are neither so frequent nor so severe as in Samoa. New Caledonia is of volcanic origin, and possesses a chain of volcanic mountains and hummocks on the coast. There is no active volcano now, and very slight trace of any having existed for some ages past, though the contour of the country presents unmistakable evidences of volcanic operations in the distant past. Mount D'Or, at the back of Nouméa, shows many volcanic features. The Isle of Pines is situated at the south of New Caledonia, and is of similar conformation.

The Loyalty Group is composed of coral Islands, raised upon a volcanic base, connected with New Caledonia and the Isle of Pines. They are situated on the south-eastern side of New Caledonia, running parallel with it, from 35 to 60 miles from that island. Earthquakes are simultaneously felt on the Loyalty Group, New Caledonia, and the Isle of Pines, denoting a common base. New Caledonia is surrounded by an extensive lagoon, enclosed by a coral reef from half a mile to two or three miles from the mainland, and extending still further at the north end. Here and there islets are formed on the reef and plentifully interspersed within the lagoon. Uvéa (or Iai), the most northern of the Loyalty Group, is a lagoon island (or rather islands), the inhabited part of which is composed of three islands, running from north to south, and separated from each other by narrow channels. These form one side of a circular lagoon, which stretches out westward for fifteen miles, and is enclosed by a reef and numerous islets, broken by three navigable channels in the south, south-west, and northern divisions. The deepest part of the lagoon is not more than four fathoms. There are traces of an upheaval of the Loyalty Islands at three periods. Three distinct water-lines may be discerned on the coast of each island of nearly equal heights, in the northern island of Uvéa, on the southern island of Maré, and also upon Lifu, lying between these two. There is not a great difference in the height of these several islands on the seaboard, about 150 feet. The centre of Lifu is higher than any other part, and in several places high coral cliffs exist at a considerable distance from the shore, probably denoting that that part of the island was of earlier formation than the lower land on the coast. It is also evident that the island of Iai at one period was merely an atoll; for, running through its centre are lakes, lagoons, and low marsh-lands, which probably supply the place of the lagoon of the atoll. Great changes have evidently taken place in the group from seismic disturbances.

The most alarming series of earthquakes I experienced in the Loyalty Islands occurred in March, 1875. This was accompanied by a disastrous tidal wave, causing serious destruction of property and loss of life, on the neighbouring islands of Lifu. The tremors were the most severe and frequent of any I had ever felt, and the natives said they never before knew anything like it. The first shock came at midnight of Sunday; a second tremor was felt at 3.15 a.m. on Monday; and a third shock at 6.30 a.m.; a fourth at 7.10 a.m.; and a fifth about an hour afterwards. On Tuesday forenoon there were two slight tremors, a sharp shock at 3.30 p.m., and a very severe continuous tremor at 8.30 p.m., similar in force to that on Sunday midnight. The following evening, at a quarter to 6, there was another slight tremor, and a little after 10 a.m. on Friday there was a similar oscillation. I noted the time on Uvéa, and found they were simultaneously felt on the other islands of the group and on New Caledonia. This continued succession of tremors was quite phenomenal, and the cause is difficult to define. It was supposed to have arisen from some unusual outbursts on the volcanic islands of the New Hebrides.

Of late years very great changes have taken place in the New Hebrides from earthquakes and palpable upheavals on some of the islands. Port Resolution, Tanna, which formerly was a secure anchorage for vessels of large burthen, has lately become quite shallow, except at the mouth of the bay. The Bay of Pango, Faté (Sandwich Islands), has also quite changed in character. Where vessels could formerly anchor the water is too shallow now for such a purpose. The volcano on Tanna, although still active, has become less eruptive. On the island of Ambrym, also, a great change has occurred, as previously noticed, and the larger volcano is extinct, but the smaller one, on the other side of the island, has become more active. On the hill side of Dillon's Bay, Erromanga, I was struck by the peculiar geological formation; interspersed with basaltic and lava rocks. I observed here and there blocks of coral, indicating that, at some period, that part of the land had been below the sea. Along the shore, outside the bay, high cavernous cliffs are seen. These are of coral and volcanic formation, and must at one time have been below the sea, for coral polypes do not work above high-water mark.

(3).—The Tides.

A remarkable phenomenon in respect to the tides of the Pacific has been observed from the time of the earliest settlement in the Windwards and Society Islands, viz., the singular deviation from the universal rule of tides being governed by lunar and solar attractions. In this part of the Pacific high-water occurs about noon and at midnight, and the rise is very limited—not exceeding fifteen or eighteen inches. The ebb tides occur correspondingly at about 6 o'clock in the morning and 6 in the evening. Regarding this phenomenon, the Rev. Mr. Nott, one of the earliest missionaries at Tahiti, wrote in 1834:—"From what I have observed during a long residence here, the rise of the tide is seldom more than a foot or fifteen inches, and there is no difference between what is called the neap and the spring tides; or, in other words, there is no difference in the tides at Tahiti, whether it be the full or change of the moon, half-moon, or quarter. There is, however, sometimes a higher sea about the change of the moon, because a change of the wind then frequently, but not always, happens. Nevertheless, the higher sea is not a higher tide, but it is owing to the change of the wind, or some great commotion at a distance, and never lasts more than four or five days, during which time the tides continue as usual, namely, high or full tide about noon (or from 12 to 1 in the day) and about 12 at night, and ebb tide about 6 o'clock in the morning, and about the same hour in the evening. This is uniformly the time of full and ebb tides at Tahiti. . . . . At the islands of Tubuai and Raivavai the tide is much greater than at Tahiti, rising about two feet and a half." (Tyerman and Bennet's *Voyage Round the World*, p. viii.) Other missionaries, his contemporaries, confirm these remarks of Mr. Nott; one of these, the Rev. D. Darling, whose station was at Bunaauia, at the western side of Tahiti, adds—"That the natives can always tell when it is midnight by going to the seashore." Captain Cook remarked this peculiarity in the Georgian and Society Islands, but his editor falls into an error by supposing that this fixed time of the ebb and flow of the tides and the limited rise prevailed in the other islands of the Pacific. In a note in the *Voyages*, speaking of the Friendly Islands, he said, "At these islands the tides are more considerable than at any other of Captain Cook's discoveries in this ocean—that are situated within either tropics. At Annamooka it is high-water near 6 o'clock on the full and change of the moon, and the tide rises and falls about six feet upon a perpendicular. In the harbour of Tongataboo the tide rises and falls four feet and a half at the quadratures." (*Cook's Voyages*, fol. ed. p. 470). The Rev. Mr. Ellis, a missionary who spent some years in the Sandwich and Society Islands, falls into a similar mistake. In his *Polynesian Researches*, he says, "Among the natural phenomena of the South Sea islands, the tide is one of the most singular, and presents as great an exception to the theory of Sir Isaac Newton as is to be met with in any part of the world. The rising and falling of the waters of the ocean appear, if influenced at all, to be so in a small degree only, by the moon. The height to which the water rises varies but a few inches during the whole year, and at no time is it elevated more than a foot, or a foot and a half." (Vol. 4, p. 28). The writer on the subject of "Waves," in the *Penny Cyclopædia*, speaking of the tide-wave in the Pacific, says, "In the Pacific Ocean the general direction of the tide-wave is from east to west; but the heights of the tides are small, not exceeding two feet at the islands of the South Sea. It is observed, however, by Mr. Whewell (*Phil. Trans.*, 1833) that this must not be understood to be the tide which would be raised if the whole earth were covered with water, on account of the modifications produced by the form of the continent of South America. The most eastern part of New South Wales,* between 25 deg. and 30 deg. south lat., has the high-tide earlier than points which are situated towards the north or south of that tract. Peculiarities in tides, arising from the interference of waves, occur in many different places. In the middle of the North Sea there is supposed to be a considerable space, within which the tide produced by the waves coming from the north and south takes place at one time. And Mr. Whewell states, on the authority of Captain Hewett, that about the Ower Shoal there is no sensible rise of the tide till three hours after the time of low water; but, when the ebb-stream has nearly ceased, there is a sudden rise of five or six feet, so that nearly the whole rise of the tide occurs in the last three hours." This writer has repeated the misleading statement that the phenomenon noticed in the eastern islands is the rule throughout the Pacific. Such is far from being the case, and the oscillations of the tide-wave in all the other islands I find are governed by the lunar and solar influences as

* Formerly; now north of New South Wales and south of Queensland.

in other parts of the world. In Samoa and the adjacent groups the difference of ebb and flow is from five to six feet. At the Marquesas the rise of the tide seldom exceeds two feet, but that group is in the vicinity of Tahiti—about 600 miles to the north-east.

I am not acquainted with the views of modern hydrographers respecting this phenomenon. It is a question which arouses inquiry, and offers an interesting subject for investigation. What are the disturbing influences which thus interrupt the wave-tide in this part of the Pacific? and why are the times of ebb and flow so fixed at 6 and 12 o'clock in the day and night? The late Rev. W. Mills, a scientific missionary of Samoa, diffidently ventured many years ago a few ideas with regard to the elucidation of the matter—not, however, as a decision, but by way of suggestion. He remarked, "When others have contented themselves in merely giving their observations, without attempting to account for the diversity, I can hardly venture a single suggestion to solve the difficulty. If Professor Whewell's Map of Co-tidal Lines be correct, the tide travels, on the western coast of America, from north to south, between Acapulco and the Straits of Magellan; while from the former it travels northward and westward. The first, most likely, moves south until it meets with the great tidal oscillation, which proceeds with great rapidity in a westerly direction, round Cape Horn. There is, then, no difficulty in conceiving that between these two great tidal waves, running in an ellipsis to the westward, the Society Islands are left in the intervening space, or what a Scotchman would call a 'strath,' unaffected by either of these waves, but still subject to the solar oscillation, which may form apart from that of the lunar. The tide-wave on the north will be inclined to the south according to the moon's excursions in declination, or southing; and this may account for the diversity at times of high-water being frequently an hour before or after noon, just as the base of the lunar wave may advance more or less to the south, by the moon's declination and parallax."—(*Samoan Reporter*, September, 1852.)

(4).—Tidal Waves.

Another striking phenomenon in the Pacific connected with the rising of the ocean, and one of tremendous power, often producing terribly destructive effects, is the tidal wave, caused by the oscillation of earthquakes producing a similar oscillation of the ocean. Tidal waves arise as suddenly and unexpectedly as the visitation of earthquakes, and often overwhelm districts and engulph the inhabitants without a moment's warning, and cut off all means of escape. During my residence in Samoa and the Loyalty Islands, I have occasionally witnessed this alarming visitation. The first occurred in Samoa on 29th September, 1849, about 9 o'clock in the morning. At that hour the sea suddenly receded from the shore at a rapid rate, and continued to fall till the reef was left quite bare, and the surface standing about eighteen inches out of the water. In about three minutes the sea returned and rose to half-tide, thus making the fall and rise to about five feet. Immediately the sea again receded, and flowed back to its proper height. Then the sudden rise and fall were repeated three times within an hour. The oscillation continued between 11 a.m. and noon; and after this the tide rose in its normal state. About half-ebb, between 3 and 4 p.m., the sea suddenly rose again, and flowed to the shore above high-water mark, and ebbed quietly to its former position; and then again arose to high-water, and continued oscillating till a quarter past 4 p.m. The sea then resumed ebbing in its ordinary manner. There were no earth-tremors perceptible in Samoa, and the wind was moderate. Similar oscillations were noticed at the same time on Aneityum, New Hebrides, 1300 miles distant.

The next recurrence of a tidal wave in Samoa was witnessed in 1863. It was not so continuous, but of larger magnitude, in many places overflowing the shore, and doing considerable damage. Being absent from Samoa at the time, I have no particulars of the event.

A terrible catastrophe of this kind occurred on the north-east side of Lifu, Loyalty Islands, on Sunday night, 28th March, 1875. Twenty-six lives were sacrificed, chiefly of women and young children. Nothing more serious was felt in the neighbouring islands of Maré and Uvea beyond the repeated succession of earth-tremors already described. On Lifu the tidal wave rose more than twelve feet above the shore, and swept over the land, bearing down with irresistible force everything within its impetuous course. In an instant all the native houses within its reach were hurled into a mass of ruins, whirling hither and thither where the swirling waves bore them. The unfortunate natives were hardly aroused from sleep by a sharp shock of earthquake when the sea burst upon them, and they were buried under their fallen houses, and swept they knew not whither. In some of the low-lying villages along the shore scarcely a house was left standing, and the land and beach were strewn with ruins. The taro patches in marsh-lands in the hollows were covered with boxes, articles of furniture, implements, and *débris* of fallen houses, &c. When the sea subsided, heaps of fishes and turtles were found along the coast, and even far inland. Several remarkable and narrow escapes were experienced. Some of the poor natives managed to extricate themselves from the ruins of their huts, and to cling to the cocoanut trees against which they were hurled by the rush of the sea. One hut, with its inmates, was carried out to sea by the receding wave. A lad got clear of the ruins, and swam to a cutter that was also being borne out to sea; the next minute the wave returned and swept the cutter ashore, and stranded it on the ruins of the store of its owner. An infant was found entangled in its bed clothes in the branches of a tree, about twelve feet above the ground. A cutter was sailing by at the time of the ocean's irruption, and the mate was alarmed by finding the vessel close to the reef when he thought they were three miles off. He gave orders to put the vessel about, but before this could be done he saw they were fast drifting away from the threatening danger. In addition to the twenty-six who lost their lives, many others were injured by blows from the falling houses, and by being dashed against the trees, &c. Large coral rocks that formerly stood in the lagoon were swept up on to the beach, and big trees also, not belonging to the group, were afterwards found stranded on the rocks and shore. These had probably been carried from the New Hebrides or other northern islands.

(5).—Hurricanes and Cyclones.

During seven months of the year, from April to October inclusive, the ordinary trade wind prevails. Near the equator* this wind is east-south-east, but higher up, near the temperate zone, they are a little more southerly. Mariners aver that of late trade winds have proved very irregular. This may be a mere supposition. They commence about 9 o'clock a.m., and continue till 5 p.m., generally with greater force about 2 p.m. They are strongest in the vicinity of large islands and groups, on account of the greater rarefaction of the atmosphere in those regions and the more abundant evaporation occasioned by mountainous lands. This variation I have remarked during my experience in Samoa, the New Hebrides, and the Loyalty Islands. After sundown a gentle land breeze is felt near the coast of the larger islands, and this in Samoa is surcharged with moisture, causing an appreciable fall in the barometer, and thermometer likewise, especially in the middle of the year.

As the sun reaches the summer solstice the monsoon season begins, and the winds become very variable, often accompanied with heavy rain and thunderstorms, gales, hurricanes, and calms. The wind now blows frequently from the north and north-west, strongest from January to March. Hurricanes and cyclones, of more or less magnitude, occur during these months, particularly the last, to which the islands situated between 10 deg. and 24 deg. are mostly exposed, especially those lying between 15 deg. and 24 deg., as frequently experienced in the New Hebrides and Hervey Groups. The Georgian and Society Islands, in the east, and New Caledonia, in the west, though within the belt, escape the destructive influence of the cyclones; probably the vicinity of the American continent on the one hand, and Australia on the

* For three or four degrees on each side of the equator the trade winds are rarely met with.

other, presents some deflective forces which cause a divergence in the cyclone. Seldom a year passes without a severe gale or hurricane in these latitudes. These are ordinarily preceded by close, sultry weather, with a murky sky. The barometer falls rapidly, or oscillates, between 30 deg. and 29 deg.—sometimes sinks as low as 28 deg. 50 sec.; even the native (or natural) barometer gives unmistakable indications of an approaching storm. The gale generally commences in the south, and veers round to the west and north-west, which is the culminating point, and blows strongest. The sea rises to a tremendous height, sweeping in long and overwhelming waves. One vessel near Samoa suddenly foundered by such a wave breaking over her and carrying her down stern foremost.

At Christmas, 1848, I first experienced this cyclone storm in Samoa. It was very powerful on the north side of Upolu, but on the south side and on the other islands it was scarcely felt. In some places the wind gyrated like a whirlwind. Near my residence I observed the roof of a native hut torn bodily off from its supporting posts and whirled in the air for a time, and then cast down in fragments a considerable distance away. A still more severe hurricane occurred in April, 1850, and was widely extensive and continuous, lasting for two days, with a brief interval in which the rain poured down in torrents. My house was unroofed, and not a native hut was left standing in the district. Stone churches were either unroofed or blown down, and the land was strewed with fallen trees. Some natives were killed and others wounded by falling houses and trees; one man was killed by a rock falling upon him. Three vessels at anchor in the harbour of Apia were driven ashore and wrecked; another foundered at the entrance to the harbour, while endeavouring—like H.M.S. *Calliope*, in March last—to escape out to sea; and a small cutter went down at her anchorage by a sea sweeping over it.

The next severe hurricane in Samoa was experienced in January, '65. The neighbourhood of Apia harbour was especially exposed to its fury. The German barque *Alster* was driven on to the reef, and all hands, with one exception, were lost. In March, '79, another cyclone swept over Upolu, but the current took a favourable direction for the shipping at Apia, so that the vessels were able to ride out the gale. Again, in March, '83, a destructive hurricane was experienced in Samoa, and the island of Upolu suffered severely, and a large number of houses and trees were destroyed. Several vesssel and ten lives were lost.

The latest catastrophe occasioned by a hurricane in Samoa is that which has become painfully familiar to us in Australia, and of historical interest universally, occurred last March. The height of the storm burst with unexpected suddenness and strength upon the roadstead of Apia Bay. At that time, unfortunately, there was a larger amount of shipping in the bay than on any former occasion. Besides several merchant vessels and small trading craft, there were no less than seven war steamers lying at anchor—three German, three American, and one British, the famous *Calliope*, which so marvellously escaped destruction when the other vessels were either driven ashore or on to the reef.

Notwithstanding the brave, noble, and self-sacrificing efforts of the natives of Apia to rescue the shipwrecked mariners, a large number of the seamen and officers perished in the raging waters; in all, upwards of 150 lives were lost, among them some of the brave Samoans who went to the rescue.

The lamentable event will, it is to be hoped, convey a useful lesson to captains of ships and others not to despise the indications given by the weather and the readings of their barometers, to place undue credence on the statements of residents, not generally well-informed, that the gathering storm will be but partial and speedily pass off. The spiral movement of a cyclone current may suddenly burst with overwhelming power on a spot which had just previously been considered to have escaped the force of the hurricane.

There are really no secure harbours in Samoa, the New Hebrides, and the Loyalty islands during the monsoon season. The Bay of Pangopango, in Tutuila, which is land-locked, presents the safest anchorage; but it is narrow, open to the south-east trade, and has a hidden rock near the entrance. Captains of sailing vessels, therefore, rarely enter the harbour; and baffling winds, occasioned by the mountains and gullies on either side, offer another impediment to its navigation, except by steam power. Fagaloa Bay, at the east of Upolu, is also an unsafe harbour from similar reasons; and deep water prevails to within half a mile of the extreme end of the bay.

2.—EARLY DISCOVERY, EXPLORATION AND PHYSICAL GEOGRAPHY OF AUSTRALIA.

By A. C. Macdonald, F.R.G.S.

3.—AUSTRALIAN EXPLORATION.

By P. G. Mueller.

4.—ANTARCTIC EXPLORATION.

By Commander Crawford Pasco, R.N., F.R.G.S.

5—ON THE DISTRIBUTION OF LAND AND WATER ON THE TERRESTRIAL GLOBE.

By J. J. Wild, Ph.D., F.R.G.S.

6—ANTARCTIC WHALING IN THE OLD DAYS.

By J. J. Shillinglaw, V.P.R.G.S. Aust.

Section F.

ECONOMIC AND SOCIAL SCIENCE AND STATISTICS.

President of Section: R. M. Johnston, Esq., F.L.S., Registrar General of Tasmania.

1.—OUR MEAT SUPPLY.

By H. H. Hayter, C.M.G.

Mr. Coghlan, the Government Statistician of New South Wales, some time since published a series of calculations in regard to the supply of meat in continental Australia, and the probability of its continuing to be sufficient for the wants of the fast-increasing population. As the result of his investigations, Mr. Coghlan came to the conclusion that for many years to come the supply of mutton would be amply sufficient, but that the demand for beef would probably overtake the supply in the course of six years.

At first sight it appears hardly probable in a scantily-populated country like Australia, with millions of sheep and cattle roaming at large on plain and hill, having also immense tracts suitable for pastoral purposes still unstocked, that there should be any danger of the meat supply falling short; still, since an experienced statistician, after much patient investigation, has pronounced that the danger exists—at any rate, so far as the supply of beef is concerned—the matter certainly merits to be fully enquired into.

Mr. Coghlan starts with the assumption that the population of Australia is increasing at the rate of 4 per cent. per annum. This, it may be observed, is a faster rate than that at which the population of any country, starting with a population as large as that Australia contains at the present time, has ever been known to increase for long together, and would result in the population doubling itself in rather less than eighteen years, which is an unheard-of result. It is true that since 1881 the population, according to estimates made in the different colonies, has apparently increased at the annual rate of rather over 4 per cent., but this estimate, if correct, which is doubtful, must be looked upon as quite exceptional and impossible to be sustained. The present rate of increase by excess of births over deaths is something under 2 per cent., which being much higher than the rate prevailing in any other country, may also be expected to fall; but supposing it to continue, and another 1 per cent. to be allowed for excess of immigration over emigration, or 3 per cent. in all, this is quite as high a rate of increase as is at all likely to be realised, and one which would admit of the population doubling itself in 22½ years, or in a shorter period by 2½ years than the unprecedently short time in which the population of the United States has become doubled.

The official statistics of past years afford no guide as to what the increase in the numbers of sheep and cattle has been in the past or is likely to be in the future, as those statistics have been based upon estimates which, in the few cases in which an attempt has been made to verify them at a general census, have been found to be quite erroneous. Their unreliable character, moreover, is borne out by the fluctuations which the figures would make it appear had taken place in the rates of increase at the different periods, as shown in the following table:—

APPARENT INCREASE IN THE NUMBER OF SHEEP AND CATTLE IN AUSTRALIA AT QUINQUENNIAL PERIODS.

Year.	Sheep.			Cattle.		
	Estimated Number.	Apparent Quinquennial Increase.		Estimated Number.	Apparent Quinquennial Increase.	
		Numerical.	C'nt'sml		Numerical.	Centesimal.
1863	24,819,312	—	—	3,853,688	—	—
1868	39,346,008	14,526,696	58·53	3,592,796	−260,892	−6·77
1873	43,948,576	4,602,568	11·70	5,243,204	1,650,408	45·93
1878	49,737,531	5,788,955	13·17	6,733,941	1,490,737	28·43
1883	68,154,228	18,416,697	37·03	7,568,618	834,677	12·39
1888	80,028,442	11,874,214	17·42	8,172,321	603,703	7·98

The figures in the table would appear to indicate, in regard to sheep, that whilst the large increase of 59 per cent. took place between 1863 and 1868, the increase was only 12 per cent. between 1868 and 1873, and no more than 13 per cent. between 1873 and 1878; that it rose to 37 per cent. between 1878 and 1883, and was only 17 per cent. between 1883 and 1888; also, in regard to cattle, that there was an actual falling-off of 7 per cent. between 1863 and 1868, followed by the large increase of 46 per cent. in the next quinquennial period, by the increase of 28 per cent. between 1873 and 1878, 12 per cent. between 1878 and 1883, and only 8 per cent. between 1883 and 1888.

Such irregularities show the figures to be utterly unreliable. It is therefore necessary to take the estimated numbers as they stand at the present time, and to find what the possible rate of increase would be after deducting the numbers required to feed the population, for which Mr. Coghlan's estimate may be accepted, viz., 2 sheep and ·26—or rather more than a fourth part—of a head of cattle to each person per annum.

I am informed by competent authories that upon the existing numbers of sheep and cattle of both sexes and all ages there may be expected to be an annual increase of 30 per cent., by the birth of lambs and calves. The average number likely to die annually by drought and disease is more difficult to estimate—Mr. Coghlan sets it down at 5 per cent; but from numerous inquiries I have made, I am led to believe that, taking one year with another, the allowance should not be less than 10 per cent. There being thus a 30 per cent. increase by births and a 10 per cent. decrease by natural deaths, there remains a net increase of 20 per cent., and the question to be solved is—Will this increase upon the present numbers of our stock admit of 2 sheep and ·26 of a head of cattle being provided annually for the food of our population, which population may be expected to increase at the rate of 3 per cent. each year?

This is a matter of easy calculation. If, after all deductions are made, the stock is able to increase at a faster rate than the population, there is evidently no danger of the supply falling short; but if the population is increasing the faster of the two, it must be only a question of time when the supply will be overtaken. Such a calculation, together with the data on which it is based, will be found in the following table, which relates to the four years ending with 1892:—

POPULATION, SHEEP, AND CATTLE IN AUSTRALIA, 1889 TO 1892. (000's OMITTED).

Year.	Population at Middle of each Year (increasing 3 per cent. per annum).	At Beginning of each Year.		Increase by Births each Year (30 per cent.), less Deaths by Disease and Drought (10 per cent.) Net Increase—say 20 per cent.	
		Sheep.	Cattle.	Sheep.	Cattle.
1889	2,983	80,028	8,172	16,006	1,634
1890	3,072	90,068	9,030	18,014	1,806
1891	3,165	101,938	10,037	20,375	2,006
1892	3,260	115,983	11,220	23,160	2,240

Year.	Killed each Year (2 Sheep and ·26 Cattle per head of the population).		At End of each Year.	
	Sheep.	Cattle.	Sheep.	Cattle.
1889	5,966	775	90,068	9,030
1890	6,144	799	101,938	10,037
1891	6,330	823	115,983	11,220
1892	6,520	848	132,623	12,612

From these figures it is ascertained that after, making what appear to be ample deductions for the numbers dying naturally and for the food supply of the increasing population of Australia, there will be a large possible increase from year to year in the numbers not only of the sheep—which Mr. Coghlan admits—but also of the cattle, and that the possible *rate* of increase, as well as the possible increase *in numbers* of both descriptions of stock during each year, is in every case larger than it was in the year which preceded it, so that there is no danger of either sheep or cattle falling short. The figures are as follows :—

POSSIBLE INCREASE OF SHEEP AND CATTLE, 1889 TO 1892. (000's OMITTED.)

Year.	Sheep.		Cattle.	
	Number.	Percentage.	Number.	Percentage.
1889	10,040	12·55	858	10·50
1890	11,870	13·18	1,007	11·15
1891	14,045	13·78	1,183	11·79
1892	16,640	14·35	1,392	12·41

I use the word "possible" instead of "probable" advisedly, for it is not at all likely such increases will actually take place, as the numbers will be kept down by the slaughtering of lambs and calves, by the spaying of heifers, and by exportations. But should the surplus at any time be nearly overtaken by the food requirements of the population, the price of meat will of course rise, and these practices will at once cease.

With the fresh country which is continually being discovered and opened up, there will, I believe, be pasturage to maintain any increase in the numbers of live stock which is likely to take place during the existence of every person now living; and with the benefit of irrigation and the saving of surplus herbage by means of ensilage in seasons when feed is plentiful, it is impossible to place any limit on the quantity of live stock this great continent may ultimately be able to carry.

Where Mr. Coghlan seems to me to be in error is, first, that he has very much over-estimated the rate at which the population of Australia is likely to increase; and, secondly, that he has only taken what he considers to have been the *actual* rate of increase of stock in the past as a guide to the future, and has left out of consideration what might be the *possible* increase if the slaughtering of young stock, the unsexing of heifers, and the exportation of meat were abandoned, which any rise in prices would inevitably cause them to be.

2.—THE COMING CENSUS.

By H. H. Hayter, C.M.G.

The officers charged with the collection and compilation of statistics throughout her Majesty's dominions have no doubt for some time past had under consideration the necessity of making early provision for taking the census of 1891, and some have probably already commenced their preparations for that important national undertaking.

Having been connected officially with four censuses of this colony, the last two of which have been entirely under my own management, I can confidently say that upon the intelligence and forethought exercised in devising and planning the preliminary arrangements, the success of a census mainly depends. It is impossible that these arrangements can be made satisfactorily unless sufficient time is allowed for them to be perfected, and experience has shown they ought to be commenced at least twelve months before the period for taking the census arrives.

It must be remembered that the preparations involve, in the first instance, the passing of an Act giving the requisite power to take the census. This Act will no doubt be based upon former Census Acts, but it is the duty and will certainly be to the advantage of the superintending officer to weigh well all the provisions of the proposed measure prior to its becoming law, so that he may be in the position to recommend the addition of any which his experience and judgment tell him are wanting, and the exclusion of any which he has reason to believe are likely to operate prejudicially. If this is done thoughtfully and with due consideration for the requirements of the undertaking, much after trouble will be saved. Nothing is more vexatious than for the officer charged with the conduct of the work to find himself armed with insufficient powers, or cramped and hampered by annoying and unnecessary restrictions.

Much inconvenience has been found to result where the householder's schedule has been attached to the Census Act. I therefore recommend that only the heads of inquiry be embodied in the Act, on which a schedule should be based which might be afterwards approved by the Governor-in-Council and gazetted. There are matters of detail in this schedule which it is sometimes desirable to alter even at the last moment, and this could be done readily if the schedule were, within certain limits, merely a matter of regulation; whereas, the Act once passed with the schedule attached, however desirable it may be to effect changes, it is impossible to vary the form of the schedule in the slightest degree.

Attempts are sometimes made to collect agricultural statistics and statistics of mining, manufactures, school attendance, &c., by means of the census enumerators, but this should not be permitted. The collecting officers have quite enough to do to attend to their own duties, and any extra work imposed upon them causes loss of time and tends to make the census inaccurate. It may perhaps be allowable for the census collectors to take an account of the live stock, as that can only be done accurately when a census is taken, and is not likely to cause much delay, but with this exception, they should not be required to do anything unconnected with their own legitimate work, viz., that connected with the enumeration of the population.

In one of the colonies a return of the religious belief of the people has hitherto not been asked for, and in more than one of the others no attempt has been made to obtain a statement of the numbers sick, blind, deaf and dumb, lunatic and idiotic. The information embodied under these heads is interesting and valuable, and as it can be got without extra expense or trouble, there seems no good reason why it should not be obtained in every one of the colonies.

The preparation of the instructions to the persons employed to collect the census will require much intelligent consideration, especially as most of such persons, particularly in colonies which take the census only once in ten years, will be new to the work, and some, especially in country districts—though perhaps hardy bushmen—will in all probability be of defective education. The systems of census-taking no doubt vary in the different colonies; but the fact remains that in every colony it is necessary that a staff should be so organised as to act over its entire length and breadth, and to extends even to its most remote limits; also that each member of this staff should be made to thoroughly understand his duties. It is therefore essential that his instructions should be precise and definite, as well as simple and easy to be understood.

The division of the colony into districts suitable for the census-taking should be done upon a definite principle. In Victoria, and, I believe, in most of the other colonies, it is the practice to have superintending collectors, called "enumerators," and working collectors, called "sub-enumerators," the districts assigned to the former being arranged in the central office, whilst those of the latter are planned by the enumerators.

For the enumerators' districts the whole colony should be mapped out, no portion of it being omitted under the assumption of its being uninhabited. In forming these districts the principal objects to be kept in view are, first, that each district should be of such an extent, having regard to the work to be done, as to be readily under the control of its enumerator; secondly, that its boundary lines should, where possible, coincide with the boundaries of existing districts, such as counties, electorates, municipalities, &c.; and thirdly, that its boundaries should be well defined, and easily discoverable on the ground.

The formation of the sub-enumerators' districts (or sub-districts as they are usually called) is, as has been stated, left to the enumerator, but subject to instructions from the central office. At the last census of Victoria these instructions were to the effect that, unless under exceptional circumstances, each sub-district should be of such a size as to permit the work of enumeration to be performed in three days, viz., one day for depositing and two days for collecting the schedules; that in towns, where the dwellings were close together, a sub-district might contain from 150 to 200 inhabited houses; in suburban districts, villages, and goldfields, where the dwellings were not so near to one another as in a closely-built town, it might contain from 100 to 150 such houses; in the more settled agricultural districts, where not more than half a mile intervened between a dwelling and the next nearest, it might contain from 50 to 100; and in scattered agricultural districts, where intervals of two miles or upwards sometimes occurred between two dwellings, less than 50 might be allowed. In laying out pastoral and other widely-scattered districts the enumerator was enjoined to use his own judgment, both as regards the number of habitations in a sub-district and the time to be allowed for the enumeration.

I may observe that, probably for the sake of saving themselves trouble, and sometimes, no doubt, from the desire to give the sub-enumerators—perhaps their own relatives or friends—an opportunity of drawing as much money as possible, the general tendency of enumerators is to make the sub-districts too large, thus causing the work to extend over a longer period than is desirable. This should not be permitted, as from the fact of population being always on the move, it is an ascertained fact that the longer the time which is taken over the collection of a census the less accurate it is likely to be.

On the maps to be supplied to the enumerators—one to be returned to the central office with the proposed sub-districts marked thereon, and the other to be retained by the enumerator for his own guidance—should be plainly delineated before sending them out from the central office, not only the outside boundaries of the district, but all county, electoral, or municipal boundaries which cross it, and all towns, villages, goldfields or other groupings of population it is desired should be kept separate. If this is not done mistakes are apt to occur in the marking and arrangement of the schedules, which are likely to lead to much after trouble.

In order to calculate the number of householders' schedules which will be wanted, the enumerators must be required to estimate carefully beforehand the number of houses in each sub-district under their charge; but to guard against the possibility of running short, each sub-enumerator must be supplied with more schedules than he would appear to require from the estimate of houses in his division. Then the enumerator must have a number of schedules in stock, ready to supply any sub-enumerator who, in spite of this precaution, may find himself deficient, and a large reserve must be kept at the central office, in order to supply any enumerator who may want them at the last moment. A surplus is therefore required in all directions, and it will generally be found necessary to have nearly 50 per cent. more schedules printed than calculations show are likely to be filled.

Special arrangements should be made and interpreters engaged for the enumeration of the Chinese; the enumeration of the aborigines should also be attempted, and timely application be made to the superintendents of mission stations and aboriginal reserves, who will, no doubt, not only give information respecting those staying at such establishments, but supply reliable estimates of those who may be living elsewhere.

In order to secure a complete enumeration, arrangements should be made to take an account of all who arrive in the colony either by land or sea, up to 12 o'clock on the night of the census; provision should, moreover, be made for enumerating not only those who pass the night indoors, but of those who may be camping out, fishing, or taking night duty at mines or elsewhere, and persons should be specially told off in the principal towns to visit reserves, wharves, or other places where tramps and vagrants may be expected to pass the night. As in certain cases this service may be not unattended with danger, it is desirable that the police should be requested to afford protection to those charged with the duty.

In order to prepare the public mind for the event of the census, printed notices should be posted at all police stations, railway stations, post offices, and other prominent places throughout the colony, also be several times inserted as an advertisement in all the newspapers. The same notices, translated into the Chinese language, should be posted in the Chinese quarters of the towns and goldfields, and distributed amongst the leading persons of the Chinese race.

After the census has been taken, the Government, the Press, and the public are, as may well be supposed, anxious to obtain a rough statement of the results as speedily as possible. To afford means of satisfying this very natural wish, each sub-enumerator should be required to extract from the householders' schedules he collects the totals of the population, distinguishing the sexes, also the Chinese and aborigines, and should insert the figures in a form supplied to him for that purpose, which he should forward to his enumerator as soon as completed. From these forms the enumerator should make a summary of his whole district, adding the columns so that the total result may appear in one line, and this summary he should transmit to the central office at the earliest possible moment. Immediately all these summaries are received, no time should be lost in preparing a summary of the whole colony, which should be at once published for general information. By following this practice, I was able on the occasion of the census of 1881, to publish the approximate totals for Victoria exactly one month from the census-day, a speediness of publication which, so far as I am aware, has not even yet ever been equalled in any other country.

Various methods have been adopted for compiling a census, but so far as my experience goes the most convenient way of performing the operation is by means of cards, one card being devoted to each individual of the population. The cards may be about the size of ordinary playing-cards, and should be of two colours, one colour for the males, the other for the females. For their custody and arrangement pigeon-holes should be provided, which should have partitions, four inches—or little more than the width of the cards—apart, and movable cross shelves, constructed to slide in and out between the partitions through grooves placed every three inches, so that a large or a small space can be obtained according as it is required to place a greater or a less number of cards therein. It will be readily understood that it would be a serious matter if the cards, numbering as they must one for each person in the colony, were to become disordered or misplaced, and that upon the perfection of the methods adopted for the arrangement and disposal of the cards, much of the success of the card system depends.

The process of using the cards is as follows:—The name or number of the place to which the entries are to relate, and the number of the schedule from which the particulars are to be extracted, having been stamped upon the card, the entries are to be made with pen and ink. After these have been made, and their correctness has been verified by examination, the next proceeding is to reduce the results to a tabular form. This is done by sorting the cards of each place into heaps, according to whatever enquiry it is desired to work out, after which it is only necessary to count the cards in each heap, and to enter the numbers so obtained in the columns of specially prepared summary sheets. As a matter of course, the respective heaps will be entirely different in number, size and contents, according to which of the heads of enquiry is being dealt with, but the total results under each head must exactly balance with one another.

It is to be hoped that in all the colonies a careful selection will be made of the extra officers to be engaged to compile the census. It has been too often the practice, both in these colonies and in the United Kingdom, to consider the census office as a sort of refuge for the destitute, and to appoint thereto persons who have failed in other occupations, and are not unfrequently of bad character and inebriate habits. In consequence of this, the expense of compiling the census has been materially added to, the work has been unduly protracted, and it has also suffered in point of accuracy. It cannot be too forcibly impressed upon those by whom the appointments are made that it is a mistake to suppose that incapable persons can be made useful on the compilation of a census. All the work in connection with that operation is of a more intricate and complex character than that which occurs in the routine of most Government departments; to the bulk of those appointed it is entirely novel; it is therefore desirable that they should possess quick comprehension and aptitude for grasping fresh subjects, as well as a fair share of ordinary intelligence. Should it be found that such qualities are absent in an officer, or should his conduct be such as to be subversive of the discipline of the office, the head of the census department ought to have full power at once to dispense with his services.

The forms for compiling the census should be got ready before the actual work of the census commences, for when that operation is in progress the time and thoughts of the superintending officer are fully occupied with the work on hand. To give an Imperial character to the returns, the forms should be so arranged that the compilation might be effected as nearly as possible upon the English principle, such divergencies only being allowed as might be necessary to suit local circumstances. It is much to be desired that before the census is taken it may be arranged that the heads of the statistical departments of the different colonies may meet in conference, with the view to an agreement being arrived at for the adoption of a uniform system of compilation throughout the group.

Federation is said to be in the air, and it seems possible that at a not very distant period there may be one central Government over the whole of Australasia, in which case there would, I assume, be also one central statistical department. Such a department will, in all probability, not come into existence until after my own official career has terminated, but it may do so during the period of service of some of my brother statisticians, and I may observe that I know of no one who would be better fitted to be at its head than the talented president of this section. But cannot its establishment be anticipated by an agreement to establish uniformity in statistical compilation throughout the colonies of this group? It is true that for the time being there must nominally be as many statistical departments as there are colonies, but if all work as one, the desired union (or federation, if the term be preferred) will practically be accomplished. Statisticians should have no petty jealousies or ambitions, no desire to take credit for originality, or to obtain notoriety by unnecessarily making their work different from that of others. The publication of truth in the most useful form possible should be their aim and object, and they should not mind following in the footsteps of others, if what they follow is really good. Let all then agree to state their facts when arrived at in the same manner and after the same form, and if any change should be desirable let it be made by mutual agreement. If all act upon these lines, there will soon be the same uniformity in the statistical records of the various colonies that there would be if a general federation of the whole had become an accomplished fact.

3.—FORESTRY: ITS SCOPE AND APPLICATION.

By M. H. Clifford.

4.—A RESERVE INDUSTRY AS A REMEDY FOR ENFORCED IDLENESS.

By W. J. Curry.

5.—SETTLEMENT OF AN INDUSTRIAL POPULATION ON THE LAND, BY MEANS OF SMALL HOLDINGS.

By Hon. G. W. Cotton, M.L.C.

6.—FODDER PLANTS AND GRASSES OF AUSTRALIA.

By Fred. Turner, F.R.H.S. London, Botanist to the Department of Agriculture, N.S.W.

My object in reading before the "Economic and Social Science Section" of the Australasian Association for the Advancement of Science an account of my experiments and observations on the fodder plants and grasses of Australia is that more interest may be taken in them by scientists, pastoralists, and agriculturists. "Grass," says Professor Martyn, in his letters on the "Elements of Botany," "vulgarly forms one single idea, and the husbandman when looking over his enclosure does not dream there are upwards of three hundred species, of which thirty or forty may be at present under his eye." These remarks of Professor Martyn's, made so many years ago, are substantially correct at the present day.

Distinguished agriculturists have often remarked that a knowledge of the comparative merits and the value of the different species of grasses, and the best mode of cultivating them, is very much below other branches of agriculture. With regard to Australian grasses, these remarks are singularly appropriate, notwithstanding that they are the principal source from which Australians derive their greatest wealth. However, a new era seems to have dawned upon Australia. By establishing departments of agriculture throughout the colonies, we may reasonably expect most valuable results to accrue therefrom, and if these are assisted by the patriotic exertions of private individuals, much of the prejudice at present existing with regard to the value of our native pasture-plants may be consigned to oblivion. By systematic experiments their yield could be ascertained, and by analysis their nutritive qualities proved. This would be an invaluable guide to pastoralists and agriculturists, who could see at a glance what species were most suitable to their requirements.

The comparative merits of our native fodder-plants and grasses should form a part of the curriculum of the national education. If there were placed in all country State schools an enlarged drawing of each species that is peculiar to the district the school was situated in, with its botanical and common name, together with a short popular description and analysis, it might form a lasting impression upon the young mind, and would most probably lead to valuable results in after-years. It cannot be said we have no material to work upon, for there are upwards of three hundred and sixty species of grasses indigenous to this continent. All these, of course, are not valuable fodder, but they have their uses in the economy of nature, which I shall show in another part of this paper. Amongst other native fodder plants, the most numerous and valuable are to be found in the natural order *Chenopodiaceæ*, numbering as they do for all Australia about one hundred and twelve species, arranged under fifteen genera, eight of which are endemic. Some are found on the littoral sands, whilst others extend to the arid plains of the interior, and are remarkable for their drought-enduring qualities. There are also many other trees, shrubs, and herbs, represented in other natural orders, which are largely used as fodder, especially so during long droughts; though there is still much doubt to be cleared up with respect to the value of many of them. Even in the same district, some persons will assert that a particular species of plant is poisonous, while the testimony of others, which is equally reliable, will assert that it makes capital feed. There are, perhaps, no more conflicting statements made than with regard to the genus *Eremophila*, and the allied one *Myoporum*. Whilst I must admit that so very little is known of the physiological properties of the order *Myoporineæ*, still I cannot close my eyes to the fact that both cattle and sheep, kept in country where these shrubs are plentiful, eat them with avidity, and thrive on them, without any ill effects. Some persons assert that these *Myoporinous* plants develop their poisonous properties when in fruit, but whoever has studied the habits of the birds of Central Australia will assure you that someof them greatly depend upon the fruits of these plants for sustenance; which in fact, in some seasons are their principal food supply. Moreover, the aboriginals in the early days, before they tasted the sweets of civilisation, used to eat the fruits of several *Myoporinous* plants. There is no doubt that when cattle and sheep are taken from one district to another, where the natural herbage is somewhat dissimilar, it must have, for a time at least, some effect upon their systems, especially when they are taken from rolling-downs of grass to country where shrubs and herbs predominate. And this brings to mind a question which I think has not received the attention of stock-owners that its importance justifies, viz., the mechanical action that hard-foliaged shrubs have upon the larynx of both cattle and sheep which are not used to eating them. This irritation of the larynx not only brings on laryngitis, but often extends to and brings on inflammation of the intestines. Further, when hungry sheep have partaken too freely of some leguminous plants, especially when in seed, they have died. But this is caused during the process of digestion, when great volunes of gas are formed, which cause an abnormal distention of the stomach, thus preventing the lungs working freely, and of course strangling the animals. On this account many leguminous plants are called poisonous which are not really so. Still, these causes could not account for all the sheep that die somewhat mysteriously. I use the word "mysteriously" advisedly, for many plants have been sent to me as poisonous which, on examination, have proved to be quite harmless. Nor is my case a singular one; many others have had the same experience. We have a far more insidious enemy to contend against in the parasitic fungi which affect grasses, not only in the damp coastal districts, but far into the interior. Some few years ago I drew attention to the great increase of parasitic fungi on some of our most valuable grasses, and I then said, what I think now, that fungoid growth on grasses is the primary cause of many sheep dying so mysteriously. For we have abundant proof of the destructive agency of microscopic fungi on both animals and plants that have not sufficient vigour to repel them. The life history of these native fungoid growths is well worthy the attention of specialists, if only to show what their effects are upon animals.

As long as a greater portion of this continent is devoted to depasturing sheep and cattle, and Australia intends to hold her own against the world in the production of high-class wool, also in the matter of the frozen meat export trade, it becomes of vital importance to the population that more attention should be paid to our native fodder-plants and grasses than has hitherto been the case, to save some of them from extinction by a proper system of conservation, and even cultivation. There is no gainsaying the fact that during recent droughts large tracts of country have been so overstocked that many valuable pasture-plants and grasses have become so scarce that it would take years of careful conservation to bring them back to anything like their original state. Being so closely fed down, their only natural means of reproducing themselves by seed is partially destroyed, and every year makes matters worse. An occasional good season may, to a slight extent, remedy this; but observant and thoughtful persons can see that in the near future more vigorous action will have to be taken to keep our pastures up to their normal state, or the number of sheep and cattle to each station will have to be considerably lessened, which, of course, means the export of less wool, tallow, hides and mutton. It should also be borne in mind that every fleece of wool which is produced takes a percentage of potash and other fertilising substances out of the soil, and nothing so far has been done to restore these natural elements to the earth. It must naturally follow that the more valuable herbage will gradually give way and a more worthless one take its place, that is, from an economic point of view. An instance of this is already taking place in the interior, where the pine scrub (*Frenela*) has already taken possession of thousands of acres of what was, at one time, splendid pastoral country.

By the following figures some idea may be formed of the quantity of grass-seeds required for one acre, supposing it to be sown at the usual rate of thirty-six pounds (36lbs.), which, approximately stated, is equal to about twenty-two (22) millions of grains. This applies to ordinary grass-seeds, such as some species of *Andropogons*, *Chloris*, *Eragrostis*, *Panicums*, &c. The number of grains vary somewhat one way or the other (for no other seeds in the vegetable kingdom vary more, either in weight or number) according to the good or bad season they were harvested in. An acre well clothed with grass would contain from fifteen to twenty millions of plants, though, in some exceptional cases, as many as forty millions of plants have been recorded to the acre. When such appalling facts as these are brought to mind they cannot be trifled with, and it is no wonder that thinking persons are apprehensive as to the future condition of our pastures unless some radical change takes place.

Many persons have thought that by introducing exotic fodder-plants and grasses they would, in a great measure, supersede and be an improvement upon the indigenous ones. But it has often struck me as being a most remarkable thing that those persons who have written up the supposed virtues of exotics have given no guarantee that our high-class wool would be maintained under this new diet. Climate, no doubt, has a great deal to do with the production of high-class wool. Still, I cannot close my eyes to the fact that the indigenous vegetation is the principal factor. Keeping these circumstances in view, it is much better to systematically conserve, and even cultivate, our native fodder plants than introduce others of which we have only a superficial knowledge.

Many exotic species have been introduced as good fodder-plants which have proved a positive pest to the country. Everyone must be painfully reminded of this fact when they see that ubiquitous Cape composite, *Cryptostemma calendulacea*, which already covers large areas of pasture-land, and from year to year the area widens, to the gradual extinction of native herbs and grasses. Over two hundred species of worthless weeds have been introduced with seeds of exotic fodder plants, or in an accidental way along with other seeds. So great a pest to the country have some of these proved, that laws have been directed towards their extermination. The prickly comfrey (*Symphytum asperrimum*) was heralded throughout Australasia, a few years ago, as the fodder plant that was to supersede all others. What is the consequence, after years of careful nursing? It has proved to be a positive failure in the country, after all the money expended in introducing and cultivating it. A Canary Island shrub, called Tagasasta (*Cytisus proliferus*) is now occupying much attention in some quarters, which experience will eventually prove to have been misdirected. I have observed this shrub for a number of years, having raised from seed some of the first plants ever seen in Australia. I have a shrub now under my charge which is about fifteen feet high, but I can firmly assert that our old man salt-bush (*Rhagodia parabolica*) would at the same age have produced about twice the amount of a superior fodder, and would grow in even more adverse circumstances of drought and heat. To give even a synopsis of all the introduced plants that have proved a pest in the country would occupy much time. There is one more, however, I should like to draw attention to. It is the European dodder (*Cuscuta trifolii*), a parasitic plant which grows on the roots of lucerne and clover, and is doing much harm to those pastures in New South Wales. The dodder seeds, no doubt, have been imported with unclean samples of clover and lucerne seed, and the climate being favourable, it has spread very rapidly of late years.

I must confess that at one period I held the views of those persons who thought to supplant our native herbage by a free introduction of exotics, but after an observation extending over fifteen years, I have outlived these erroneous ideas. My first observations were made when I had charge of a series of experiments, carried out with both native and exotic fodder-plants and grasses, with a view of proving their true qualities by comparison.* To enumerate all the species experimented with (upwards of one hundred), together with a detailed description, would occupy too much time ; but to sum up briefly, I may state that the native ones yielded more at the rate per acre than did exotics, with the exception of such tall-growing grasses as *Panicum maximum*, *Panicum spectabile*, *Reana luxurians*, *Sorghum vulgare*, *Zea mays*, and some of the larger kinds of millet. But these were run very close by the following native ones :—*Anthistiria avenacea*, *Astrebla pectinata*, *Heteropogon insignis*, *Panicum crus-galli*, *Pollinia fulva*, *Rottboellia ophiuroides*, *Sorghum halepense*, and *Sorghum plumosum*. It is a well-known fact, however, among agriculturists that tall-growing grasses are not always, in fact, scarcely ever so nutritious as the more dwarf ones, though they are of the greatest use for ensilage, where bulk is a great consideration. Another point to be noted with these fodder plants and grasses is that horses eat the native ones in preference to exotics, which proves conclusively that with cultivation native grasses will become as succulent, as tempting to the appetite, and as nutritious as the best of exotics. Those species experimented with, that were indigenous to Northern Europe and North America, proved to be the most unsuitable, with two exceptions—one of annual growth, *Ceratochloa unioloides*, a capital winter species, and the other a perennial, *Poa pratensis* (var. *virginiana*). This grass has underground stoloniferous stems like our native *Cynodon dactylon*, so on this account is not easy to exterminate, while it affords a good fodder for sheep. Those from South Africa did fairly well, especially *Tricholœna rosea*, which is quite acclimatised in some situations. Its ripe seeds, being light, are distributed far and wide by every wind that

* They were sown or planted in spaces exactly one yard square, which was an accurate way to compute the yield of produce per acre of each species.

blows. Some South American species did well, as also the Californian bunch-grass, *Elymus condensatus*. But it must be borne in mind that all these grasses were tested in the coastal districts, and it is a question whether they would have grown at all if they had been sown or planted on the arid western plains of Australia. All these experiments were carried out on a black loamy soil, but I saw other experiments carried out on different soils. Still, the results were much the same, with the exception, of course, of pure sand, which appears less favourable to their growth than any other; but even this has species peculiar to itself. I mention this fact, for much prominence has been given by some persons to the relative values of the different geological formations as being necessary to the growth of particular pasture-plants, but this has really an unimportant bearing upon the subject, and is more likely to lead to confusion than otherwise. Of course, where soils are naturally very light, or very heavy, very dry, or excessively wet, it is then necessary to make a selection of the most suitable species for such situations. But to advise fifty different geological formations for the same number of pasture-plants is mere pedantry.

Grasses and other fodder-plants have been recommended by persons who had formed their judgments of their merits upon imperfect trials, or upon every-day evidence. This has caused much disappointment, and discouraged many persons from further endeavours at improvement of their pastures. To this, also, we may attribute the general indifference towards obtaining a knowledge of the comparative merits of grasses and other fodder-plants. There is one good thing, however, those persons have done for the country who have recommended exotic grasses, for they have always given directions for the soil to be broken up and brought to a fine tilth before the sowing takes place. But what a contrast this is to the continual struggle for existence our native grasses have to undergo, for the paddocks are often as hard as the roads throughout the country. In these circumstances it can hardly be wondered at that many of them present a wiry appearance, and if it were not for the sharp points on many of our native grass-seeds some of them would have been extinct long ago. These sharp-pointed seeds burrow into the soil, and when rain falls to soften it they germinate and grow, where it would be practically impossible for exotic ones to live.

There is no doubt that the pastures in the coastal districts can be improved by introducing some exotics, especially those that make their growth during winter and early spring, for as a general rule most of our grasses make their growth during the summer season. Amongst the exceptions are—*Agropyron scabrum*, *Andropogon affinis*, *Bromus arenarius*, *Eriochloa annulata*, *Eriochloa punctata*, *Echinopogon ovatus*, *Danthonia semi-annularis*, *Deyeuxia forsteri*, *Dichelachne crinita*, *Dichelachne sciurea*, *Festuca* *bromoides*, *Lappago racemosa*, and *Microlæna stipoides*. Before an attempt is made at the systematic cultivation of our indigenous fodder-plants and grasses, it will be necessary to have some data to work upon. For the benefit of those persons who desire to enter upon their cultivation, I shall divide them into groups, and give a synopsis of those species which, after a long study, I am led to believe will be most suited to the requirements for general pasture and hay-making, cultivating for grain, species suitable for wet and undrained soils, also for dry soils, and for binding the littoral sands. I have already mentioned those species most suitable to cultivate for ensilage.

Those species suitable for general pasture and hay-making are —*Agropyron scabrum*, *Andropogon bombycinus*, *A. erianthoides*, *A. intermedius*, *A. pertusus*, *A. refractus*, *A. sericeus*, *Anthisteria ciliata*, *A. membranacea*, *Astrebla elymoides*, *A. pectinata*, *A. triticoides*, *Chloris acicularis*, *C. truncata*, *C. ventricosa*, *Chrysopogon gryllus*, *Cynodon dactylon*, *Danthonia longifolia*, *D. pallida*, *D. pilosa*, *D. semiannularis*, *Dichelachne crinita*, *Eleusine ægyptica*, *Eragrostis brownii*, *E. pilosa*, *Eriochloa annulata*, *E. punctata*, *Microlæna stipoides*, *Panicum decompositum*, *P. distachyum*, *P. divaricatissimum*, *P. effusum*, *P. flavidum*, *P. leucophæum*, *P. macractinum*, *P. melananthum*, *P reversum*, *P. trachyrachis*, *P. prolutum*, *Poa cæspitosa*, and *Setaria glauca*.

Grasses to Cultivate for Grain.—It is a most remarkable fact that the native country of wheat, oats, and barley should be entirely unknown. Many eminent botanists are of opinion that all our cereals are artificial productions, obtained accidentally, but retaining their habits, which have become fixed in the long course of ages, and the following observations seem to bear out this theory. It has been observed that when oats are grown on poor land, and shed their grain, the progeny will, if left uncultivated for a generation or two, revert to the wild oat, but that cultivation will bring the grain back to its proper standard. *Ægilops ovata* is said to be the origin of all our cultivated wheats, and as a convincing proof of this it is a remarkable fact that this genus of grass is subject to the attacks of the same species of parasitic fungi which affect the wheat crops of the present day, and render them somewhat uncertain in some districts during some seasons. When these plants can be so changed with cultivation as to afford us useful grain, it seems a most feasible thing that out of three hundred and sixty species found on this continent some could be cultivated that would yield good grain, without its attendant drawbacks in the way of parasitic fungi, especially on the arid central plains of Australia, where wheat and other cereals would not mature grain, on account of the great climatic heat. During my experiments I observed that the grains of some of our grasses developed very much under cultivation, more especially in one species, *Astrebla triticoides* (var.

lappacea). This grass produced ears nearly six inches in length, and were well filled with a clean-looking firm grain, which separated easily from the chaff, somewhat like wheat. During my long observations I never have seen any species of parasitic fungi attack either the straw or grain of this grass, nor from enquiries have I ever heard that this grass is affected with fungoid growth. Most grain-producing plants are of annual growth, but this species is perennial, and attains a height of from three to four feet. It has a stout, clean straw, which would, after the grain was threshed out, make good fodder. Other species that might be cultivated for grain are—*Leersia hexandra* (the native rice grass), *Panicum decompositum*, *P. flavidum*, *P. semialatum*, *P. trachyrachis*, *Setaria glauca*, and *S. macrostachya*.

The following species are the most suitable for growing on wet or undrained lands:—*Arthraxon ciliara*, *Diplachne fusca*, *Elionurus citreus*, *Glyceria fluitans*, *G. fordeana*, *G. ramigera*, *Hemarthria compressa*, *Imperata arundinacea*, *Isachne australis*, *Ischæmum australe*, *Leersia hexandra*, *Leptochloa chinensis*, *L. subdigitata*, *Panicum indicum*, *P. melananthum*, *P. prolutum*, *Paspalum distichum*, *P. scrobiculatum*, *Pennisetum compressum*, *Phragmites communis*, *Pollinia fulva*, *Sporobolus diander*, *S. virginicus*, and *S. indicus*. The last is an exceedingly tough grass, which I have often recommended for paper-making. In strength it is equal to the esparto grass of Spain (*Stipa tenacissima*), when cultivated in Australia.

Grasses suitable for growing on dry, stony ridges, or on poor soils, are *Amphipogon strictus*, *Arundinella nepalensis*, *Cenchrus australis*, *Echinopogon ovatus*, *Eragrostis chætophylla*, *E. eriopoda*, *E. falcata*, *E. laniflora*, *E. lacunaria*, *Festuca bromoides*, and *Neurachne mitchelliana*.

Grasses that will grow on the littoral sandy wastes of this continent are of especial value, not only as fodder-plants, but they assist in binding, and thus prevent the loose sand from being blown inland by the fury of sea winds. The following species are amongst the best for this purpose:—*Distichlis maritima*, *Imperata arundinacea*, *Lepturus incurvatus*. *L. repens*, *L. cylindricus*, *Paspalum distichum*, *Schedonorus littoralis*, *Spinifex hirsutus*, *Sporobolus virginicus*, *Thuarea sarmentosa*, and *Zoysia pungens*.

It has been often remarked that many of our native grasses, while young, are really good pasture-plants, but at the season of ripening their seeds are irritating and dangerous to the eyes of sheep, often causing blindness, and this is no doubt correct. But, in a great measure, this could be guarded against, if pastoralists were to confine their sheep to small areas until the seeds had fallen to the ground, which, under ordinary circumstances, would not be longer than three weeks, when most of the danger would be past. Once the seeds, with their adherent awns, are shed, they are comparatively harmless to the animals' eyes, though they may get into the wool. Unfortunately, the grasses that bear these long awns are not so freely eaten when they become old by cattle or sheep as most other species are, consequently they grow and produce seed almost undisturbed. I have noted, however, that when these grasses are brought under cultivation their seeds and awns lose much of the rigidity common to uncultivated ones. After some years of observation I have arrived at the conclusion that the following species are most to be dreaded, on account of their long seed awns, or sharp pointed leaves :—*Aristida arenaria*, *A. behriana*, *A. calycina*, *A. depressa*, *A. hygrometrica*, *A. leptopoda*, *A. ramosa*, *A. stipoides*, *A. vagans*, *Heteropogon contortus*, *H. insignis*, *Pollinia irritans*, *Stipa aristiglumis*, *S. flavescens*, *S. micrantha*, *S. pubescens*, *Stipa scabra*, *S. semibarbata*, *S. setacea*, *Triodia cunninghami*, *T. irritans*, *T. mitchelli*, *T. microstachya*, *T. procera*, *T. pungens*, and *Eriachne squarrosa*, thus making in all twenty-six species, which is a little over seven per cent. of those recorded for the whole of Australia ; not a very formidable array, it must be admitted, still of sufficient importance to make their position felt, and somewhat dreaded, by the sheep-owner.

It has been often asked of me whether I favour the annual burning-off of grasses. With three exceptions I am decidedly against burning-off, for the following reasons :—1st. It destroys millions of grass-seeds, which an occasional good season may have brought to maturity, thereby destroying the only natural means for their reproduction. A fire also destroys many valuable salsolaceous and other plants. 2nd. Because, after burning-off, if favourable weather ensues, new growth is made quickly, and sheep turned on to this eat greedily of it, which gives them what is commonly termed the scours, or diarrhœa, which often becomes chronic, and of course has such a weakening effect upon them that many die. Nor is this all, for when biting out the young growth from the heart of the plant, the sheep often takes the whole plant out by the roots and thus destroys it. If a fire should take place, sheep should never be turned into the pasture until it has made considerable growth, though cattle may be turned in without any serious damage being done, for they never eat grasses so low as do sheep. I may here mention the fact that sheep destroy the natural grasses and herbage in much less time than horses, and they again much sooner than cattle.

I am in favour of burning-off annually under such conditions as the following :—1st. Where grasses are much diseased with parasitic fungi ; 2nd, where there is a predominance of spear-grasses ; and 3rd, where such rank grasses grow as those I described suitable for wet or undrained soils, for along with this coarse growth many noxious plants and fungoid pests are destroyed. (It is very rarely good pasture plants, other than grasses, will grow in such situations). Pasture in these circumstances becomes more healthy, the fire acting as a disinfectant, and contagious diseases disappear. Grasses that will grow in low, damp situations are a valuable stand-by for the pastoralist during protracted droughts.

Salsolaceous or Chenopodiaceous Plants.—These most valuable plants are, from year to year, becoming more scarce on the western plains of this continent. Being so closely fed down gives them little chance to mature seed, which is their only natural means of reproduction. When left unmolested for a time, however, they will produce an abundance of seed, which germinates readily under ordinary conditions; many of them, also, are readily increased by cuttings, so that it would require no great outlay to enter upon a proper system of conservation, and even cultivation. Moreover, once the plants are established, they will continue to grow in the most adverse circumstances of drought and great heat; in fact, very few other kinds of plants, so useful for fodder purposes, could exist under such adverse circumstances as do most kinds of the saltbush family. There is abundant proof that when sheep are depastured in country where plenty of salinous plants are growing amongst the natural grasses, fluke and other allied ailments are entirely unknown. It has been said that, when horses which are subject to swamp cancer on the low coast lands are turned into pasture where salinous plants are plentiful, this disease entirely disappears. While on the subject of Distoma-disease and other allied ailments, I may mention another genus of plants which should not be overlooked in any system of conservation. It is that of *Zygophyllum*, some species of which act as vermifuges. There are very few species arranged under the order *Chenopodiaceæ*, which are not available for fodder, though exception might be taken to the following species. During protracted droughts balls of cotton-like substance form on *Kochia aphylla*, *Enchylæna tomentosa*, and a few other plants of the order. The fulvous tomentum on some species of *Sclerolæna*, and the woolly covering of the fruits of some species of *Chenolea*, have been known to kill sheep when they have partaken too freely of this indigestible stuff, along with parts of the plants. The dorsal spines on the fruit of all species of *Anisacantha* cause some trouble to the salivary glands of sheep and other small herbivora when they partake too freely of the plants when the fruits are near maturity. *Anisacantha muricata*, makes the troublesome "roley-poleys' of our central plains. The following is a synopsis of those species which have come under my observation, and I can recommend as being worthy of conservation :—*Rhagodia billardieri*, *R. gaudichaudiana*, *R. hastata*, *R. nutans*, and *R. parabolica*, *Chenopodium carinatum*, *C. auricomum*, *C. atriplicinum*, and *C. triangulare*, *Atriplex campanulata*, *A. cinerea*, *A. halimoides*, *A. holocarpa*, *A. muelleri*, *A. nummularia*, *A. rhagodioides*, *A. semibaccata*, *A. leptocarpa*, *A. spongiosa*, *A. velutinella*, *A. vesicaria*, and *A. stipitata*. Many of these Atriplexes, when cooked, are excellent table esculents. *Kochia aphylla*, *K. ciliata*, *K. eriantha*, *K. lobiflora*, *K. pyramidata*, *K. sedifolia*, and *K. villosa*. A detailed description of all these valuable salinous and other plants used for fodder in Australia will be found in an illustrated work I am compiling, and which will shortly be out of the printer's hands, when, I hope (for the welfare of the pastoral industry), more attention will be devoted, if not to their cultivation, at least to a system of conservation.

7.—AN INDUSTRIAL FEDERAL DEBT.

By J. J. Fenton, F.S.S.

8.—REGULATION OF THE LIQUOR TRADE AS A MEANS OF PROMOTING TEMPERANCE.

By J. B. Gregory.

9.—CO-OPERATION: DISTRIBUTIVE AND PRODUCTIVE.

By W. Nutall.

10.—SOUTHERN WHALING.

By S. W. Viney.

Section G.

ANTHROPOLOGY.

President of the Section: Hon. John Forrest, C.M.G., M.L.C.

1.—ABORIGINES OF TASMANIA.

By James Barnard, Vice-President of the Royal Society of Tasmania.

The extinction of a race of people, however insignificant, is an event which cannot be contemplated without some degree of emotion, and must awaken in the mind a desire to trace out the cause of such a phenomenon. It cannot, therefore, but prove of interest to investigate the facts connected with the gradual dwindling down, and ultimate disappearance from the world, of any portion of the family of man.

Such is the case of the aborigines of Tasmania—its former princes of wastes and lords of deserts—who have now ceased to exist as a distinct people; and therefore it is my purpose to rescue their memory from oblivion by collating from all available sources particulars of their life's history from the cradle to the grave, and embodying the result of my researches in this memoir. But it must be understood that scarcely any knowledge of their condition prior to contact with the white man is attainable. Their past is wrapt in impenetrable obscurity, without any monument or historical record existing to tell of their origin and mode of life, save only some faint traditionary lore gathered from their lips by successive inquirers.

It has become an axiom that, following the law of evolution and survival of the fittest, the inferior races of mankind must give place to the highest type of man, and that this law is adequate to account for the gradual decline in numbers of the aboriginal inhabitants of a country before the march of civilisation. Whatever degree of force or truth there may be in this statement, it may be fairly admitted that partial amelioration in the condition of the original natives of a country has not exercised the benign influence upon their existence which might have been reasonably inferred. From previous habits and modes of life the indigenous inhabitants are not placed in harmony with their new surroundings physically or morally, and are consequently disqualified from deriving a full share of benefits therefrom. Now, must it be supposed that this race of our fellow-creatures—the original lords of the soil—have not as a general rule been duly cared for since their enclosure within the pale of civilised life? So far, however, from there being reason to suppose that there has been any culpable neglect, it is believed that the most humane sympathy and consideration have been constantly evinced on the part of successive Governments, and that whatever was likely to render the condition of these "children of nature" happy and comfortable have been freely bestowed; nor has this been confined to physical enjoyments alone, to the bestowal of mere clothing, food, shelter, and amusements. Education, to the extent of which their faculties are susceptible, has been attempted, but with varying degrees of success.

Conflicts between the intruders on a territory and its original possessors become inevitable until the supremacy of the invader has been once established; and in the case of the Tasmanian race this state of things has been largely aggravated by the influx of Britain's criminals—the outcasts of society—in days gone by, resulting in many a deed of violence and cruelty towards the poor natives, causing much bloodshed and leading to heavy reprisals. This forms a very painful episode in the annals of Tasmania, which it is beyond the proper scope of this paper to enlarge upon.

With these preliminary observations I pass on to a general description of the physical and other characteristics of the aborigines of Tasmania, and shall then enter into details under distinct sectional headings, of the several particulars concerning the race.

In stature some of the natives were tall, and a few were robust, but most of them were slimly built, wiry, and very agile. Their colour was bluish-black, less black than African negroes, but slightly more so than Lascars. The features of neither sex were prepossessing, especially after passing middle age. Their noses were broad, and their mouths generally protruded. In youth, some of the women were passably good-looking, but not so the most of them. The women had a fashion of shaving the head quite closely, which, in their wild state, was done with flints and shells, and subsequently with glass when they could get it. The men, on the contrary, allowed their hair, which was black and woolly, to grow very long and plastered it all over very thickly with red ochre and grease, and when it dried a little their locks resembled a bundle of painted ropes, the red powder from which gave the native savage a most repulsive look. The shoulders and breasts were marked by short raised scars, caused by cutting through the skin and rubbing in charcoal, somewhat resembling the marks made by a cupping instrument, but much larger and wider apart.

It has been customary to describe these natives as the lowest in the scale of humanity, and if this opinion be founded upon the absence of accountability for their actions, such an estimate of their moral condition can scarcely be controverted. If, however, we regard the methods which they devised for procuring shelter and subsistence in their native wilds, the skill and precision with which they tracked the mazes of the bush, and the force of invention and of memory which is conveyed in the copious vocabulary of their language, we must allow them to have possessed no inconsiderable share of mental power and activity. Their migratory habits, arising from their dependence upon the chase, combined with the mildness of the climate, rendered unnecessary the building of huts of a substantial character. In the neighbourhood of the sea they sought no other retreat than the caves on the coast; and in the more open country they erected breakwinds, which consisted of huge branches of trees firmly wedged together, and supported by stakes in the form of a crescent, the convex side of which was so placed as to oppose itself to the wind. A fire was kept burning to leeward, so that they were cheered by its heat without suffering annoyance from the smoke. Rude and insufficient as such structures may appear to us, they afforded as much protection and comfort as they cared for. Even subsequently, after being accustomed to the shelter of a cottage, they would gladly escape from it for the luxury of roaming through the bush, and of reclining under the shade of a roofless breakwind. In sickness, and on the approach of death, their desire was to meet it under the view of the heavens.

Coming now to the more immediate scope of this paper, which is to present in detail the several particulars outlined under special sectional headings, I may be permitted to state that I was led to undertake this task from having been occasionally, some forty years ago, a visitor to the home of the aborigines at Oyster Cove, then consisting of a remnant of some 30 to 40 men, women and children, and had opportunities of observing their habits and manners in their semi-civilised condition. I deem it right also to say that I have freely drawn from the best sources of information available, without assigning the particular authority for each statement, but the writers to whom I am chiefly indebted are Strzelecki, Dove, Davies, Friend, Milligan, West, Bonwick, Calder and Smyth, the titles of whose books and articles will be found in the bibliography appended.

BIRTH AND CHILDHOOD.

There are no special observances or superstitious beliefs in connection with the birth of a child, whether male or female; but when a woman was taken in labour during the wanderings of a tribe, she was not waited for, but left behind with another woman, and afterwards followed as best she could. Soon after the birth she carried her baby to the river, and plunged in with it. The child at its birth was white, and gradually assumed the dark colour; and it was usual, when its head was a bad shape, to improve it by bandaging. Mothers suckled their infants for a long time, two years or more; in fact, until they could walk about, and, as a rule, were extremely fond of their offspring, and when otherwise occupied they were accustomed to place their babies in the hot sand to keep them warm. They carried their infants in a kangaroo-skin at their backs, and suckled them over their shoulders; the breasts of the female became consequently much elongated. The fathers never carried their children. Mothers were generally averse from having a family, as it so materially interfered with their hunting, and they frequently resorted to artificial means to prevent it, such as placing a hot sandstone on the abdomen.

There is no reason to suppose that infanticide existed among them in their wild state. There is little doubt, however, but that it was not uncommon in late years, driven to it as they in all probability were by the continued harassing of the whites; in fact, when their fear of the latter prevented their killing the kangaroo in their usual manner, dogs became so extremely valuable that the females have been known to desert their infants for the sake of suckling the puppies! Infanticide, in the case of half-castes, was not unknown. An instance is given of a mother who had immolated her infant of mixed origin, excusing herself by saying it was not a "pretty baby." This was, however, far from universal, and was more commonly the act of the tribe than of the mother. A native woman, who had an infant of this class, fell accidentally into the hands of her tribe, who tore the child from her arms and threw it into the flames. The mother instantly snatched it from death, and, quick as lightning, dashed into the bush, where she concealed herself until she made her escape. The injuries which she received were, however, fatal.

Cannibalism seems, on the best authority, to have been only partially practised among a few tribes of natives in their wild state, but under what circumstances is not clear. Truganini denied that it ever existed in her own tribe, that of Bruni Island.

The male children were taught by their elders to throw the spear, to use the waddy, to climb trees, and to throw stones, and were made fit to take part in fights and dances.

Names were given in infancy by parents, and were usually taken from any surrounding object that took their fancy, such as an animal, shell, tuft of grass, &c. Later on, when the church intervened to perform the rite of baptism, suitable Christian names were duly forthcoming.

MATURITY.

No particular age has been fixed for the attainment of maturity by either sex, but some ceremonies attended the initiation of the young males into the rights and privileges of manhood. They were given over to the old women, who cut them on the thighs, shoulders, and muscles of the breast with stone-cutting implements, and thus raised cicatrices. These scarifications were intended as ornaments.

The women had raised cicatrices on their bodies, but it is uncertain whether they were purposely made and intended as ornaments, or were the result of the cuttings and bleedings to which they were subjected when sick.

There is no evidence of circumcision having been known to the aborigines.

MARRIAGE.

There were restrictions on marriage amongst the aborigines. A man was not permitted to marry a woman of his own tribe. Little or nothing beyond this is known of the customs which the men followed in selecting wives; but it is believed that, as in the case of other barbarous races, they often resorted to violence in choosing their brides. A man had usually but one wife, but polygamy was not unknown. Polyandry, or something very like it, also existed; and widows, it is affirmed, were, unless given in marriage, the common property of the males of the tribes into which they had married.

The women were seldom accompanied by many children; but there is no reason to suppose that, in their natural condition, they were less prolific than people of other races.

Strzelecki relates the remarkable fact that after intercourse has taken place between an aboriginal female and a European male, the former loses the power of conception on the renewal of intercourse with the male of her own race. This writer mentions that hundreds of instances are on record among other aboriginal races in support of this hypothesis. This curious theory is refuted by Lieut. M. C. Friend, R.N., in a paper read by him before the Tasmanian Society on 10th March, 1847, "On the Decrease of the Aborigines of Tasmania," quoting two instances to the contrary which came under his notice while visiting Flinders Island. He writes:—"One, a black woman named Sarah, the mother of four half-caste children by a sealer, who afterwards married a man of her own race, by whom she had three black children. The other, a black woman named Harriet, who similarly had two half-caste children, and afterwards married a black man, and became the mother of a healthy black infant." Bonwick, in opposition to Strzelecki's theory, quotes the following letter from Mr. Hagenauer, German missionary at Gippsland:—

"This is not true, for every woman (at his mission) who had a half-caste child has had black children afterwards, and is still getting them." He also cites the testimony of the Rev. George Taplin, of Queensland mission: "I have known many instances of women bearing black children after half-castes." Other evidence to the same effect has been furnished me by a gentleman of considerable experience as a squatter and landholder, both in New South Wales and Queensland, conclusively proving Strzelecki's theory to be untenable.

West justly remarks, in his "History of Tasmania," that a natural law by which the extinction of a race is predicted will not admit of such serious deviations. The condition of an aboriginal wife was abject in the extreme, having to labour unceasingly. She had to provide food for her master, to keep his fire ready for cooking, and to cook his food, and, when marching, whatever was deemed necessary for the new encampment. With one or two children, and a heavy load of weapons and utensils, her progress was painful. In fact, while the men hunted and amused themselves, their wives did all the drudgery.

THE TRIBE.

When Tasmania was first occupied by Europeans, its aboriginal population spread in tribes, sub-tribes, and families over the length and breadth of the island, from Cape Portland to Port Davey, and from Oyster Bay to Macquarie Harbour. Assuming that these groups were then about 20, and that each consisted, in men, women and children, of from 50 to 250 individuals, and allowing to them numbers proportional to the means of subsistence within the limits of their respective hunting-grounds, it does not appear probable that the aggregate aboriginal population exceeded 2000. These tribes were distinct, and were known as the Oyster Bay, the Big River, the Stony Creek, and the Western; but there was a sub-division of these into smaller communities, besides separation from each other by dialects and well-established boundaries.

The open grassy plains, and thinly-timbered forest ground along the eastern and central portions of the island were the most attractive to the early settlers, and were consequently the first occupied; but these were the districts chiefly frequented by the aborigines at that time. It is to be regretted that the pioneers of civilisation, enjoying such facilities for studying the habits and customs of the people with whom they enjoyed familiar intercourse, have left no record of the simple race whose position, rights and very existence they had come to usurp and supersede.

Every tribe was sub-divided into families, and each family was regulated by the elders. Again, in these tribes there existed three distinct classes, or social gradations, which were attained through age and fidelity to the tribe; but it was only the third class which was initiated into the hidden mysteries, and possessed the power of regulating its affairs. Secrecy was usually observed in the ceremonies of admitting the youth to the first class, and in raising those of the first to the second, but the secrecy was most rigidly observed whenever an initiation into the third class took place.

The customs attending births, marriages, sickness, funerals and feasts were traditionary, and rigorously adhered to.

SOCIAL AND DOMESTIC.

The aborigines generally selected the banks of a river or lagoon for their encampment. Each family had its fire, hunted separately, and erected a hut for its own accommodation. On mountains, and beside the sea-shore, they lodged in caverns, or where these were not found, as in the open country, they constructed huts, or rather screens. These were of bark, half-circular, and gathered at top, and supported by stakes; and in front they kindled a fire. These huts formed rude villages, of some seventeen to forty together; the former number being raised by a tribe of seventy, from four to five must have lodged under one shelter. Some, found at the westward, resembling beehives, and thatched, were evidently for permanent occupation. Water was drawn for the sick in shells; those in health threw themselves on the bank and drank as they lay. Fire was preserved usually by carrying a brand; and it is believed they were not ignorant of the mode of producing fire by friction.

As to food, their appetite was voracious. A woman was watched one day, during which she devoured about fifty eggs of the sooty petrel (*Procellaria* sp.); and an eye-witness beheld a child, eight years old, eat a kangaroo-rat and attack a crayfish. Animals and birds were roasted by being thrown on the fire with their skins on. Shell-fish were also roasted. The natives were very partial to a large white grub found in rotten wood; and they used as food various roots, as an indigenous potato, a fungus called native bread *(Mylitta australis)*, which tasted like cold boiled rice. The animals on which they subsisted chiefly were the emu, kangaroo, wallaby, bandicoot, and the opossum, the latter living in trees. The women were accustomed to dive for shell-fish, which they placed in a rude basket tied round the waist. Mounds of oyster-shells, the accumulation of ages, are met with on various parts of the sea-coasts.

During the winter the natives visited the sea-shore, disappearing from the interior about June, and returning to their settlement in October.

As to dress and ornaments. In summer both sexes went entirely naked, and in the winter the shoulders and waist were protected by dried kangaroo-skins. During days of rain they kept under shelter, cowering over their fires. The men smeared their heads with grease and red ochre, partly for ornament and partly as a substitute for cleanliness. Bits of wood, feathers, flowers, and kangaroo-teeth were inserted in the hair, which was separated into tufts, rolled and matted together. This decoration was denied the women, whose hair was cropped close with a sharp crystal, some on one side of the head only, in others like a priest's tonsure. Several methods of ornamenting the body were adopted by the different tribes; patches of ochre and grease formed a considerable portion of such adornment. A necklace was worn called *Merrina*, composed of pearly-blue shells (*Elenchus irisodontes*), bored by the eyetooth, and strung on the sinews, of the kangaroo. These shells were cleansed, and received a high polish.

The arms and implements of the natives were of the simplest description. The waddy was a short piece of wood, reduced and notched towards the grasp, and slightly rounded at the point. The spear, nine or ten feet long, was pointed at the larger end, straightened by the teeth, and balanced with great nicety. The spearman, while poising the weapon, held others in his left hand, prepared for instant use. The spear, thus poised, seemed for a few seconds to spin, and would strike at sixty yards with an unerring aim.

In the Tasmanian museum there is an aboriginal stone hatchet having a wooden handle, secured with gum of the grass-tree (*Xanthorrhœa australis*). The head of the axe is made of greenstone, and is double-edged. There are also waddies and hunting spears, ten to fifteen feet in length, and made of the tall straight-grained *Leptospermum*, or tea-tree, of the colony.

In procuring foods the natives were agile and dexterous. The opossum was hunted by the women, and in doing so they ascended trees of an immense height. They first threw round the tree a rope of kangaroo sinews twice its girth, which they held in one hand; then, having cut the first notch for the toe, they raised themselves up by the rope, in an attitude sufficiently perpendicular to carry the hatchet or the stone on the head; they then cut a second notch, and by a jerk of the bight of the rope raised it up; thus, step by step, they reached the branch, over which the loose end of the rope being cast, they were enabled to draw themselves round.

The acquaintance of the aborigines with arts of any kind was of the most limited description, being confined to the fabrication of their simple arms, baskets, canoes, ropes of kangaroo sinews, and necklaces. The baskets were made of the long leaves of a cyperaceous plant called cutting-grass, very neatly woven together; and the necklaces of small, beautiful shells, iridescent, the purple tint preponderating. In the natural state they have no great beauty, but after the removal of their outer coating their appearance was quite altered.

Their corrobories and dances were attended by great numbers. At these meetings they raised large fires, and continued dancing till midnight. They first began with slow steps and soft tunes, then advanced more quickly, when their voices became more sharp and loud; they then closed in upon the fire, and, keeping close to the flame, appeared in considerable peril. These movements they continued, shrieking and whooping, until thoroughly exhausted. The dances were various: the emu dance, representing the motions of that bird; the horse dance (necessarily modern) was performed by their trotting after each other in a stooping posture, and holding the foremost by the loins; the thunder-and-lightning dance was merely stamping the ground.

WIZARDS.

No pretensions to any kind of witchcraft seem to have ever sprung up among these aborigines. The character of the tribe was stamped, with very slight varieties, on all the individuals of whom it was composed. In cases of sickness or violent pain relief was generally sought by bleeding the sufferer, which was effected by means of sharpened flint or crystals. No one claimed to be better qualified than another to administer a cure. The office of watching over the sick and dying was left to the women.

Several diseases prevailed among the natives, especially rheumatism and inflammation, which were cured by gashes cut with crystal. A loathsome eruption, of the nature of leprosy, was relieved by wallowing in ashes; and the catarrh was often fatal. Snake-bite was treated by boring the wound with a charred peg, stuffing it with fur, and then singeing to the level of the skin. As charms, thigh-bones were fastened on the head in a triangle. The sick were often deserted by the tribes, food being left within their reach.

Two superstitious customs prevailed among them. One was an anxiety to possess themselves of a bone from the skull or the arms of their deceased relatives, which, sewn up in a piece of skin, they wore around their necks, confessedly as a charm against sickness or premature death. The other was a fear of pronouncing the name by which a deceased friend was known, as if his shade might thus be offended. To introduce, for any purpose whatever, the name of any one of their deceased relatives, called up at once a frown of horror and indignation, from a fear that it would be followed by some dire calamity.

DEATH.

When a death occurred in a tribe they placed the body upright in a hollow tree, and, having no fixed habitation, pursued their way. When a year or so had passed, they would return to the spot and burn the body, with the exception of the skull; this they carried with them until they chanced to fall in with a cemetery in which a number of skulls were heaped together, when they added the one with them to the number, and covered it up with bark, leaves, &c. They do not bury their dead in the earth, nor is there any ground for supposing that either weapons or food were placed in the tree with the corpse.

During the whole of the first night after the death of one of their tribe they will sit round the body, using rapidly a low, continuous wail or recitation to prevent the evil spirit from taking it away. They were exceedingly jealous of this ceremony being witnessed by strangers, but an opportunity was afforded to Mr. R. H. Davies, to whose highly interesting account of the aborigines I have been much indebted in the compilation of this paper, of becoming an eye-witness of the proceedings during the whole night.

According to Dr. Milligan, the dead were variously disposed of by different tribes: by some the bodies were burnt, by others placed in various attitudes in hollow trees and abandoned; while by others the dead bodies were thrown into holes made by the casual uprooting of large trees, and partially covered with leaves and rubbish.

When they go into mourning they rub themselves over with white pipe-clay, giving them a ghastly appearance.

SPIRIT WORLD AND MYTHOLOGY.

The moral apprehensions which prevailed amongst the aborigines were peculiarly dark and meagre. It is remarkable that a persuasion of their being ushered by death into a happier state of existence was almost the only remnant of a primitive religion which maintained a firm hold on their minds; but their ideas of a life beyond the grave were entirely of a sensual kind. To be enabled to pursue the chase with unwearied ardour and unfailing success, and to enjoy with unsated appetite the pleasures which they counted on earth, were the chief elements which entered into their picture of an elysium. While there was no term in their vocabulary to designate the Supreme Being, they stood in awe of an imaginary spirit, who was disposed to annoy and hurt them. The appearance of this malignant demon in some horrible form was especially dreaded by them in the season of night. They seem to have thought the spirit world was above, and believed in the continued existence of spirits, whom they called "Rowra," and that the spirits of departed friends came and talked with them, and that at death they joined them. Some imagined they would go back to their own tribes, and that spirits came to them before death and conversed with them.

An excellent authority, Dr. Milligan, who lived in familiar intercourse with the aborigines both at Flinders Island and Oyster Cove, said he had ascertained that previous to their intercourse with Europeans they distinctly entertained the idea of immortality as regarded the soul or spirit of man. Their legends proved also their belief in a host of malevolent spirits whose abodes were caverns and dark recesses of the dense forests, clefts in rocks on the mountain tops, &c. At the same time they reposed unqualified trust in the tutular agencies of the spirits of their departed friends. To these guardian spirits they gave the generic name "Warruwah," an aboriginal term like the Latin word *umbra*, signifying shade, shadow, ghost or apparition.

PHILOLOGY.

According to Strzelecki, the language of the aborigines was highly sonorous and euphonious, and he would class it among those called transpositive—those which are independent of articles and pronouns, the case and person being determined by the difference in the inflexion.

R. H. Davies remarks that the language of the natives is very soft and liquid, as loro-loubra, a white woman; loro-whanga, a white mountain; ringarooma, booby alla, &c. The dialects are numerous, and the language in different parts of the island appears to be wholly different; to the westward they call water "mocha" and "mogana"; to the eastward, "lina." The aborigines acquired great facility in pronouncing English words, but they could not pronounce the hard letters as *d* and *s*; doctor they pronounced "togata" or "tokatu"; sugar, "tuguna"; tea, "teana."

The best authority, however, on the dialects and language of the aboriginal tribes of Tasmania was the late Dr. Joseph Milligan, F.L.S., who was for some time in charge of the establishment at Flinders Island, and subsequently, upon the removal of the natives to the mainland, became medical superintendent to the settlement at Oyster Cove. Dr. Milligan communicated to the Royal Society of Tasmania a copious vocabulary of dialects of aboriginal tribes of Tasmania, tabulated alphabetically, together with numerous short sentences in the native language, with their English equivalents, and also some names of places and persons in both languages, the whole paper extending over 36 pages, and printed in the Transactions of that Society for the year 1854.

Dr. Milligan explains that perfect confidence may be placed by ethnologists in the words and sentences thus recorded by the method which he adopted of submitting them to several aborigines, first giving the English words and then taking down from them the corresponding native words. This, of course, he remarks, was a most tedious method to pursue, but it was the only plan which gave a fair chance of precision and truthfulness.

The aborigines had no words to express abstract ideas, or any powers of generalisation—as, for instance, they had names for each variety of gum-tree and wattle-tree, &c., but they had no equivalent for the expression "a tree;" neither could they express abstract qualities, such as hard, soft, warm, cold, long, short, round, &c. For "hard" they would say "like a stone;" for "tall" they would say "long legs;" and for "round" they said "like a ball," "like the moon," and so on.

Their numeration was limited to five, and when these were exhausted, the word "many" covers all in excess of that number. They are thus expressed :—

One	Marrawah
Two	Piawah
Three	Luwah
Four	Puguntawulliawah
Five	Puyganna marah
Many (a great number) ...	Luawah
Few	Luowa.

A few English sentences translated :—

Give me a stone	Lonna tyennabeah
Give him a stone	Lonna tyennamibeah
I give you some water ...	Lina tyennamibeah
Give me some bread	Tyanna miapa pannaboona
We drink water...	Loa liyé
This water is salt	Lia noateyé
That water is fresh	Liana elubana
The woman makes a basket ...	Lowanna olle tubbrana.

List of words for the English :—

Man	Puygaunah
Woman	Lowanna or Lowa
Head	Oolumpta
Hair of head	Poinglyenna
Eye	Mongténa
Nose	Munuua
Tongue	Kayena
Ear	Mungenna
Hand	Riéna
Thumb	Rianaoonta
Foot	Luygana
Water	Liena
Sun	Pugganoobranah
Moon	Wiggeteena
Blood (my)	Warrgata meena
Fire	Zonna
Father	Noonalmena
Mother	Neingmenna
Son	Malangaua
Daughter	Neautyména
Brother (little)	Nietta ména
Brother (big)	Puggana Tuantittyah
Sister	Nowantareena.

Some verbs :—

Give	Lonna
Take	Nuuné
Make	Wurrangaté
Burn	Punna
See	Mougtone
Hear	Toienook boorack
Go	Zuwé
Kill	Mienémiento.

Not possessing a key to the etymology of aboriginal words, or to the conjugation and declension of the verbs cited as examples, I have only been enabled to meet the other requirements of the Section by giving specimens of the aboriginal language with the corresponding English words and sentences.

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2.—TOTEMS IN MELANESIA.

By the Rev. R. H. Codrington, D.D.

The word Totem is now very commonly used in the description of the ways of life by uncivilised people. The Totem, originally a mark of family or tribe among the Indians of North America, has been recognised far away from the birth-place of its name. Totemism has come to be the name of a system of savage beliefs and practices, and also of a system of arranging and interpreting such beliefs and practices. Both Totems and Totemism have an acknowledged place in the anthropology of Australia; the present paper will contain an attempt to ascertain whether a place is equally due to them in Melanesia.

Mr. J. S. Frazer, of Trinity College, Cambridge, the writer of the article "Totemism," in the new edition of the *Encyclopædia Britannica*, gives the following descriptions and definitions of a Totem‡ :—"1. 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. 2. The connection between a man and his Totem is mutually beneficent; the Totem protects the man, and the man shows his respect for the Totem in various ways, by not killing it if it be an animal, and not cutting or gathering it if it be a plant. 3. A Totem is never an isolated individual, but always a class of objects. 4. Totems being either common to a clan, or to to a sex, or belonging to a single individual, the clan Totem is reverenced by a body of men and women who call themselves by the name of the Totem, believe themselves to be of one blood, descendants of a common ancestor. 5. The members of a Totem clan call themselves by the name of their

‡ "Totemism." Edinburgh: A. and C. Black, 1887.

Totem, and commonly believe themselves to be actually descended from it. 6. Believing himself to be descended from, and therefore akin to, his Totem, the savage will not, as a rule, kill nor eat it."

Looking for Totems answering to this description of them in Melanesia, I find them in a paper by Mr. Danks, read before the British Association at Bath in 1888. He describes Totems as he finds them in New Britain. Having no knowledge, however, of these things myself, I make no comment on them further than to observe that I believe that it must be right to interpret them according to the analogy which they bear to what has been observed in other parts of Melanesia.

Passing on to what I have myself observed and enquired into, I will arrange beliefs and customs in Melanesia which seem to belong to Totemism according to five examples:—1. In the island of Aurora, in the New Hebrides, mothers sometimes have a fancy, before the birth of a child, that the infant is connected in its origin with a cocoanut or breadfruit, or some such object, a connection which the natives express by saying that the children are a kind of echo of such things. The child, therefore, is taught not to eat that in which it has had its origin, and is told, what the mothers entirely believe, that to eat it will bring disease. In the Banks' Islands a man will get a notion that he is connected in origin with a cuttle-fish, for example, or a crab, which he sees when he dives into a pool among the coral rocks. He will say that the creature is his "beginning." 2. In the Banks' Islands, again, some men had a persuasion that there was something, generally something animate, which was peculiarly and intimately connected with himself, something either shown him by another in that character, or discovered under some circumstances by himself. Such a thing a man believed to be a kind of reflection of his own personality; he and it would live, flourish, suffer and die together. 3. In the island of Ulawa, in the Solomon group, it was observed that the people of a part of it would not eat bananas, and had ceased to plant them. The reason they gave for this was that to eat bananas would be displeasing to the objects of their worship. In the neighbouring part of Malanta it was found to be not unusual for a great man, before his death, to announce that after death he should be in or associated with some such thing as the banana, for example, which the people afterwards would not eat, because to eat it would be like eating him. 4. In the before-mentioned island of Aurora there are families within the two great exogamous divisions of the people. One of these is named from the octopus. If anyone of another family wished to get octopus for food he would ask one of this family to go to the part of the beach to which the family was said to have originally belonged, and standing there, to cry out, "So-and-so wants octopus." Then plenty would be got. 5. In Florida, of the Solomon group, the people are divided into several exogamous clans, each of which has at least one object which is prohibited to all its members. Thus the members of one division may not eat the giant clam, and the forbidden food of another is the common fruit-eating pigeon. One of these clans is named after a fishing hawk, another after a species of crab, and the crab clan may not eat the crab. A member of one of these clans would not hesitate in saying that the thing he might not eat was his ancestor. In a book called "Percy Pomo" (which describes, in fact, native life in this island), an old native is represented as horror-struck at the sight of dark blue trousers, because some part of the inside of the shark, of a dark-blue colour, was a forbidden thing to his family.

It is easy to see a Totem in each of these examples. An European observer would now be pretty certain to describe them as Totems. A boy in a mission school in Aurora would be observed to refuse to eat breadfruit; a strange phenomenon, which would call for explanation. The explanation given would be understood to be that the origin of the boy was the breadfruit. Similar explanations would connect other boys with other articles of food. They could not, under penalty of sickness or death, eat those things from which they drew their origin or beginning.

A Banks' Islander would be found to have a snake, lizard, or what not, closely connected with his life; his origin or beginning of life would be said to be in it; he would be seen to have great respect for it and care for its well-being, and to believe in a certain influence exercised by it over him. This would be his Totem.

When the people of Ulawa were found to view the eating of bananas with horror, because to eat them would be the same thing as eating their ancestor, the banana would be pronounced to be the Totem of the natives of Ulawa.

Clearest of all would be the Totems of the people of Florida, where one of the crab family might not eat the crab, and where the prohibition of some living object to the members of each clan would be explained by the belief that such object was the ancestor of the clan.

But however readily these things may adjust themselves to a system of Totemism, as conceived in the European observer's mind, it is the conception of them in the native mind, which is really of value; and this is not very easy to apprehend. Investigation and examination does not seem to me to bring out more clearly the character of a Totem in any one of these examples. In Aurora and the Banks' Islands the objects regarded as the origin or beginning of those who so regard them are in no way family or tribal marks; they belong entirely to individuals. The family in Aurora named after the octopus, though it is believed to have some connection with that creature, has no hesitation in eating it, and does not regard it as its origin. The octopus, therefore, is not the Totem of the octopus family. A closer acquaintance with the Florida customs raises many difficulties. It is true that the crab clan does not eat the crab, but the clan named after the fish-hawk has no objections whatever to eating that bird, and does not eat the pigeon; the crab clan, also, is as careful not to eat one kind of parrot as it is to avoid the kind of crab from which it takes its name. Moreover, only two clans out of six are named after living creatures; and there is good reason to believe that the practice of prohibiting some one or more things to all the members of a clan is very much later that the formation of these clans in their present shape. Men alive in Ysabel, very close to Florida, within the last few years could remember when these prohibitions were introduced among themselves, and knew from what quarter they were introduced. Again, it is most important to observe that the worship of the people in the Solomon Islands is directed to those who may be called, though hardly in the common sense of the word, their ancestors, that is, to such of their deceased predecessors as are believed to be now potent in their disembodied state, whose names are known. When they speak of the crab, or the clam, as being ancestors, they mean not an ancestor whose name was crab or clam, but someone of a previous generation, now deceased, whose name is well remembered, who was a man, not a crab or clam, when alive, and now is disembodied as regards his human form, but is in some way embodied in one of those creatures. They do not in the least believe that a crab or a clam begat them or their fathers; they do not in the least believe that the beings once embodied like themselves were ever anything but men, or that they are, when now disembodied, anything else than what they expect to be themselves after their decease, that is, ghosts. As, then, the crab, or clam, is not really an ancestor in the flesh, so the ancestor is not a god.

The explanation of the Ulawa practice of rejecting bananas as food is happily at hand as a matter of history. A powerful man not long ago made it known before his death that after his decease he should be in a banana. The proof of the novelty of this prohibition was found in the abundance of bananas round the village, in which none were eaten. That, then, could not be a Totem which had but lately assumed its special character in consequence of the arbitrary selection of a well-remembered man, although it might well be that some native would explain the reason of his not eating bananas to be that his ancestor (rather, grandfather, great-uncle, &c.) was a banana.

It appears, therefore, that in Melanesia a woman's fancy before her child is born will sometimes connect her child with some object, which the child is taught afterwards to regard as closely related to him; it should be rather said, perhaps, that her fancy connects him with some class of objects, all of which he equally regards. If it be convenient to call that object a Totem, the word must be used with the understanding that no family or tribe mark is meant, and that the origin of the connection is in the fancy of a mother. If the creature with which the Banks' Islander believes himself somehow to be connected in the origin of his life is different from this, it is only that the connection starts from a fancy conceived by himself or suggested by another; the connection is with the single life of the individual man—there is no true Totem. The case of the forbidden food of the Florida clans comes very much nearer to a case of Totemism, though Mr. Frazer's definitions are by no means satisfactory; but the Florida practice is explained by that of Ulawa and Malomba. The fact that the members of each clan abstain from eating something, or more than one thing, which represents to them some ancestor, can be accounted for on the supposition that such an ancestor himself associated his memory with that object. It is, indeed, difficult to believe that any people could seriously think themselves the offspring, however remotely, of a clam or a crab or a banana; the statement that they make, however, means not that a banana was their ancestor, but that their ancestor is a banana.

I conclude, therefore, that to arrange certain Melanesian customs according to a system of Totemism is not difficult, but that to examine them and find true Totems is not easy. It may be that customs in other parts of the world which have been set down to Totemism have been too hastily so characterised; or it may be that the definition of what constitutes a Totem will have to be so altered as to carry the application of the name very far away from that to which it originally and properly belonged. In that case it may be doubtful whether the large use now made of the words Totem and Totemism has been happily begun. In any case these Melanesian examples may be useful, as showing how what really are Totems may have arisen; they throw some light upon that condition of the uncivilised mind in which it seems to be natural to men to conceive some special relation to exist between themselves and some object with which they have no physical connection.

3.—THE AINUS OF NORTH JAPAN.

By Professor Odlum.

4.—THE FOUNTAIN OF "THE MIST."—A RAROTONGAN MYTH.

By the Rev. William Wyatt Gill, LL.D.

The central mountain of Rarotonga is about 3,000 feet above the level of the sea. On account of its being usually enveloped in cloud and mist, it is appropriately named "Te kou," *i.e.*, "The Mist." Unlike most of the other mountains of Rarotonga, which terminate in almost inaccessible peaks, "The Mist" seems perfectly level, as if its summit had been sliced off. From the centre—a weird spot, shut in on all sides by rank vegetation—gushes forth a copious and never-failing fountain. Two species of fish are found in it; one, called the "karaea," about eighteen inches in length, of a yellow colour, and somewhat resembling a lizard; the other, a little fish known at Rarotonga as the "taputapu." How did these fish get there? The natives absurdly imagine that there is a subterranean communication with the ocean, as both are found in salt water.

To this day a hot controversy rages as to the real proprietor of this fountain. Makea, the queen on the northern side of Rarotonga, asserts that it is *hers*, because it originally flowed down her side of "The Mist." The Ngatangiia queens are content to point to the stream actually leaping over the cliff on *their* (the eastern) side of the majestic mountain. The true history of this ancient feud is supposed to be given in the following myth, which I derived from the sage Tearikitaraaere:—

There once lived at Avarua, close to the sea, a divinity named "The Tongan" (Tonga-iti) and his wife Rangatira,‡ usually known as "The Beauty" (Te Ari) One day "The Beauty" said to her husband, "What a lovely creature is yon spotted lizard! Would that you were like him!"

In a moment the complaisant husband entered the lizard. But when the fickle beauty perceived that her once noble husband had actually changed into a crawling reptile, she vented her disgust in the well-known song—

> "The fair Rangatira is angry with the Tongan.
> Disgusted at his altered form.
> She will henceforth deem herself a widow!"

At this the crafty husband remarked, "What a beautiful cuttle-fish is that I see yonder on the reef! I wish you would enter it!" Pleased at this fancy, Rangatira at once did so, but only to earn the disgust of her husband. In her turn she was greatly vexed, and, intent on immediate revenge, she dived to the

‡ Chief or chieftainess.

very depths of the ocean, little thinking that she was closely followed by her husband. On reaching the very foundations of Rarotonga, she clave a hole in the solid rock and earth until she actually emerged at the very crest of the mountain of "The Mist." "Ah!" thought the chagrined beauty, "my husband will never find out my hiding-place." Scarcely had she uttered these words when she discovered her faithful Tongan (Tonga-iti) at her side, in outward appearance resembling a lizard and a fish; so that, whilst she had merely preserved her cuttle-fish form, he had changed his into that of a sea-lizard, to enable him to give chase to his runaway spouse.

For awhile they lived pleasantly together in the spring on the top of "The Mist," which thenceforth was called "The Fountain of the Followed One (Aruea)." It is also denominated "The Fountain of Rangatira," inasmuch as she first made the waters to well up from the heart of the mountain. Facetiously it is also known as "The Shaggy Mouth of the Mist," in allusion to the tall trees and ferns surrounding it.

After a time, becoming weary of their solitary life on the mountain-top, they resolved to return to their old abode near the sea. They accordingly left the fountain in charge of Niu and Nānā, *i.e.*, the "taputapu" and the "karaea," or lizard-fish. But unluckily for their own interests, they omitted to give instructions to these guardians. However, a long reed, which had the wonderful virtue of directing the course of the stream, was inserted in the hole through which the waters rushed. The upper end of the reed was inclined towards the north, so that a stream of crystal water now for the first time hurried on towards the home of these gods† at Avarua.

Shortly after, Toutika (= Hit-the-mark‡) made his appearance on the crest of "The Mist," and found a copious stream flowing in a northerly direction. Addressing the sparkling, gushing fountain, Toutika inquired whether there were any guardians there. A voice from the depths of the waters answered, "Yes; here are two fairies, Niu and Nānā." "Who placed you there?" "The Tongan deity and his wife." "Where are they gone?" "To guide the course of the stream to their home at Avarua." "Well, then," said the crafty Toutika, "should they come back and speak to you, be sure to remain silent, or I will kill you both. When I speak respond at once." Niu and Nānā agreed to this. Toutika now altered the direction of the long reed to due east, and the obedient waters at once abandoned their former channel, and flowed towards Ngatangiia. The successful interloper ran on with the stream, to watch the leaping of the waters from the precipice in the direction of his home.

The lizard god and his mate, the cuttle-fish, finding the waters

† Tongaiti and Rangatira. ‡ Or, "Point aright," doubtless in allusion to this myth.

suddenly fail, hurried back to the fountain to ascertain the cause. They discovered that the direction of the long wonder-working reed had been altered. They soon came upon the unblushing Toutika, and high words ensued. The lizard and cuttle-fish gods claimed the fountain as theirs. Toutika as positively claimed it as his. Toutika demanded proof. Said the Avaruan divinities, "We have appointed two servants of ours as guardians of this spring." It was accordingly agreed that to them the final appeal should be made, and the party to whom these fairies might respond should be regarded as the true lord of the fountain. The lizard and the cuttle-fish gods then confidently and in unison chaunted to the guardians of the spring, but there was no response whatever.

Toutika now exultingly exclaimed, "Did I not tell you that the water is not yours?" The Avaruan divinities faintly said to the interloper, "It is your turn to address the fairies of the spring." Toutika sang these words—

"Oh, Niu! oh, Nānā! come forth from your hiding-place!
Transform yourselves into a stream, a vast volume of water,
And leap, leap with resplendent brilliancy, oh, Niu!"

At this the waters, which had entirely ceased to flow during the long dispute of the gods, rushed forth from their secret hiding-place, and quickly moved on to the edge of the cliff towards Ngatangiia, to which the reed still kept pointing. Stung with disappointment and rage, the lizard and cuttle-fish gods chased the advancing stream in the vain hope of checking its progress. But without heeding their futile attempts, the stream rushed on and on, until, reaching the perpendicular cliff, it took a wild and defiant leap far down into the deep gorge at the base of the eastern side of the mountain. The angry Avaruan gods dared not follow the beautiful waterfall through fear of being dashed to pieces, so they slunk back as best they could to their own territory near the sea. The dejected lizard god, Tonga-iti, was only too glad to sun himself after his long and bootless journey; hence it has come to pass that all his descendants are yellow, sallow-looking, spiritless reptiles, who can find nothing better to do than to bask through the livelong day in the sun. Thus shame‡ has caused the pretty spots of their ancestor to change into a dirty yellow complexion.

As for Rangatira (the cuttle-fish god), she was so utterly wearied with travelling through fern and grass from the summit of "The Mist," that she gladly rested in a shady spot, thenceforth named "Pārai," or "Resting-place."

Such is the myth connected with the fountain of "The Mist." The "Pārai" referred to is the ancient "resting" or burial-place of the Makea kings, who, down to 1823, worshipped the cuttle-fish.

‡ The Hervey Islanders speak of a person being "yellow with shame"; and not without reason, as paleness thus shows itself on their dark skins.

About half a mile from "Pārai," close to the usual landing-place, is a remarkable natural basin of fresh water, called "The cuttle-fish stream." At certain seasons the water assumes a dark, cloudy appearance, as if a cuttle-fish had ejected its ink into the stream. Yet in the course of a day or two the water again becomes clear, and sailors fill their water-casks as before. Doubtless this is owing to the presence of cuttle-fish, who come out of the sea there to spawn.

The stream which leaps from the precipitous eastern side of "The Mist" flows into the ocean by three channels; so that it may be fairly said that the fountain referred to in the preceding myth is the unfailing source of the water-supply of the beautiful island of Rarotonga.

The following invocation to the divinities worshipped by the Makea tribe at Rarotonga was invariably used by the master of the ceremonies as a preliminary to all state feasts until the subversion of idolatry in 1823. As the name of each god was pronounced with a loud voice and in the prescribed order, a portion of food was thrown into the bush. The divinities were believed to feed at dusk upon *the essence* of these offerings, the visible part being devoured by rats.

The reader will note that two of the gods (Tonga-iti and Toutika) invoked, are referred to in the preceding myth. This will show that the myth was not intended merely as a pleasant fairy story, but was to their minds the veritable history of a quarrel between the great divinities of Rarotonga, which, however, ended disastrously for the Makea tribe.

E pure kai (=Prayer before a feast).

To kai, e Marumamao!	Marumamao (= Shadow, *i.e.*, protection, thrown from afar), here is thy food; (O eat!).
To kai, e Tangaroa!	Tangaroa, here is thy food; (O eat!).
To kai, e Eturere!	Eturere* (= Falling-star), here is thy food (O eat!).
To kai, e Tonga-iti!	Tonga-iti (= Little Tongan), here is thy food; (O eat!).
To kai, e Toutika!	Toutika, here is thy food; (O eat!).
To kai, e aku Atua, kai katoa mai!	All (other) divinities worshipped by me, here is your food; (O eat!).

When this was over, the chiefs, greater and lesser, were named in a prescribed order, and each took possession of the pile of food allotted to him.

* A female divinity.

5.—OBSERVATIONS ON THE HILL TRIBES OF NAVITILEVU, FIJI.

By the Rev. Arthur J. Webb, of Goulburn, N.S.W.

Fiji is an archipelago containing 220 islands, 80 of them inhabited. Two of these, Na Vitilevu and Vanua Levu, are of considerable size, and are not only largely peopled along the coast line, but the hills and valleys of the interior are held by mountaineers. The largest island, Na Vitilevu, has a numerous hill population, of which very little was known until late years. The country is extremely mountainous, but fertile, and abundantly watered; the food supply is large, and the air healthy; and the people are well developed, particularly so in the calves of their legs, and are superior in physical energy to those of the coast. The character of the land is sharply divided into the timbered and grassy divisions, and the people are divided into two colours, the black and the red men, the latter, by tradition, being descendants of a Tongan party once cast upon the shores of Nadroga, on the west coast. The black race, again, is divided into a class of tall, handsome natives, and a class of smaller, less pleasing folk. There are reasons for believing the mountaineers to be the oldest inhabitants of the country, having been, in all probability, the first settlers on the coast, and presumably driven by later arrivals back into the hills. Some communities among them claim to have come from people who have long been settled on the sea shore, and tribes on the coast claim to have descended from others in the hills. But on the south-west part of the great island are people who seem to be distinct in some respects from the rest of the Fijians, not only in speech, but in temperament and habits, and in the very shape of their houses. Their huts on the south-west end of Na Vitilevu are square, with one central post, and a round-shaped roof; the dwellings everywhere else in Fiji being more akin to European shape. A remnant of a tribe still exists in the middle of the island, called Na Kai Navitilevu (the people of Navitilevu). Whether this fact indicates that they were the original holders of the island is a matter of conjecture. Many of the men are fine looking, though in their heathen state frequently characterised by a peculiarly furtive and savage glance. The women, as a rule, are remarkably plain, and in many cases ugly, their hard life no doubt contributing to this. The hill languages strike the ear as less euphonious than the other dialects of Fiji; they are harder to understand, and peculiarly difficult to imitate. To hear a mountaineer speak first his own *patois*, and then the smoother dialect of Bau or Rewa, would make the listener doubt as to whether it was the same man speaking. They have a curious fashion of sounding a "w"* after the "k," so that "Na ka ko ya" of Bau would be "Na kwa kwo ya" at Namosi. Similar words to those spoken on the coast are sometimes used in a somewhat different sense. At Bau they say "vondo," of the act of going on board a canoe. In the hills of Serua "vondo" is applied to the act of ascending a hill. Of course, the same action of the leg is involved in each instance. Words, too, of an innocent meaning at the eastern end are vilely significant in the interior of the country. One remarkable fact may be touched in this connection, that the mountain people have a word for the sea, "tathi," which is allied to, if not identical with, a similar word found all through Polynesia, but nowhere else in Fiji.† They, too, have words of their own for introduced animals, where the tribes of the littoral and smaller islands have only names derived from the European, such as "nggou," the mountaineer's name for pig, which everywhere else in the group is "vuaka," from "porker."

Their villages were mostly perched on most inaccessible peaks and precipices, very romantic to look at, but, as I found from experience, rather distressing to gain. These eyries were skilfully fortified with palisades and galleries for sharpshooters, which, with their well-chosen strategic position, rendered some of them traditionally impregnable; and until the introduction of European arms of precision, and the leadership of English officers, they were never taken. I have even seen fortified places on a plain so surrounded by moats, where the mud was armed with stakes and split bamboos, and so encompassed with clay ramparts and stout palisades line within line, that the taking of them in purely native warfare was a very tedious or very fatal undertaking. I saw one village of the tribe of Navunanggumu, called Waini makutu (water of content), where the mountain stream had been most ingeniously diverted into the circular moat, in which it was swirling round the town on its onward progress through the country to the sea, and thus forming a perpetual defence to the people. An officer in the English army, who had to take some of these forts of the hillmen, expressed to me his surprise at the skill and science of the engineering they displayed. Covered galleries and lanes, and curious platforms for sentinels and marksmen, were also features in these works. Some of these mountain strongholds I found had suggestive names, such as "Na Vere" (The Plot), "Na Laba" (The Murder), "Lawaki" (Cunning), while the inhabitants, male and female, rejoiced in appellations curious, terrible, or obscene. The history of the people here is crystallised in their names. On the other hand, I observed that many of the mountain villages were poetically called after trees, "Namoli," "Na Vunibua," "Nakuluva."

* This is the sound which is written *q* by the Melanesian Mission. It is a queer compound of kpw or kbw, the p or b varying in distinctness, sometimes quite inaudible.

† Excepting in one or two places on the coast.

The mountaineers were unceasingly at war with each other, but since 1868 seemed to unite more to fight the people of the coast. For some years they terrorized Navitilevu. A stratagem in which they were peculiarly effective, particularly when dealing with expeditions from the seaboard and other islands, was the "Undu." Decoying their foes into a ravine, they allowed them to get well in, where they had ambuscades planted on either side; a considerable part of the force then closed in the rear, and an attack was made in the front, followed up by simultaneous charges on each flank. The invading party, disconcerted, turned and ran, when they were thrown into utter panic by finding their retreat blocked. A massacre easily ensued. Several of these mountain man-traps have been shown me where great slaughter was done, and the coast tribes, I found, greatly feared the highland "Undu," as a mode of tactics peculiar to the interior tribes. Even on more level country these people could resort to peculiar decoy methods to lure opponents into an ambush. Apart from the use of arms, the mountaineers prepared themselves for battle by rites of *invulnerability*, thus striking terror into their enemies, while sustaining their own courage with the thought. For days before a fight the warriors would steadily prepare themselves by songs and chants in honour of "Na kalouvatu" (Stone God), which was their war-god, the Deity being held to enter into a selected stone taken from the larger water-worn pebbles of a running stream. For hours night after night would their chants be heard, accompanied by the monotonous booming of large bamboos struck upon the ground, and such sounds would strike mysterious fears into the coast people who had come to attack them. Certain pleasures and foods were rigorously abstained from, and the rubbing of the body with prescribed leaves was a later part of the performance. At length one man would exclaim that the demon had entered into him, and that he was now invulnerable; no weapon formed against him should prosper, the battle-axe would bound back from his toughened skin, the musket bullet would flatten against his body, and the spear-point glance harmlessly aside.

In the last war of the mountaineers they put the *Vodevode* ("leaping aside" of lethal weapons) to a practical test. At Vatuvoko, a hill town near the mouth of the Segatoka River, the men were in the Bure (men's house) chanting the *Vodevode* song to the weird bamboo accompaniment when a warrior deemed himself possessed by the *Kalouvatu*. He bent low and sprang through the doorway, then moved about making sharp, nervous exclamations. The *Vuniduvu* (priest of the ceremonies) followed from the Bure, and fired a gun at him to prove how impervious he was to ball. This much-desired fact was demonstrated by the bullet striking him fair in the chest, and— passing right through him. He fell prone in the arena but the ball sped through the reed wall of the Bure, and hit a boy within, who was doing the invocation chant and beating his bamboo upon the ground. The lad fell back, breathing quick, and the people cried out that he was possessed; but he was dying. When they saw the blood flowing they then woke up to the fact. The *Vuniduvu* then professed to be possessed, ran backwards, shaking all over his frame with simulated "possession," and as soon as he reached the bushes, ran at full speed from the scene. This belief in the *Vodevode* proved, as I had abundant opportunities of observing, a most obstinate infatuation. I pointed out a young man with a gunshot wound through the neck, who, a few days before, had been in the invulnerable condition, and asked how they accounted for his hurt. "He had broken the *tabu*, and eaten bananas" was the reply. Another warrior limped past, with a hole in his thigh. "He had connection with a woman just before the fight," they explained, "and that destroyed the charm." These people are full of explanations as to failures. Another of the beliefs of the people is that in sprites or fairies. "Veli" they call them. A *Veli* they describe as a little hairy figure carrying a spear. A similar belief is to be found in Melanesia, and also in British Venezuela, and Brazilian Guiana, where the Indians tell of a wild hairy man, who they call "didi"; short, thick-set, powerful, his body covered with hair, and who lives in the forest. The Fijians avow that the *Velis* produce the echoes, and I was told, when in the hills, that at the town of Nasaucoko was a woman who had been under their power for some months. When in the district of Wainimala, at the foot of the Dividing Range, a thick wood was shown where the secret rites of the "Nanga," or "Mbaki," were performed. It was extremely difficult to extract from the natives any information as to these. They resemble those of Freemasonry in their initiations and mysteries, and the secret was kept until lately with a like marvellous success. The secret mysteries of the *Nanga*, practised for years before the open demonstration; the stone enclosures containing men of different grades of initiation; the central mound, with the boar's head upon the top, dedicate to the demon; the extraordinary proceedings that form a part of the more public ceremonies surpassing and forbidding description, together with the magic charm that the whole affair is supposed to exert upon the health of the ruling chief, make it a most interesting study, particularly when taken in conjunction with the "Duk Duk" of the Duke of York's Group and other secret societies throughout Polynesia.

The mountaineers practice circumcision and some very horrible surgical rites, such as the patients rarely recover from. They also tattoo women, first in their private parts and then at the corners of the mouth; the latter tattoo marks being indicative of the existence of more elaborate tattooing in the former locality.

A social peculiarity, distinguishing the hill men from those of the coast and the lesser islands, is their Bure life, or clubs. These again distinguish the tribes inhabiting the wooded half of the island of Navitilevu from the people of Navosā, or the grassy districs. The distinctive mountain *Bure* is a long building,* the largest in the village; and some villages have two or three. Ranged along the walls the chiefs and elders of the tribe have their places. Stalls are fitted up, with fire-places between; grass is laid down, and on that a mat, and here the occupants lie at ease, resting their arms on the poles that form the top of the low stalls, and exposing their bodies to the genial warmth of the burning logs in the fire-places—for the night-air of those hill regions is chilly. Here, in the *bure*, they eat, drink *yanggona*,† smoke, discuss local matters and such news from other parts of the country as filtrates to them, and fall asleep one after another at their own sweet will. The institution is a most sociable one for the men. What of family life there is exists during the day, for married men have their small houses, some having more than one, in which they meet their wives and children; a good part of their day, too, is spent in the woods, where they have gardens at a considerable distance from the village. At night the men congregate together in the club-houses. The club, that recognised offspring of our civilised life, has its analogue in the so-called barbarous life of the Fijian mountaineer; and there is really something very cosy, sociable, and jolly about this comfortable Highland Club.

Another building, without which a mountain town would have been incomplete, was the *Bure Kalou* (spirit bure or temple). These were picturesque erections, perched on very high mounds,‡ and further conspicuous by tall, narrow roofs, somewhat suggestive of a pagoda. The last I saw was in the village of Bengga, on the head-waters of the Navua River. It was small and entirely new, and had just been built for a war begun with Namosi. It was very neat and carefully built, and stood upon a high foundation formed of pebbles from the stream hard by. Close to it stood an orange-tree, from which depended a sacred axe brightly gleaming in the sun. I was told that on special occasions the priest of the temple would take down this weapon, and entering into the *Bure Kalou*, rub it with certain leaves to "make it kill." During my stay in this village the axe *was* taken down and carried into the temple under suspicious circumstances, but for sundry reasons we did not wait for developments. Another temple that I saw was at Narokorokoyawa, on the Wai-ni-mala; the building was larger and older than the one at Beqa—the interior was very unattractive, but at the door hung two large shells of the conch species, called "Davui" by the natives. These were suspended by stout,

* This is the Long House of the Banks' Islanders, the N. A. Indians, and other tribes.
† Kava, the *piper methysticum*. ‡ The *teocallis* of Mexico, the "high places" of Scripture.

elaborately-plaited ropes of cocoanut-fibre, and were the gods of the place. According to the chief, one was a god and the other a goddess ; he had known them to engage in a sharp altercation, and, on the eve of an event of great tribal importance, the shells had grown strangely restless, climbed the upright post at one end of the interior of the temple, and made their way along the ridge-pole. The god and goddess were deities of war, and when the Nuya Malu warriors were about to attack, these divine shells were blown, and the noise reverberated through the hills and struck terror into the souls of those who were awaiting the onset. The tribe having then recently professed Christianity, I was able to purchase these curiosities, and took them with me down the Waidina. My lads amused themselves with sounding the gods when we came near to a village, and the people turned out in excitement to look at these dread powers, for the report of our bearing the shells preceded us. It was like the Egyptians running along the banks of the Nile to view their old Pharaohs floated down in charge of the archæologists who had exhumed the mummy-cases.

The hill men have their amusements, principal among which are war-dances, in which they decidedly excel. The dance with war fans is a wild proceeding, carried on with great vigour, and in curious evolutions. The spear dance is exceedingly graceful, though at times verging on the alarming; but the club dance surpasses anything of the kind done by natives from anywhere else in Fiji. For agility and rapidity of spring, for wild, terrific bounds (to say nothing of ear-piercing shouts and yells), for vigour of execution, for grace and power of movement, a club dance by the Kai Namosi could scarcely be equalled.

In their manners the tribes differ much. Those living in the wooded half of Na Vitilevu possess an aristocracy, show very great respect to chiefs, and the latter are severely exacting in matters of etiquette. The people, on the other hand, living on the Sigatoka River and the grass country of Navosa are more of a democracy, pay less attention to such chiefs as they have, and are uncouth in their manner altogether. They have fewer words and acts denoting respect, nor have the chiefs anything like the same influence. All alike were polygamists, and gave their wives a hard time of it by making them beasts of burden, on Petruchio's maxim, that "women are made to bear." I have seen a procession of women going in single file through the woods, bent double under heavy loads, while the lord and husband of the lot marched with stately masculine dignity behind, carrying a spear. A chief explained to me that every additional wife meant an increased food supply, as there was one more tiller of the soil added to the establishment. As a result of this condition of things the women rapidly look old, and are then very ugly, the old hags being perfectly hideous. Even the younger women lack the comeliness of their better-treated sisters in the other parts of Fiji. Cannibalism prevailed amongst the mountaineers, as it previously did throughout Fiji generally, but the hills were the last place in which it disappeared. When the dreaded Nuya Malu warriors came as allies to Soloira, an abundant feast was provided for them, in which figured several roast pigs; but the "friends" murmured that that was not a feast for warriors, and asked why no human bodies were provided for them. Human flesh was then obtained for their sustenance, but as none of the enemy had been sufficiently accommodating to come within the power of the Soloira club-men, the source from whence the stimulating banquet was furnished can be surmised. The mountain men were not fastidious where human meat was concerned; they have dug up bodies that had been buried for days, and eaten parts of them done up into puddings. On their war marches, when they have killed victims, they have been known to cut up the bodies and carry portions in their "kit" for provender on the way, as with other forms of food. In eating human flesh the chiefs used wooden forks, and for human flesh alone. Why this distinction I could never learn, except that the pieces being boiled in large quantities of broth the fork was used to secure the pieces of meat, and draw them up from the liquid. The flesh was sometimes baked first and boiled afterwards. In special cases, where a particular enmity existed against a certain chief, who had been slain but buried by his friends, a party has gone at night, after the fighting had ceased for a few days, and exhumed the body; then, taking a living man, they have bound the corpse to him upon his back, feet to feet, middle to middle, arms to arms, head to head, and then the man walks, a ghastly double, into the village. Cannibal preparations are at once made, and the feast held on the morrow. The rites and practice of cannibalism have now entirely ceased in Fiji, and during the present decade the avowed heathenism of the hill tribes has been completely abandoned. Fiji, in all her islands, and from the coast of Na Vitilevu to the remotest parts of the interior, is a Christian country, with mission schools throughout the territory, and churches and native pastors.

6.—SOME BELIEFS AND CUSTOMS OF THE NEW BRITAIN PEOPLE.

By the Rev. B. Danks.

7.—THE ABORIGINES OF VICTORIA.

By the Rev. J. Mathew, M.A.

8.—THE GENEALOGY OF THE KINGS OF RAROTONGA AND MANGAIA, AS ILLUSTRATING THE COLONISATION OF THAT ISLAND AND THE HERVEY GROUP.

By the Rev. William Wyatt Gill, LL.D.

Anything that can throw light upon the original colonisation of the South Pacific Islands must be of the deepest interest to scientists. In the absence of books and inscriptions, we can only look to the traditions of the islanders themselves. No surer ground can be found than the well-preserved genealogies of the reigning families.

In 1888 Great Britain annexed the Hervey Group, the principal island of which is Rarotonga. I propose to give the pedigree of the Makea and Tinomana regal families of Rarotonga. These families claim to be descended from the renowned Makea Karika, who, with Tangiia, centuries ago colonised Rarotonga.

Rarotonga was practically discovered by the late Rev. John Williams in 1823. On that occasion he landed native teachers, and thus introduced Christianity and civilisation.

Five years subsequently Mr. Williams, after paying a second and prolonged visit to the queen-island of the Hervey Group, sailed back to his own station at Raiatea, in the famous *Messenger of Peace*, accompanied by Makea Davida, principal king of Rarotonga at that date. Referring to this chief, Mr. Williams writes† :—" The present Makea is the twenty-ninth of that family." In a note he adds :—" When we were departing for Raiatea, the uncle of Makea, whom he had appointed Regent, delivered a most interesting address, in which he enumerated the ancestry of the king, commencing with Makea Karika, and for every one of whom he had a peculiar designation descriptive of his character, as was the case with the Pharaohs of Egypt. I much regret that I did not obtain a correct report of this address, as I listened to it with peculiar interest."

In 1869 I endeavoured to ascertain whether this account of the ancestry of the Makea kings was still extant. After many inquiries, Teaoa, at that period native pastor at Avarua, placed in my hands the greater part of the materials out of which the following list is composed. For the subsidiary genealogy of the kings of the split, or Puaikura, tribe I was indebted to Tinomana Samuela, or Rongo-oe the Second, the brother and predecessor of the present chieftainess.

All this information was imparted with a request for secrecy, as the following pedigree is the native title to the kingly office

† " Missionary Enterprises," page 199.

and ancestral lands. But so many years having elapsed, and the Hervey Group having been annexed, there is no longer any reason to fear inter-tribal war and dispossession. So that I now feel justified in putting this genealogy on permanent record for scientific purposes. And for this special reason—it places beyond the shadow of doubt the number of generations during which Rarotonga has been inhabited by the present brown (Maori) race.

Now, in regard to this genealogy itself. The descent of these kings is from father to son, excepting in the eleventh generation, when "Makea teina," younger brother to the "Makea Rongo-oe" who, by his arrogance and cruelty, split up the island into hostile clans, was, "by the fiat of the gods," appointed king of the tribe at Avarua. When Mr. Williams discovered Rarotonga in 1823, Makea Pori and his cousin, Makea Karika the Second, *reigned jointly* at "Araitetonga" (the royal marae). The origin of this dual kingship of later times in the family of Makea was merely to make a suitable provision for the eldest sons of the two wives of "Makea-patua-kino." In consequence of this dual kingship, Makea Davida, in 1828, was not (as Mr. Williams thought) the 29th, but the 25th in direct succession from Makea Karika, the founder of the dynasty. If it were allowable, native fashion, to add the names of the four other* joint kings, Makea Davida would be the 29th descendant of the famous Makea Karika, who had reigned, representing, however, only 25 generations.† Native etiquette made it imperative for the Regent to include the four joint kings referred to. The custom has always obtained in the "Tongan kingdom" ("te au o Tonga") that whilst both kings enjoyed regal honours, only one wielded authority, wielding it, however, in the name of both Makeas.

Coming on to my own time, it may suffice to remark that Makea Tevairua (who welcomed me in 1852) was sister to Makea Davida (Mr. Williams' friend in 1828); Makea Daniela and Makea Abela were their younger brothers. So that, strangely enough, four children of Makea Pori, who welcomed civilisation in 1823, came to the throne. The present queen, Makea Takau, is the only child of the Makea Davida who accompanied Mr. Williams to Raiatea in 1828.

Allowing to each Makea a reign of twenty-five years, we obtain a total of six hundred (or possibly 625) years from the landing of Makea Karika on Rarotonga down to the accession of Makea Pori and Makea Karika II., whom Mr. Williams found in possession of regal authority in 1823. Doubtless the first ten sovereigns reigned longest and most happily, before the pride and cruelty of "Rongo-oe" split up the island into hostile factions. The reader

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* Makea Keu, Makea Tekao, Makea Karika II., one of reigning chiefs, who, in 1823, welcomed Mr. Williams; Makea Pa, who, with Makea Davida, reigned in 1828.

† Or, with absolute correctness, the 24th, "Makea teina" being younger brother (or more probably cousin, "teina," meaning both) to "Makea Rongo-oe."

will bear in mind that twenty-four English sovereigns, from the Norman Conquest to the death of Charles I., reigned *less* than 600 years.

The Makeas were held in great veneration by their vassals. In 1858 I asked a serf why he looked aside when interrogated by Makea. The reply was—"Did not my father tell me never to look Makea in the face, lest the regal glance should devour me?" The angry glance of a high chief was believed to induce that frightful disease, *lupus*, or cancer of the nose and face. So, too, the thieving of food by the slaves who waited on them.

The mythical account of the origin of the regal name Makea is this: "Ātea* married Papa. To them were born Rongo and Tane; also Ruenuku,† Tu-the Great (Tu-nui), Tangaroa, Teuira (= the lightning), and Aa (= cyclone). The sign of royalty being the (bowl of) intoxicating pepper, shouts ever following (the king)."

"Now Rongo and Tane‡ said, Let us name our son The Saliva (kea) of our mouths and the aching of our heads. Hence the name Makea."

"Ma" is a mere prefix, so that this regal title may be rendered The Saliva and Head-ache of the gods!

Many have asked me whether I have discovered in the Hervey Group any trace of a prior Negrillo people. My answer is, None whatever. Indeed, I believe the idea of a black race formerly overrunning the Eastern Pacific to be a pure fiction. When Karika landed on Rarotonga he found a few *Maori*, or brown, people from Ivà (= Nukuiva), originally from Avaiki. Their chief was named Ata. These Maories were all—or nearly§ all—slain by Karika. A *black* aboriginal race was never heard of in the Hervey Group. Some accounts assert that Ou and Ruariki were the chiefs of these brown people from Iva, and that *not one* was spared by Karikà. It is well known that the Rarotongans from time immemorial were addicted to killing and eating women; at Mangaia the rule was to spare women.

On the west of Rarotonga is now settled the smaller and, but for Christianity, doomed tribe of Puaikura. In 1823 Mr. Williams found Tinomana,|| the eighteenth in direct succession from Karika, swaying its destinies. Allowing, as with the Makeas, 25 years to the reign of each of that line of chiefs, we get only 450 years. My own impression is that one or two links in this genealogy are irrecoverably lost, owing to the perpetual slaughter of their leading men—a slaughter which ceased only on the acceptance of Christianity by the rulers of Rarotonga in 1823.

I infer, then, that Rarotonga was colonised by Karika and Tangiia 600 years before the discovery of the island by Mr.

* Vātea or Avatea, *i.e.*, Noon.
† The Ruanuka of Mangaian mythology.
‡ Primary male gods of Polynesia.
§ The young women were spared as slave wives for the victors.
|| This same Tinomana was living in 1852, when I first visited Rarotonga He was a most interesting chief, and of commanding presence.

Williams, *i.e.*, about A.D. 1223, or possibly A.D. 1198. This conclusion was arrived at many years before I found that M. Quatrefages, in his admirable book, entitled "The Human Species" (page 194), places it in A.D. 1207. For the story of Tangiia's voyage to Rarotonga I must refer the student to my "Myths and Songs" (pp. 23-4), and Williams' "Enterprises" (pp. 195-6). In their inter-tribal wars the numerous descendants of Tangiia defeated the less numerous descendants of Karika in many a conflict; but the regal supremacy was allowed to remain with the Makea Karika family.

In passing, I may mention the (to the European mind) singular circumstance that in 1823 Makea Tinirau and Makea Tekao were both alive, but had voluntarily devolved the regal authority and title upon their sons, Makea Pori and Makea Karika II. This, however, is no uncommon occurrence amongst chiefs, greater and lesser, of the Polynesian race.

But Karika found on the island a few brown people, ruled by Ata, representing a single canoe-load from Iva. Allowing to these prior *Maori* settlers on Rarotonga a residence of 50 or 75 years (a period far too long, judging from what I have myself seen of stray canoes in the South Pacific), we may safely conclude that Rarotonga has been inhabited somewhat less than 700 years prior to its discovery by Williams in 1823.

In my "Life in the Southern Isles" (pp. 23-5) and "Historical Sketches of Savage Life in Polynesia" (pp. 227-9), I have given historical data for my belief that the rest of the islands of the Hervey Group have been inhabited only about six centuries. I would especially commend to the student the *unquestionably correct* list of the three great orders of priests and the "rulers of food" on the island of Mangaia, given in "Historical Sketches of Savage Life" (pp. 227-8). Only twelve generations of the "rulers of food" have obtained on Mangaia, and fewer still of the priests proper.

All the traditions of Eastern Polynesia point to a western origin—Avaiki (= Savai'i), Tonga, Rotumah, Upolu, Tutuila, and Manu'a. Amid wonderful diversity of detail there is a unity of tradition in regard to the western origin of their race.

After giving the genealogy of the kings of Rarotonga, I will add the succession of the kings of Mangaia, to enable the reader to judge for himself. I think it is evident from these lists that Rarotonga was the first island of the Hervey Group that was colonised. The island of Rarotonga, which towers 3000 feet above the level of the ocean, is, of course, visible at a great distance, and yet, strangely enough, escaped the eye of the renowned Cook.

In passing, I may observe that the knowledge of the calendar belonged exclusively to the kings proper of each island of the Hervey Group, as they alone fixed the date of the various feasts in honour of the gods. This was done by them as mouth-pieces of the tutelar divinities. For others to keep the calendar was a sin against the gods, to be punished with hydrocele. It was even thus of old in the Tahitian and Society Groups. Very appropriately, the calendar printed in Ellis' book is said to have been derived from Pomare, the sovereign of that day. Of course, this fact is a guarantee for its correctness.

I.—Kings of Rarotonga, as given by the "wise men" of Makea and Tinomana in 1869.

1. Makea Karika, father of ... Makea-the-terrible. His wife was Ina-nui-i-te-rangi = Ina-the-Great-and-Heavenly.
2. Makea Putakitetai ... Makea-lord-leading-captives.
3. Makea i te au ... ... Makea-the-peaceful.
4. Makea noo marie ... Makea-the quiet.
5. Makea pūretu (= purotu)... Makea-the-handsome.
6. Makea peau rango ... Makea-of-fly-like-wings, *i.e.*, swift to execute his purpose.
7. Makea teko nako ... Makea-the-ubiquitous (literally, "hither, thither.
8. Makea te taiti ... ... Makea-the-fisherman.
9. Makea te rā tu ... ... Makea-(like)-the-upright-mast (ra* = tira.
10. Makea Rongo-oe ... Makea - Rongo - of - the - paddle. But usually known as Te ariki ape tini = The-king-with-many-faults. Until his reign there was at Rarotonga but one king, whose united and powerful tribe was named "Takitumu," or "All-destroying." A warrior, maternal uncle to Rongo-oe, named Takaia, split the tribe into two hostile camps. Rongo-oe remained king over the smaller or doomed portion, which took the name of "Puaikura" at Arorangi. Makea's portion was named "Te au o - Tonga" = "The-Tongan-kingdom," and remained at Avarua, retaining the family marae "Araitetongā" = "The-Tongan-Mediator" (or "Warder-off-of-Tongans").
11. Makea teina ... ... Makea-the-younger-brother.
12. Makea tumu pu ... ... Makea-of-the-(royal)-conch-shell.
13. Makea tinorei ... ... Makea-of-the-handsome-person.
14. Makea tari ua ... ... Makea-the-dilatory.
15. Makea potiki ... ... Makes-the-youngest (a term of endearment).
16. Makea mangungu ... Makea-the-thunderer.
17. Makea taik ... ... Makea-of-the-spear.

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* To be distinguished from rā = sun. It is merely an abbreviation of "tira" = "mast." Because the first syllable is dropped, the remaining one (ra) is lengthened (rā). In New Zealand, "mast" is "tiratu" = "the mast that stands up" (masts were set up or lowered at pleasure).

18. Makea tukerae ... ... Makea-the-beloved (literally "of-the-eye-brows").

19. Makea te rangi tu ki vao ... Makea-the-solid-sky-standing-up-outside.

20. Rangi Makea ... ... Heavenly Makea. Drowned in Lake Tiriara, on the south of Mangaia.

21. Makea te patua kino ... Makea-badly-beaten. In his reign another split took place, and thenceforth two Makeas reigned jointly at "Araitetonga," the royal "koutu" = "marae," or idol-grove, of the Makea family.

22. Makea pini and ... ... Makea-the-sorrowful and
Makea keu ... ... Makea-of-the-flaxen-hair.

23. Makea Tinirau and ... Makea-lord-of-all-fish and
Makea Tekao ... ... Makea-the-bud (= hope or glory of the family).

24. Makea Pori and ... ... Makea-the-fat and
Makea Karika II. ... Makea-the-terrible, second of that name. These were the reigning chiefs at Avarua in 1823, when the Rev. John Williams conveyed the Gospel to Rarotonga. Since then have reigned—

25. Makea Davida and ... Makea-David.
Makea Pa ... ... Makea-the-defender.

26. Makea Te vairua and ... Makea-the-spirit and
Makea Tuaivi ... ... Makea-the-hill.

27. Makea Daniela and ... Makea-Daniel and
Makea Tavake ... ... Makea-the-tropic-bird.

28. Makea Abela and the above-named Makea Tavake ... Makea-Abel and the above-named Makea-Tavake.

29. Makea Takau and the above-named Makea Tavake. Makea-Twenty and the above-named Makea Tavake. *Both now living.*

Kings of the "Puaikura" tribe.

1. Rongo-oe, or Napa; otherwise named "Te ariki ape tini" = "The-king-with many faults."
2. Tamatoa ... ... The-brave-son.
3. Tekao ... ... The-bud.
4. Papa (female) ... ... Foundation.
5. Temutu ... ... The-end.
6. Enua tama nui ... ... Land-full-of-offspring.
7. Ru ... ... Trembling.
8. Teau ariki ... ... Royal-domination.
9. Tinomana ... ... Mighty-frame, or Wonder-working-body. In this king's reign Christianity was introduced to Rarotonga (*i.e.*, 1823) by the late Rev. John Williams. Tinomana represented the eighteenth generation from Karika. Some say the nineteenth.
10. Tinomana te ariki tāpu rangi ... Tinomana-the-king-who-sustains-the-sky. His baptised name was "Setephano" = Stephen.

11. Tinomana Rongo-oe II. His baptised name was "Samuela" = Samuel.

12. Tinomana Mereane (= Mary Ann). Her baptised name was "Mereane" = Mary Ann. *Now living.* She is the twentieth direct descendant of Karika in the Rongo-oe line, being sister (but by a different mother) to the previous sovereign. She is niece to Makea Takau of Avarua.

Pedigree of Makea Takau, as given to me by herself in 1883.

1. Makea Karika ... ... Makea-the-terrible.
2. Makea Putakitetai ... Makea-lord-leading-captives.
3. Makea te ariki akamataku ... Makea-the-king-striking-terror.
4. Makea Ātea* rere ao ... Makea-Noon*-rushing-on-the-world
5. Makea te ariki iti au ... Makea-the-king-giving-peace.
6. Makea te ariki noo marie ... Makea-the-quiet-king.
7. Makea te rā tu ... ... Makea-(like)-the-upright-mast.
8. Makea Rongo-oe† ... ... Makea-Rongo†-of-the-paddle.
9. Makea vai katau ... ... Makea-of-the-right-wing.
10. Makea peau rango ... Makea-of-the-fly-like-wings.
11. Makea putua ariki ... Makea-the-feasted-king.
12. Makea tinorei ... ... Makea-of-the-handsome-person.
13. Rangi Makea ko Takaia ... Heavenly Makea or Takaia (who went to Mangaia to wage war).
14. Makea tumu pu ... ... Makea-of-the-(royal)-conch-shell (who went to Atiu to wage war).
15. Makea, who went to Tahiti on a peaceful errand.
16. Makea te ariki ape tini ... Makea-the-king-with-many-faults.
17. Makea taruia ... ... Makea-heaped-up.
18. Makea te-patua-kino ... Makea-badly-beaten.
19. Makea pini ... ... Makea-the-sorrowful.
20. Makea Tinirau‡ ... ... Makea-lord‡-of-all-fish.
21. Makea Pori ... ... Makea the fat (who welcomed Mr. Williams in 1823).
22. Makea Davida ... ... Makea David.
23. Makea Tevairua ... ... Makea-the-spirit.
24. Makea Daniela ... .. Makea-Daniel.
25. Maker Abela ... ... Makea-Abel.

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* Ātea = Vātea = Avatea = Noon. The full form is Avatea. This Ātea, or Vātea, is one of the great divinities of Polynesia.

† Rongo is the son of Ātea, or Vātea, whose sanguinary worship was so general in Eastern Polynesia. Rongo-oe probably means "Rongo-the-steersman," *i.e.*, of the ship of the state.

‡ Tinirau was brother to Atea, Vātea, or Avatea, and was lord of all fish. This fish-god Tinirau, was accordingly one of the great primary deities of Polynesia.

26. Makea Takau* ... ... Makea-Twenty,* now living.

There can be no doubt that the first list is the complete one. In this latter account there is no reference to the dual kingship at "Araitetonga." It is confessed that Rarotongan *history* (so far as Makea is concerned) begins with Karika; but there is lying before me a list of purely mythological names, given as ancestors of the Karika who sailed from Tonga, Rotuma, Avaiki (=Savai'i), and Manuka (the Manu'a cluster of three islands, forming the eastern portion of the Samoan group. Sometimes Tau, the largest of these three islands, is called by Hervey Islanders Manuka). It is believed that Karika made his final start for the south-east and Rarotonga from the island of Tau or Manu'a, where the marae of "Salia" = "Karika" may still be seen. The place is called "Rarotonga." Tau is 700 miles north-west of the island of Rarotonga.

Karika's great double canoe, in which he made eight wonderful voyages, had two masts, and carried (tradition says) 170 people (okoitu). He gave to the queen-island of the Hervey Group, the home of his descendants, its name "Rarotonga" = "(in memory of) Western Tonga." Karika selected as his followers the fleetest runners and the bravest men of the various islands he touched at, *i.e.*, of Tonga, Rotuma, Savai'i, and Tau.

It is said that on the island of Rotuma is still shown the "footprint of Salia" = Karika. And at the famous marae of Opoa, in the island of Raiatea, "the stone-seat of Ari'a" = Karika

II.—Kings of Mangaia, Hervey Group.

The island of Mangaia was discovered by Captain Cook in 1777.

The sign of installation of the kings of Mangaia was to be formally seated by the temporal lord, in the presence of the leading under-chiefs, upon "the sacred sandstone" (*te kea inamoa*) in Rongo's marae (O-Rongo) on the seashore, facing the setting sun. This was *their* equivalent of our coronation in Westminster Abbey. The special duty of a king was by rhythmical prayers† to Great Rongo to keep away evil-minded spirits (pa tuarangi) that might injure the island. For this end the principal‡ king (*te ariki pa‡uta*) lived in the interior, in the midst of abundance, in the sacred district of Keia. His prayers (*karakia*) were supposed to keep away bad spirits coming from the *east.* On the barren seashore, at O-Rongo, lived the secondary king (*te ariki pa tai*), who kept away bad spirits coming from the *west.* Besides

* In the memory of "twenty" heads obtained at Mangaia by Makea's warriors generations ago. It is an ancient name. See my "Savage Life in Polynesia," page 17.

† Of great antiquity.

‡ Also called "the praying king" (*te ariki karakia*).

this primary ghostly function, many other important duties devolved upon these royal personages (see "Myths and Songs," page 293, &c.).

I derived the following information (under promise of secrecy) many years ago from my late valued friend, King Numangatini. These lists are the most accurate now obtainable; some points, however are disputed. The kingly office was hereditary; nevertheless the investiture rested with "the lord of Mangaia" for the time being. A father *might* be set aside in favour of his eldest son, or one brother in favour of another, for special reasons; but still it must be the same blood divine (as it was believed to be). The *shore* king was not unfrequently an illegitimate child of a great *interior* king. All kings were *ex-officio* high priests of Rongo (=ara pia o Rongo), tutelar god of Mangaia.

Succession of Kings defending the Interior (= Te au ariki pa uta).

1. Rangi ... ... Sky.
2. Te-akatauira-ariki ... The-arrived-king.
3. Te.mata-o-Tangaroa ... The-face-of-Tangaroa.
4. Te-upoku-rau ... ... Two-hundred-heads.
5. Rua-ika I. ... ... Fish-hole I. Slain by Ngauta, when for the first time "lord of Mangaia."
6. Rau-ue ... ... Gourd-leaf. Son of the shore king Vae-rua-rau. The drum of peace for the *last* (seventh) "lordship" of Ngauta (enjoyed by Terea) was beaten by Rau-ue over the body of Inangaro.
7. Poa-iti ... ... Small-scale. Reigned in the days of Ngangati.
8. Te-ao I. ... ... Day I. Reigned in the days of Mautara.
9. Rua-ika II. ... ... Fish-hole II.
10. Te-tipi ... ... The cutting (*i.e.*, slaughtering).
11. Te-ao II. ... ... Day II. Died A.D. 1829. Professed Christianity.
12. Nu-manga-tini ... Palm-of-many-branches (purely allegorical). Reigned from A.D. 1821 till his lamented death in 1878.
13. { Ioane Terego ... ... John Trego, *son* of Numangatini
14. { Davida-iti ... ... David-the-younger, *grandson* of Numangatini.
(Reign jointly now by will of the late king).

Succession of Kings defending the Shore (= Te au ariki pa tai).

1. Tui ... ... Sew. From Rarotonga.
2. Tama-tapu ... Sacred son. Son of preceding. Some say Te-pa = The-defender, who was born on "the sacred sandstone" (te kea inamoa).
3. Vari ... ... Beginning. Vari was sister to Te-pa.

4. Buanga ... Budding (a female).
5. Vaerua-rau ... Two-hundred-spirits. Son of Buanga. His son, Rau-ue, was made principal (the sixth) king of Mangaia. Deified after his violent death.
6. Oito ... ... The-ancient. Slain and eaten by his hereditary foes in Mautara's time.
7. Kai-au paku ... Kingly-office-holder I. Also called Tuki-rangi = Sky-striker. Son of Oito.
8. Tenio-pakari ... The-strong-toothed.
9. Kanune. In the days of Mautara. Slain by Raumea.
10 Te-ivi-rau ... Two-hundred-bones (*i.e.*, relatives). Drowned at sea when in chase of Paoa.
11. Kai-au II. ... Kingly-office-holder II.
12. Numangatini. Appointed shore-king by Pangemiro in A.D. 1814. When (in 1821) Teao was deposed, he became sole king of Mangaia. The final word and collective kingly authority were then vested by the conquering chiefs in Numangantini alone.

In the incessant fighting of Ngauta's younger days the kingly family was almost exterminated by their hereditary enemies, *i.e.*, the Teipe and Tongan tribes, then masters of the island. Only a royal female (Buanga) and her infant son (Vaeruarau) survived. Even Vaeruarau was eventually murdered at the suggestion (not by the hand) of Ngauta.

Even the shore-king, after he had been formally seated on the sacred sandstone at O-Rongo, was so sacred *(tapu)* in the estimation of the men of past generations that even "the lord of Mangaia" approached him, not without an offering, *on all fours!* Yet, when the charm of peace had been broken by the wanton shedding of human blood, this sanctity (tapu) departed, and the shore-king went to his ancestral lands in the interior without any special reverence being paid to him. So sacred were the persons of the kings that no part of their bodies might be tattooed, nor could they take part in actual warfare.

I would earnestly warn all students of these pages of the danger of laying too great stress upon the meaning of these royal names. In *mythology* nothing is more important than the study of names, as showing how naturally the myth originated in the minds of "the wise men" of past ages; but in *history* (which this undoubtedly is) nothing can be more misleading.

As to the origin of the people, the universal tradition of the Hervey Islanders points to Avaiki (= Hawaiki, Hawai'i, Savaiki, Savai'i) as the original home of their ancestors. Sometimes this region is called "the night" (te po), *i.e.*, the place where the sun hides itself at night, or, in other words, "the west." Their ancestors are said to have "come up," *i.e.*, to *have sailed eastward.* When a man died his spirit returned to Avaiki, *i.e.*, the original home of their ancestors in the region of sunset.

Owing probably to the hiding of their dead in deep caves, so numerous in these coral islands, Avaiki came to be conceived of as a vast hollow beneath them.

In Avaiki are many regions, bearing separate names, but all to be regarded as part of spirit-land. For example, spirits are said to travel to Manuka (=Manu'a), or Tutuila, or Upolu, or Vavau, or Tonga, or Iva, or Rotuma (=Rotumah), &c., &c., &c. The problem now is to determine whence the Samoans (*i.e.*, the clan or family of Moa), sprang. This "Moa" is the hereditary king of the Samoans, his residence being always on "Tau," the largest of the three islets collectively designated "Manu'a."

9.—NOTE ON THE USE OF GESTURE LANGUAGE IN AUSTRALIAN TRIBES.

By A. W. Howitt.

The use of gestures accompanying, supplementing, or replacing speech is, I doubt not, to some extent inherent in the human race. Children make use naturally, or, as some might prefer to say, instinctively, of certain simple signs. Deaf-mutes necessarily use them to communicate their needs or wishes, and some simple signs are so universally used that the term "natural gestures" is not inapplicable to them.

Moreover, the rudiments of gesture language may even be observed among animals, and especially in those which have been domesticated, and have become the companions of man.

It may be inferred that gesture language is of earlier origin than speech, and also would have been found, at one time, to be more universal in the least advanced races of mankind. Whether this is so or not I am not prepared to maintain, but this much may be said, that with the exception of the Neapolitans, there seems to be scarcely any civilised people who habitually use a recognised code of signs having a settled meaning, whilst in savage tribes the practice is very common.

It has been long known that gesture language was much used among the North American Indians, and some remarkable statements have been made as to the reasons for its use. Burton attributed it to the paucity of language, which compelled the use of supplementary signs. It was even said that certain tribes were not able to communicate freely unless when daylight permitted the use of gestures. This statement has been completely disposed of by the researches of American anthropologists, especially those of Col. Garrick Mallery, to whose exhaustive treatise upon his subject of gesture language the reader is referred.

Nor can it be said that the use of signs by the Australian aborigines is in any way due to paucity of language, their languages being fully competent to provide for every mental or material necessity of their life. Those who have had an opportunity of becoming intimately acquainted with these savages in their social life will agree fully with me in this statement, and no one can feel the slightest doubt who has heard one of their orators addressing an assembly of the men, and with a flow of persuasive eloquence moulding opinion to his will. Indeed, in some respects, the languages of the Australian savages are more copious than our own, for instance, in defining degrees of relationship, which our tongue groups under the same term. It is somewhat remarkable, and at the same time difficult, to explain, that the use of gesture language varies so much in different tribes of this continent. Some have a very extensive code of signs, which admit of being so used as almost to amount to a medium of general communication. Other tribes have no more than those gestures which may be considered as the general property of mankind.

The occurrence or absence of gestures as an aid or substitute for speech does not, so far as I can ascertain, depend upon social status or the locality in which any given tribe lives. But, as to this, the materials which I have collected are certainly insufficient to form a positive opinion, being few in number, and scattered over a wide area. Yet, so far as I can venture to form an opinion from my own observations, and from the statements made to me by correspondents, the use of sign language is more common in Central and Eastern Australia than in the south-eastern part of the continent. The very different degrees in which gesture language is made use of may best be seen by taking a few illustrations from tribes of my acquaintance.

The Kurnai of Gippsland had no gesture language, but they made use of certain signs in lieu of words, when they were for some reason or other prevented from using or were reluctant to use the words themselves. Thus the messenger who conveyed the news of death of some individual to his friends or kindred, either spoke of the deceased in some roundabout manner, as the "father, brother, son" (as the case might be) of "that person" (pointing to him) "is dead"; or, what was perhaps more common, owing to the objection to refer to the dead, the messenger said, naming the relationship, for instance, "the father of that one is —," here concluding the sentence by pointing with the forefinger to the ground or up to the sky. Thus intimating that he was buried, or that he had gone up to the "Leën wruk," or celestial land. I have observed that when the aborigines of Victoria and New South Wales have spoken to me of the great Supernatural Being in whom they believe as having once inhabited the earth and now the sky,* they have either uttered the sacred name with bated breath, or have used gestures signifying the "great old man up in the sky."

If to this are added the signs for "come here," "go away," "there," or "in that direction," as indicated by the natural signs of beckoning and pointing with the hand, the gesture language of the Kurnai is almost exhausted.

The Woiwurung Kulin, who inhabited the Yarra watershed, had a much more extensive code of signs, which are recorded herein so far as I have been able to obtain them.

The tribes of the Barcoo delta have a most extensive system of gestures, which, it seems, is able to completely take the place of speech. According to Mr. Gason, whose authority on the Dieri customs is beyond question, a widow is not permitted to speak until the whole of the white clay which forms her "mourning" has come off without assistance. During this time (perhaps for months) she communicates by gestures alone.

I have observed the extensive use of gestures in the tribes to the northwards of the Dieri, and have learned from correspondents that they are also practised to the west of Lake Eyre, to the northward of it, at Port Essington, and also in Queensland. It may be assumed with safety that the use of gestures is more or less general throughout Australia.

Some of the statements made by my correspondent, Rev. H. Kempe, as to the gesture language used by the Aldolinga tribe at the Finke River in South Australia, are both interesting and suggestive. I have preferred to give these, with his illustrations of their use *in extenso*, rather than to embody merely the signs themselves in the succeeding list. He says that the Aldolinga have signs for nearly everything, but that it is difficult to describe them, so as to convey the proper meaning to a stranger. They have a sign for every animal. For instance, for the kangaroo, the hand is held palm upwards and the fingers a little bent. Movements are made with the hand to imitate the jumping of the animal. For an emu the hand is held palm downwards, and moved with an undulating motion from left to right. There are signs for all the varieties of snakes. For instance, the sign for the Ilyuralea (a poisonous one) is made by holding the bent fingers upwards and making some horizontal circles with the hand. For the carpet snake the hand is also held palm upwards, with thumb and fingers sticking up, and the hand is moved by successive jerks towards the person. For Patamanina, a poisonous snake, the second finger of the right hand is held upwards and moved in a vertical circle. For the native turkey, the bird's movements of its head are imitated by the second finger of the right hand.

* Bunjil, or Mamangata, by the Kulin, and Mungan ngaur, by the Kurnai, mean Our Father.

There are also gestures appropriate to the four different class names of the Aldolinga tribe :—

Bŭnanke	Lizard.
Būrūle	Ant.
Baltāre	Eaglehawk.
Kūmare	Wallaby.

The sign for Bŭnanke is that the right hand is moved up and down several times in front of the face, with all the fingers bent in towards the palm. For Būrūle, the same, but the second finger is extended and closed again several times. For Baltāre, also, the same, but all fingers are extended, and the motion of the hand thus imitates the flight of the eaglehawk. For Kūmare, the same, but the little finger and third are kept pressed to the palm, while the thumb and other two fingers are extended.

Mr. Kempe, also, in reply to my question whether a gesture was known in this tribe indicating an offer of, or request for, a temporary wife, replied that it was, and according to his description, it is precisely that which I have seen used by the Dieri and other tribes in the Barcoo delta.

The systematic use of gestures by the Australian aborigines in lieu of words, or in connection with speech, seems to have been almost overlooked until lately by writers on the Australian aborigines. It was observed that they used certain signs, such as shaking or nodding the head to signify dissent or assent. Explorers have occasionally mentioned that the blackfellows they met with used gestures to them, as, for instance, Sir Thomas Mitchell, when travelling on the Thomson River.† But the idea did not arise that in such cases these signs and gestures were not merely the natural aids to speech, but, in fact, formed part of a recognised and well-understood system of artificial language, by which these savages endeavoured to communicate with the white strangers passing through their country, just as they would have endeavoured to communicate with strangers of their own colour.

The difficulty in the way of investigations into gesture language are very great. The ordinary enquirer needs to be almost specially trained in order to prevent his falling into errors in interpreting or describing the signs made. I have found that, unfortunately, there are but few who do not break down under the process of preliminary instruction and the subsequent cross-examination to which their statements must be subjected. There is, moreover, always a danger that the blackfellow may misunderstand the meaning of the enquiry, and instead of giving such signs as were recognised in his tribe, or of saying that there were

† Stuart's well-known statement that a blackfellow in the Northern Territory made Masonic signs may be merely based upon a use of gesture language.

none at all, will endeavour to give such a translation in signs as seems to him best to express the reply to the question put to him.

I have not been able to do more than to superficially touch upon this subject. I have recorded the few data which I have been able to obtain, and I trust that now, when attention has been drawn to the subject, those who are in a position to do so will investigate the subject.

There are plenty of places in Australia where the aborigines are numerous, and still sufficiently in their original condition to maintain their old customs to a great extent.

In compiling the list of gestures given in this paper I have recorded such as I have seen used myself, and also those for which I have to thank the following correspondents:—Mr. Robinson, of Coburg Peninsular, as to the Oirig tribe, Mr. Gason and the Rev. H. Vogelsang as to the Dieri, the Rev. H. Kempe as to the Aldolinga, and Mounted-constable Hewitt as to the Kuriwalu.

All.—Hold out the clenched hands and open and shut them several times. *Urunjeri.*

All gone.—Extend both hands and arms as if in the act of swimming, then point in the direction to which they have gone. *Dieri.* Hold out both hands with widely-extended fingers, and the palms downwards in the direction in which they have gone. *Aldolinga.*

All right.—Hold the hand out palm upwards, and describe several horizontal circles with it. *Aldolinga.* Nod the head twice. *Kuriwalu.*

Anger.—Pout the lips out. *Dieri Gason.*

Attention!—Hold up the open hand, palm outwards, and move it once or twice up and down. *Woiwurng.* Wave the open hand, palm upwards, several times towards the body. *Kuriwalu.* Wave the hand from the breast, and shake the head. *Kuriwalu.*

Bad.—Shake the hand, then throw both the hands out and over the shoulder backwards. *Oirig.*

Before.—Point forwards and a little downwards with the right hand and forefinger. *Aldolinga.* Point with the hand in front downwards. *Dieri Vogelsang.* Right hand brought from the left shoulder across the body in front. *Kuriwalu.*

Behind.—Place left hand, fingers slightly closed, palm outwards, behind the hip. *Urunjeri.* Point with the hand backwards. *Dieri Vogelsang.* Point with the hand extended behind the body. *Aldolinga.* Waft the hand, fingers open, downwards, and to the rear. *Kuriwalu.* Point with forefinger of right hand over the left shoulder. *Oirig.*

Be quiet.—Close the hand loosely, the fingers being towards yourself, then make several motions with it downwards in front of the body. *Dieri Vogelsang.* Make several short movements with the right hand in front towards the ground. *Yantruwunta.* Make a motion with the clenched fist from the mouth downwards. *Aldolinga.*

Be quick.—Hold out the hand and arm stiffly, and rather high. Shake the hand several times as if flirting something off. *Dieri Vogelsang.* Make a number of circular movements from right to left in front of the body with the open hand, palm downwards. *Aldolinga.* Wave the hand several times to the body. *Kuriwalu.*

Big.—Extend both arms semi-circularly from the shoulders outwards, the fingers slightly crooked and separated, and at the same height as the shoulders. *Urunjeri.* Mark with the hand held horizontally to the ground the approximate size intended. *Dieri Vogelsang* Strike with the clenched. fist towards the ground; if for "very big" make a long stroke. *Dieri Gason.* Shut both hands, excepting the forefingers, with which indicate size by holding them apart. If very big, then very wide. *Kuriwalu.* Hold up both hands and arms in front forming a circle. *Oirig.*

Camp.—Chop twice with right hand at an angle of 45 deg. from right to left in front of yourself. Then place forefinger of right hand between the tips of first and second fingers of left hand, simulating a ridge pole. *Urunjeri.*

Come here!—Beckon with the open hand towards yourself. *Urunjeri.* Point to the person with the right hand, then point to the left. *Aldolinga.* Beckon with the open hand upwards and backwards. *Oirig.*

Danger.—Make a movement as of catching a fly close to the mouth, and then squeezing it. *Dieri Gason.* Place the right hand in front of the body, and then step back a pace or two. *Kuriwalu.*

Day.—Point to the sun. *Oirig.*

Dead, death.—Make a sign along the ground by drawing the forefinger along it. *Dieri Vogelsang.* Bring the hands together, then make a movement with them as if of concealing some thing small in the palms. *Dieri Gason.* Stoop a little, and tap the ground with the back of the hand. *Yantruwunta.* Throw the head back, close the eyes, and extend the arms and hands backwards. *Oirig.*

Distance, far off.—If near, point a little way off. If far off, point to the horizon. If very far, point above the horizon. *Urunjeri.*

Drink, drinking.—Imitate lifting water to the mouth with the hand. *Urunjeri.* Place the thumb and forefingers of the right hand together like a scoop, and carry the hand up to the mouth. *Dieri Vogelsang.* Tap the throat with the forefinger and thumb, then point to the mouth. *Oirig.* Throw the head back and carry the hand up to the mouth. *Kuriwalu.*

Eat.—Lift the hand to the mouth as if conveying food. *Dieri Vogelsang.* Point to the mouth and go through the motion of eating. *Oirig.*

Enemy (wild blackfellow).—(1), sign for man; (2), sign for far off. *Urunjeri.* Right hand open, and palm downwards. Move it two or three times vertically in front of the body. Then repeat the same at the right side. *Kuriwalu.* Place the hand, palm outwards, in front of the face, then turn it several times from inwards to outwards. *Aldolinga.*

Enough.—Hold out the hands in the sign for "big," "much," then point to yourself, and shake the head, or make the sign for "none." *Urunjeri.* Tap the stomach several times gently with the flat hand, then wave the hand with spread fingers outwards. *Dieri Vogelsang.* Tap mouth with open hand, then wave the hand away. *Kuriwalu.*

Far away.—Snap the fingers in the direction indicated. *Dieri Vogelsang.* Stretch the hand out full length, and snap the fingers. *Aldolinga.*

Give me.—Hold out the hand at full length, palm up. *Urunjeri.* Extend the hand, palm up, and then draw it back. *Dieri Vogelsang.* Right hand held out full length, fingers a little bent. *Kuriwalu.* Hold out the hand. *Oirig.*

Glad.—Pat the breasts with both hands several times. *Urunjeri.*

Good.—Make a trembling or vibrating motion with both hands, palms inwards, in front of the face, which must have a pleased expression. *Dieri Vogelsang.* Move the right hand, palm upwards, up and down in front of the body, then point downwards. *Aldolinga.* Make a slight movement downwards with both hands, palms downwards, in front of the body, at the same time inclining the head. *Oirig.*

Go away, go on!—Hand, with back to face, moved sharply outwards in a semicircle to full length of arm. *Yantruwunta.* The hand is thrown sharply from the breast, palm inwards. *Kuriwalu.* The hand is placed on the stomach, and waved outwards and upwards. *Oirig.* Hold up the hand in front of the face, palm outwards, and make several quick movements outwards from yourself. *Dieri Gason.* Point in the direction to go with the second finger of the right hand. *Aldolinga.*

Halt, stop.—Make a sign with the outstretched right hand to the ground. *Dieri Vogelsang.* Rapidly move the right hand from the breast, palm outwards, to the full length upwards, then point to the ground. *Aldolinga.* Make three waves towards the ground with the hand. *Kuriwalu.*

Hear.—Point to the ear with the forefinger of right hand. *Urunjeri.* Make a number of small circles with the finger in front of the ear. *Aldolinga.* Hold up the forefinger, and then touch the ear. *Oirig.* Fanning with the hand about two inches distant from the ear means "I cannot hear you," "Say it again." *Dieri Gason.* Extend the hand over the head as high as possible; stoop and reach as far out as possible till the hand nearly touches the ground; this means "I hear you," "I know what you mean." These signs are used when communicating from a distance. *Dieri Gason.*

Hungry.—Extend both arms upwards so as to show the stomach drawn in. *Urunjeri.* Rub the open hand over the stomach. *Yantruwunta.* Tap the stomach with the finger, and then extend the open hand. *Dieri Vogelsang.* Point to the stomach with bent fingers. *Aldolinga.* Pat the stomach with both hands, and throw the arms wide apart. *Oirig.* Pat the stomach. *Kuriwalu.*

I.—Point to the breast. *Urunjeri.* Pass the forefinger down at a little distance from the forehead along the nose. *Dieri Vogelsang.* Point to yourself. *Aldolinga.* Point to the breast. *Kuriwalu.*

Kill.—Make several movements downwards with the fist, as if striking violently. *Dieri Vogelsang.* Strike short blows with one hand on the other. *Dieri Gason.* Hold the right hand high over the head, with the palm downwards. *Kuriwalu.* Strike the head with the closed hand. *Oirig.*

Little, small.—Hold up both hands about a foot apart, the palms facing each other. *Oirig.*

Man.—Indicate with both hands the outline of a beard. The size of the beard denotes the age—a great beard is a great age, *i.e.*, an old man. *Urunjeri.* Indicate the beard with the right hand, as of passing the hand down it. *Dieri Vogelsang.* Clutch the beard and shake it. *Dieri Gason.* Close the right hand, except the middle finger, then describe a small circle with it. *Aldolinga.* Point down below the stomach. *Oirig.*

Night.—Point to the westward. *Oirig.*

No, Not, None,—Shake the head. *Urunjeri.* Shake the head several times, or shake the hand several times, the hand being raised about as high as the face and held loosely pendant from the wrist. *Dieri Vogelsang; Yantruwunta.* Shake the head. *Dieri Gason.* Hold the right-hand palm outwards, then point upwards. *Aldolinga.* Shake the head several times, then wave the hand from the breast palm downwards. *Kuriwalu.* Throw the right hand upwards and backwards, and jerk up the left shoulder. *Oirig.*

Peace.—Hold up both hands at full length, open palms outwards above the head. *Yantruwunta.* Hand thrown forward full length from the body, palm downwards, and head bent down. *Kuriwalu.* Throw the open hand from the left shoulder round to right, and then pat the mouth several times. *Oirig.*

To Run.—Hold the arms bent at the elbows, with hand clenched in front; then describe small circles outwards, indicating the movement of legs running. *Urunjeri.*

To See.—Touch the eye with the forefinger, and then point in the direction indicated. *Urunjeri.* Describe a number of small circles or a spiral with the finger from the eye, in the direction indicated. *Aldolinga.* Nod the head and touch the eye with the forefinger. *Oirig.*

Silence! Say no more!—Thumb of each hand turned inwards, then stoop and extend the hands full length. This also implies a threat of strangling, and is used, for instance, by the old men to the young men when they are misbehaving themselves. *Dieri Gason.*

Sit down.—Make the sign for "Halt!" Stop and point to the ground. *Urunjeri.* Extend the arm towards the ground, and make two or three quick movements with the open hand towards the ground. *Yantruwunta.*

Sleep.—Incline the head upon the open hand towards the shoulder. *Urunjeri.* Incline the head upon the palm of the hand near the shoulder. *Dieri Vogelsang.* Lay the head in the palm of the hand. *Oirig.* Place left hand over the eyes, and incline head on left hand. *Kuriwalu.*

Supreme Being (Bunjil).—(1) Make exaggerated sign for "old man;" (2) make exaggerated sign for "big;" (3) point to the sky. *Urunjeri.* Similar gestures are made by the Murring.

Thirsty.—Make the sign for "to drink," then hold out the open hand. *Dieri Vogelsang.* Point towards the stomach, and then snap the fingers. *Aldolinga.* Scratch the throat.

Kuriwalu. Extend the hand and shake it, then touch the mouth and throat. *Oirig.*

Where? What? Who? What is it? &c.—Hold the right hand opposite the left breast, palm downwards, then move the hand upwards and outwards higher than the shoulder, gradually turning the hand so that at last the palm is upwards; or do this so that the movement of the hand upwards and forwards only brings it level with the face. *Yantruwunta.* Place right hand at left breast, palm outwards, then move it up at an angle of 45 deg. with the horizon hold up for a moment, and let drop; when moving the hand also jerk up the chin. *Urunjeri.* Throw up the hand higher than the head, then let it fall, palm upwards. *Dieri Gason.*

Water.—Same as "thirsty." *Oirig.* Same as "to drink." *Dieri Vogelsang.*

Woman.—Point with the finger of the right hand to the breast. *Urunjeri.* Indicate the breasts with both hands. *Dieri Vogelsang.* Make a circle with the forefinger of each hand round the breast. *Dieri Gason.*

Yes.—Nod the head. *Urunjeri; Dieri; Oirig.* Make a movement with the open hand towards the ground. *Aldolinga.*

10.—ON CERTAIN MUTILATIONS PRACTISED BY NATIVES OF THE VITI ISLANDS.

By Bolton S. Corney, Chief Medical Officer, Colony of Fiji.

There are one or two mutilations commonly practised by natives of the Viti Islands, which, if they have been invested with a measure of importance, viewed from a medical standpoint, to which they have but slight claim, possess nevertheless a degree of anthropological interest which may warrant their being described and recorded in the presence of an Association for the advancement of science.

The more noteworthy of these, because the most commonly resorted to, and also the most "heroic," is that designated in the native language Thoka losi. It consists in passing a bougie or sound into the male urethra as far as the membranous portion, and in making an incision about an inch in length upon it from without at the bulbous portion. A seton may or may not then be passed in at the wound and out at the meatus, according to the whim of the operator.

THOKA LOSI is done for various ailments or illnesses, generally in cases of lumbar rheumatism and in the sequelæ of catarrhal fever, such as haric pneumonia, mild but painful pleuritis, and various neuralgic affections, and in disease of the sacro-iliac synchondroses.

The usual explanation given by natives when interrogated as to the *rationale* upon which this operation is recommended is that by incising a dependent portion of the trunk, such as the perinæum, the abdomen is relieved from an accumulation of blood about its fundus.

This theory, ingenious though it be, is, of course, as foolish in conception as it is anatomically inconsistent. Yet many Fijian natives, chiefs of intelligence among them, declare that their lives have been saved by undergoing THOKA LOSI, and that it is one of the few really good methods of treatment handed down to them by their medical experts from the dark ages of their history. The fact that this grain amongst the chaff of the mediæval lore of a race of cannibals should rest upon a principle at variance with the most rudimentary facts of human anatomy is to be explained by their custom of cooking bodies as they still cook pigs—by baking them whole in an oven or pit, lined and covered with heated stones. This process prevented the natives from acquiring any deeper knowledge of the human frame as a consequence of their cannibal habits, than the average English housewife learns from roasting a rabbit or a barn-door fowl of comparative anatomy of the Leporidæ and the Gallinaceæ.

THOKA LOSI is performed more commonly in certain districts of Fiji than in others. The central and western provinces of the main island are its strongholds, and it becomes less resorted to towards the eastern portions of the group, where the admixture with the Tongan race is more general. As the latter condition markedly influences the colour of the skin, one may say, speaking roughly, that the darker the prevailing tint of skin in any tribe or *matanggali*, the more commonly is THOKA LOSI likely to be met with amongst its members.

Fijians, however, are not the only people who practise some method of tampering with the urethra. Among certain tribes in the west and north-western portions of Australia the urethra is commonly laid open from the meatus backwards. In some tribes the slit extends two or three inches; in others it is carried quite to the scrotum. It is made on the under side of the organ, and is not expected to re-unite, but leaves a mere groove in place of the normal urethra, which becomes callous.

While the occurrence of so singular a practice in races as widely separated, both geographically and ethnologically, as the Fijians and the natives of north-western Australia is remarkable, there are essential differences between the two procedures. Their ethics are different, and their methods are dissimilar. With the

Australian blacks it is a mutilation, pure and simple. It is performed at puberty as a regular function, and its occasion is attended with much ceremony.

The Fijians, on the other hand, merely resort to their procedure for the relief of pain or illness. With them it is a venesection, and is in no way associated with any idea of conferring a *toga virilis* upon the sufferer.

The Australian lays open the urethra and leaves it so once for all, whereas the Fijian expects the edges of his incision to re-unite, and succeeds in procuring that desirable result, sometimes operating upon the same patient three or four times. This is the more surprising when the employment of the seton is borne in mind. Yet perinæal fistula is a thing never met with in the Fijians, nor have I been able to hear of any case of cicatricial contraction of the urethra in these natives, either after THOKA LOSI or from any other cause.

The staff used is made generally from a twig of the tree called by the natives *losilosi*. Hence the term employed for the whole operation, THOKA LOSI, which means piercing with *losi*, or *losi* piercing, Occasionally, however, if the *losilosi* be not at hand, a reed is made use of instead, and answers equally well, save that its point is less smooth, and requires greater care in passing. The cutting instrument is generally a piece of sharp mussel or cockle-shell, according to the locality, but occasionally a slip of bamboo. Of late years, however, a piece of a broken glass-bottle has been often employed, and is to be found in every village. The bast from the well-known *Vau* tree, *hibiscus tiliaceus*, forms a convenient seton, being both tough and unirritating.

The Fijian applies no dressing after THOKA LOSI, and I am afraid I must admit that he does not even wash the parts. This is only in accordance with his common custom of dating his convalescence from an illness from his first bathing after it. Though some urine naturally escapes during the first day or two through the wound at the times when urine is (voluntarily) passed, the natural opposition of the parts, and their elasticity, seem to be enough to ensure the satisfactory completion of the healing process, and the avoidance of fistula.

Another mutilation of the urethra practised by the natives of Fiji, bearing a still greater similiarity than THOKA LOSI to that inflicted in Western Australia, but also resorted to only as a remedial measure, is the procedure known by the native name of TAYA NGALENGALE. It consists in incising the urethra at its meatus to a point just behind the frœnum preputii, including division of its artery. This is allowed to bleed to an extent varying from a mussel shellful to a cocoanut shellful (which means the half of a cocoanut-shell used as a cup), that is to say, from half an ounce to half a pint.

The primary object of this operation seems to be blood-letting. A cutting instrument is used for it similar to that employed in THOKA LOSI, and in both the operators are men. I mention the latter fact because in another proceeding, termed SILI NDAKU, or SILI MU, performed both on women and on men, the operators are women. This process, though it cannot be termed a mutilation, is so strange a measure that it may be worth describing. The first stage of it is the administration of a prolonged sitz-bath. Afterwards the patient returns within doors, and sits on a mat on the floor of the house, the old woman doctress taking up a position immediately behind. She then, after oiling her forefinger, proceeds to insert it for its whole length (from behind the patient) into the rectum, passing it, of course, beyond the sphincter, and retains it there for a space of about five minutes. After its withdrawal the patient is told to lie down and to remain in the house for two days. It does not appear that any scarification with the finger-nail, or indeed any movement of the finger, is practised during this singular proceeding, and it is not clear what object it is expected to attain. It is administered in epidemic catarrhal fever and various forms of pain in the back, and is much more commonly resorted to in the eastern portions of the group than THOKA LOSI is, though used in others as well. The usual name by which it is known is simply "The sitz bath," and in that portion of its ceremonies the virtues or the dangers of SILINDAKU doubtless lie.

Other mutilations practised by the natives of the Viti Islands are circumcision, tattooing, flattening of the occiput, the procuration of raised scars as ornaments about the chest, shoulders, and upper arms, various shavings of the head, especially in children, and cuttings of the hair, perforation and dilatation of the lobe of the ear, and the well-known amputation of one or more fingers or finger-joints when mourning for a deceased relative. Tattooing and finger-chopping have been much discouraged by the missionaries, being regarded by them as associated with heathenism. While, however, the tatooing of women, as formerly practised, is now only seen in the persons of old people, a new description of this ornamentation has lately become popular among young men belonging to the best families. This consists in blazoning the arms of Great Britain in lamp-black and carmine upon the chest or upper-arm; and sometimes the design is varied by the employment of the American eagle-and-flag trophy instead. The most remarkable feature about this modern innovation is the exactness of the drawing. This is of a character that would do credit to the tattooing artists of Japan or Malta, and led me at first to suppose that it was the work of one man, probably a foreigner. It proved, however, to be otherwise, and native dandies tattoo each other with great skill.

Ear-piercing is not now done by natives of the coast tribes in Fiji, and it is only among the old men in the mountain districts that exaggerated instances of dilated lobes, such as are still common in the Solomon Islands and many other parts of Melanesia, are to be met with.

Raised scars are obtained by pressing some article, generally an infant orange, or a number of them, about as large as a pea each, into an incision made for their reception, and so by irritation giving rise to exuberant granulations. But, very remarkably, raised scars not infrequently result in natives of the Viti Islands from simple wounds about the chest or shoulders, and from vaccination. When produced designedly they are the result rather of a youthful freak than of any definite object or in virtue of any custom, and they do not represent any tribal mark or Totem.

Flattening of the occiput is practised only in certain families of high degree or relationship. It is effected by the pressure of a roll of native cloth *(masi)* on the forehead of the infant, the back of the head resting on a board. Its result is to make the back of the head appear almost in a straight line with the neck and to widen the skull. One of the most marked cases of this deformation that I have seen, became at nine years of age epileptic, developed epileptic insanity, at sixteen suffered from almost incessant epileptiform convulsions, and soon afterwards died (probably from starvation) after ten days' trance.

With regard to this flattening of the occiput, I have more than once suspected that it is practised only in those families whose special physiognomy already shows a tendency towards that shape of head which the artificial process in question intensifies. As these particular families are the highest in the land, it is not unreasonable to think that they may see in their peculiarity a special and distinguishing type of beauty, and that they may wish to exaggerate it artificially. Such a proceeding would be in accord with the recognised principles of skull deformation in other parts of the world, as reasoned out by students of anthropology. It is merely applying in the present case to a few families a principle which is known to influence whole races.

The principal point of interest, however, in the subject of this paper is that already alluded to, namely, that mutilations of the urethra are practised among the Fijians as a means of relief from disease, though disease at a distal part of the body; and mutilations of a kindred character, though slightly different in detail, are practised by certain tribes in the north and west portions of Australia as a matter of general custom on arrival at the age of puberty. The origin of this custom, often stated to lie in the wish to keep down the population in an infertile country, admits of the widest doubt. And it would probably not be warrantable to hazard any opinion, without first making extensive observations and enquiry among the countless tribes of Africa, Madagascar, and the Malay Archipelago, as to where these customs sprang from, and as to what circumstances called them into existence.

Addendum on the Surgical Aspects of THOKA LOSI.

An operation such as THOKA LOSI may appear coarse and inutile. It has been customary, indeed, among surgeons in Fiji to regard it, as performed by the Fijians, with aversion and contempt, and to stigmatise by various uncomplimentary epithets all natives who pose as its defenders. Those of the European lay community who have any knowledge of THOKA LOSI, whether from hearsay or from observation, regard it as barbaric and unjustifiable, and popularly believe that recovery after it is the exception rather than the rule.

Amid this storm of opposition, THOKA LOSI, though it affects but a small and imperfectly-known handful of Her Majesty's subjects, deserves, perhaps, as a surgical proceeding a word of apology, even though as a measure of medical treatment it may not be deemed worthy of support nor even justifiable. Indeed, I am by no means sure that its ill-repute amongst white people is deserved. For, though in principle it is unreservedly fallacious, in its effects it is at least free from many of the disastrous consequences with which it has been charged. Only twenty European surgeons have resided in the Viti Islands, and of this number but few have mixed freely with the aboriginal race or learned sufficient of the language and of the inner domestic life of the people to have gained an opportunity of watching a case of THOKA LOSI from its beginning to the healing period. Such cases are, from their very nature, not freely paraded, and a European surgeon is still less likely than a non-professional person to have them exhibited to his observation and, doubtless, adverse criticism. Moreover, the native operator receives his training as a family prerogative. It represents his stock-in-trade, by which he counts upon gaining presents and property. And for these reasons he is never very ready to afford another person any insight into his methods. It is only after many years' residence, therefore, and much intimacy with individual natives from different parts of the group, that a series of data, consisting of actual observations, can, in a matter like THOKA LOSI, be collected.

From what I have seen, I have formed the opinion that it is unfair to draw parallels, and then comparisons, between THOKA LOSI and our own operation of perinæal section. But this is what commonly has been done in arriving at those condemnatory statements which meet the traveller's ear in reference to this subject.

Even external urethrotomy for old or impermeable stricture is not a fair simile to use. The truer homologue, indeed (so far as etiology and method, though not purpose, are concerned), is our operation for incising the urethra in cases of impacted calculus or foreign body. The latter operation is well known to be a simple and safe proceeding—free, not only from the dangers more immediately attending perinæal section and external urethrotomy for stricture, but also from those risks which have to be run during the healing process after those operations, both as regards septicæmia and urinary fistula. Perinæal section is said to be of ancient date—practised even in the tenth century, A.D.—but was for a long period a dreaded operation. Even now the conditions which give rise to the need for its performance preclude our deriving the full advantages of aseptic dressings after it. In the native, however, upon whom THOKA LOSI is about to be undertaken, all the important dangers are absent. There is no hospital air; there is no extravasation of urine or other septic abomination in possession of the field before the operation. The incision is made through sound and uninflamed tissues. The patient has no stricture to hinder healing or to complicate the after-treatment by needing the retention of a catheter, and he is neither a drunkard nor even a moderate user of alcohol. He is also a stranger to syphilis, and his tissues possess a happy quality of healing readily even after the most severe wounds. The disease against which the THOKA LOSI is intended to militate has its seat at a distance from the site of the operation, and is often in itself a more painful than serious ailment.

For these reasons it has appeared to me that in the cases in which THOKA LOSI has been followed by the death of the patient, this consummation has been brought about, not by the THOKA LOSI, but by the original disease, which it was intended, but failed, to relieve. An examination into the circumstances of individual cases has borne out this belief. The cases which have ended fatally have been chiefly those of old men attacked by pneumonia in the wake of influenza, which in Fiji is better described by its other name—epidemic catarrhal fever—and they have died without hæmorrhage or sloughing at the seat of operation, or septicæmia. The successful cases, on the other hand, have commonly been those of less acute diseases, chiefly making their presence felt by pain lower down in the back than the bases of the lungs—pain of a rheumatic nature, commonly enough met with among a people who live in a rainy climate, dwell in damp houses, dress without discrimination, and sleep in damp bed-places, separated only from the earth by a scanty layer of mouldering grass or cocoanut leaves. Such, then, is the Fijian operation of THOKA LOSI—incision of the urethra. Let me not be considered its advocate, nor even its avenger. I merely wish to put forward an impartial criticism of a subject which has been much derided, but little studied, and which it has been the fashion, through want of knowledge of its details, to inconsistently compare with a much more serious pathological condition and remedial procedure.

11.—THE MARRIAGE LAWS OF THE ABORIGINES OF NORTH-WESTERN AUSTRALIA.

By Hon. John Forrest, C.M.G., M.L.C.

The marriage laws of the aborigines of Australia are fixed upon a general plan which restricts, to a great extent, individual choice.

1. When I visited North-western Australia, in 1878, I found that the aboriginals were divided into four families, the names of which are Boorunggnoo-Banigher, Kimera and Paljarie. The two first can intermarry, and the two last can also, but no other alliance is possible; for instance, if you meet a Boorunggnoo man, his wife must be of the Banigher family, and the wife of a Kimera could only belong to the Paljarie family, and *vice versâ.*

2. The children, however, do not follow either the father's or mother's family; for instance, if the father were Boorunggnoo the mother must be Banigher, and the children would be Kimera. If, however, the father were Banigher, and the mother Borunggnoo, the children would be Paljarie. Again, if the father were Kimera, the mother must be Paljarie, and the children would be Boorunggnoo; but if the father were Paljarie, and the mother Kimera, then the children would be Banigher. By this means the relationship progresses, and it follows that

MALE.		MALE AND FEMALE.
Boorunggnoo is father to	... ...	Kimera
Kimera is father to	... ...	Boorunggnoo.
Banigher is father to	... ...	Paljarie.
Paljarie is father to	... ...	Banigher.

FEMALE.		MALE AND FEMALE.
Boorunggnoo is mother to	... ...	Paljarie.
Paljarie is mother to	... ...	Boorunggnoo.
Banigher is mother to	... ...	Kimera.
Kimera is mother to	... ...	Banigher.

3. It therefore follows that the grandchild, in the male line, is of the same family as his grandfather, and in the female line of the same family as her grandmother. For instance, a man of the Boorunggnoo family (whose wife, of course, must be of the Banigher family) has a son, who would be Kimera, and his grandson (that is, of the Boorunggnoo) would be Boorunggnoo. The

direct line of male descent from a Boorunggnoo man would alternate from Kimera to Boorunggnoo for ever.

4. But if the child of a Boorunggnoo man and a Banigher woman were a girl, she would, of course, still be Kimera, but would have to marry a Paljarie man, and her children would be Banigher, being the same family as her grandmother; and, therefore, in the direct female line from a Boorunggnoo man and a Banigher woman, they would alternate between Kimera and Banigher for ever.

5. In the same way the son of a Kimera man and a Paljarie woman would, of course, be Boorunggnoo, and when he married he must marry a Banigher woman, whose children would be Kimera, the same as their paternal grandfather; if, however, the child of a Kimera man and a Paljarie woman were a girl, she would still be Boorunggnoo, but would have to marry a Banigher man, and her children would be Paljarie, the same as her maternal grandmother. It, therefore, follows that the offspring from a Kimera man and a Paljarie woman, in the male line, would alternate from Boorunggnoo to Kimera for ever, and in the female line from Boorunggnoo to Paljarie for ever. If, however, the parents are reversed, and are a Paljarie man and a Kimera woman, the offspring in the male line would alternate from Banigher to Paljarie for ever, and in the female line from Banigher to Kimera for ever.

6. Now, it follows that Boorunggnoos and Kimeras and Banighers and Paljaries of both sexes mix together as fathers and children of one family, although they may never have seen one another before; also, Boorunggnoos and Paljaries and Banighers and Kimeras of both sexes mix together as mothers and children of one family; not so, however, Boorunggnoos and Banighers of opposite sexes, or Kimeras and Paljaries of opposite sexes—for these may marry, and very little acquaintanceship or intercourse is allowed, and a great shyness is observed on both sides.

7. This is very noticeable when a stranger arrives, and I will suppose that it is a young member of the Boorunggnoo family. As soon as his family is ascertained, it follows that all the women of the Boorunggnoo family are to him as sisters, all the women of the Kimera family are to him as daughters, and all the women of the Paljarie family are to him as mothers; and all these at once gather round and welcome the stranger, without the slightest restraint, being relatives whom he may not marry, although he may never have seen them before, and with whom no relationship whatever may exist. Not so, however, the Banigher women, who are eligible to become his wife. They at once appear shy and reserved, and do not join in the friendly welcome. This etiquette is always observed, and is readily noticed.

12.—THE GENEALOGY OF THE KINGS AND PRINCES OF SAMOA.

By Rev. George Pratt.

(1).—Introduction.

I got this "Genealogy of the Kings of Samoa" from Rev. T. Powell, who was missionary of Manu'a; that was, perhaps, some 35 years ago. He obtained it from the Keepers of the Genealogies under a promise of not divulging it to Samoans. The office of keeper was hereditary in one family. When pressed by parties whom they could not well refuse, they were in the habit of falsifying the account, so as to render them useless. The father communicated the narrative to the son who was to be his successor, and he committed it to memory from his father's mouth. Bards as such could not be hereditary, for even among Samoans *poeta nascitur, non fit.*

The poet composed his song as occasion called for it, line by line, and as he recited it the young persons around held it in their memory. Every chief has his praises sung—every event brings forth a new song. Yet heavy fines cannot keep the poetic fire from indulging in cutting sarcastic songs, and in war time these are more stinging than gunshot wounds. As to the chronicles themselves it is clear that, like the chronicles of the kings of Israel, the chroniclers of different generations must have added to the former accounts.

It is difficult even to guess the antiquity of these records, because a brother often, nay, generally, succeeds a brother, consequently the reigns do not represent generations. For instance, two brothers of Malietoa succeeded him, one after the death of the other. Then again, the narrative begins with myths and the gods. "The eighth heaven," like the third heaven of the Hebrews, was the residence of the gods. Man, having grown out of the earth, was necessitated to seek a wife from heaven. In those days the heavens were thought so near to earth that they could be reached by climbing into a tree. "The sacred fish" was taken to Maileitele. Several fishes were considered sacred. A turtle was caught and eaten by some villagers, instead of being taken to their chief. The whole village was banished in consequence.

Meanings of Some of the Names in the Genealogy of the Samoan Kings.

Alatana	War-path.
Ali'itasi	One-chief.
Falaleomalie	Sweet-sounding mat.

Fatumanava-o-Upolu	The motion of the heart of Upolu.
Fepulea'i	Commanding one and another.
Tologataua	Deferrer of war.
Fonoso'oia	Constantly holding councils.
Fuatanga	Gathering [of thatch].
Ga'utala	My tale.
I'amafana	Warm fish.
Langituavalu	Eighth heavens.
Leifi	The chesnut.
Leifi-mouloto	Leifi of many hearts.
Leitufia-o-Atua ...	The three sides of Atua.
Le-tagata	Man.
Le-tupu-fua	Grown from nothing.
Lotoma'a	Stony-hearted.
Luafaletele	Two large houses.
Ma'ataanoa	Loose stone.
Maina	Shining.
Maileitele	Large-trap.
Malaeta	Sunny council meeting-place.
Malietoa	A proper warrior.
Mata'afa	Canoe-fastening.
Mata'utia	Dreaded.
Moegagogo	Pairing-of-gulls.
Moti	Oil.
Molioo	Take to the end.
Nofoasaefa	Seat torn in four.
Paepaetele	Large platform of stones.
Paitomaleifi	Cooking-house and chesnut.
Papaele	Earth rock.
Papapala	Mud.
Papatu	Standing rock.
Sina	White.
Sinataufafa	Sina riding pick-a-pack.
Sualauvi	Juice of the vi-leaf.
Taelalopu'a	Dung under the pu'a tree.
Taemoomanaia ...	Dung of handsome lizard.
*Taemo'otele	Dung of a great lizard.
Taeoalii	Dung of chiefs.
Teleipesega	Great-in-song.
Tonumaipe'a	Decision from Pe'a.
Tusa	Equal.
Tuala	Standing in the road.
Tualau	Back of a leaf.
Tualupetu	Back of a standing pigeon.
Tuanu'u	Back country.
Tuapu'u	Short back.
Taumi	Long back.
Tupua	Image.
Tupo	Standing up at night.
Uitua	Going behind.
Usufonoimanu ...	Go early to the council of birds.
Veletalo-ola	Weeding flourishing taro.
Velova'a	Canoe shoved off.
Nonofo-i-fale-ese ...	Dwelling in strange houses.

* "Taemo'otele" = Dung of the great lizard. Samoans were very fond of these filthy combinations of words in naming their children and towns. Several very obscene names still obtain.

(2).—The Genealogy of Papatu.

Papatu (Standing-rock) married Papaele (Earth-rock). Their son

Ma'ataanoa (Loose-stone) married Papapala (Mud). Their son

Le-tagata (Man) was called Le-tupu-fua (Grown-from-nothing.)*

Le-tupu-fua married the daughter of Tagaloa-lagi,† Tama-o-itu-faiga. Their son was Lu. King Lu, the king of heaven, was brought down. His son was born, then the title "king of heaven" was dropped, and he was called king of Atua.

Lu married Langituavalu (Eighth heavens), the daughter of the king of heaven. Their son was king of Atua. But Lu died having the title of king of Atua.

Tuapu'u (Short-back) became king. Tuapu'u died, and

Tua-umi (Long-back) became king. Tuaumi died, and

Tua-faiga became king. He was the son of Piliopo. Tuafaiga married Lemaluitongapapa. Their son

Tuaefu married Sinataufafa. Their son

Uitua married Sinalei from Paepaetele. Their son

Leilua married Sinafetuga. Their son

Pulutua married Laualae. Their son

Sangapolutele married Luafaletele of Saana. Their son

Tualemoso married Feilivaa. Their son

Tuanuu married Sautala. Their son

Teneila married Senilafanga, of Moamoa. Their son

Tuloutele married Sina, of Lotoma'a. Their son

Maileitele married Utufau, of Satoi. Their son

Maileilealea, a chief who dwelt in Malaeta. The sacred fish was taken to him by Velova'a.

Mailei married Siliomanga. Their son

Taemootele married Ulufa'ana, of Manono. Their son

Siusau married Maina, of Mutilatii, the daughter of Fiame, of Muapai, Their son

Taemoomanaia married Lepealali, of Fainiata. Their son

Leutelenaiite, that was the chief to whom was taken the fine mat‡ of the conquering party, the Fatafata, which was brought by the king of Tonga when he came seeking his brother, Lautisilingia. Lautele said that he would go to Tonga. Lautisilingia was under the deck of the large double canoe. He rushed there with the dog Uilanei and two men, Leamongia and Leatongia. Then he went there, and he found that Leutele was right, and so he got the end of his name, Leuteleleiite (the prophesier, or guesser).

Leutele married Lefetutafeilo, of Toamua. Their son

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* This gives the origin of man, made from the earth. See Glossary.

† The chief god.

‡ "The fine mat of the government, the Fatafata (breast)." These mats were very fine and very old—age and patches increased their value. One was once valued at seventy dollars, and was exchanged for a block of land. Each mat had its name. They answered the purpose of money, being used to pay carpenters, tattooers and fines.

Aumuatagafa married Fala, of Aleipata. Their son was

Fonosooia.

Aumua married again, Sulumatai'a, of Alafaalava. Their son was Tepuleai. This was the chief who was appointed to be king; but Fonosooia was appointed by the chieftesses,* who had the right and he was guarded by Ituau and Alatana.

Fepuleai married Utufaasili, the daughter of Funefeai, of Safune. Their son was Tolongataua. That Utufaasili raised war, because Funefeai was angry because they did not observe the customs in the appointment of kings of Atua when they brought his fine mats. Then Fepuleai told Utufaasili that she should go and meet her family. "Perhaps," said he, "they will see that you are pregnant, and will have pity on you, and stop the war." Then the chiefess went to meet her family; they met in the Tuamasanga. Funefeai saw that she was with child, pitied her, and stopped the war. It was on this account that this son of Utufaasili was called

Tolongataua. He married Lemulimatau, of Fagana. Their son was

Leaumualeuluai. Tolongataua again married Luafataalae. Their son was

Fatumanava-o-Upolu. Their daughter was Taelalopu'a.

These are the chiefs who fought.

Aumua was first appointed to be king, because he was weak; but the other son, Fatumanava-o-Upolu, was at Siumu. Then Luafata was appointed apparently as guardian of her son Fatumanava. The sea and the earth and other things were tabooed by her.† The girl Taelalopu'a heard that Aumua was proclaimed; then she wept. Tolongataua said to the girl, "Hide your tears; do you weep? Who is this and who is that who is proclaimed? Are they not all your brethren?" Then the girl Taelalopu'a was named Teu-ia-lilo (Hide away). The chief from Siumu came and proclaimed Aumua. They fought, and Fatumanava-o-Upolu was routed. Then Aumua took away the taboo of Luafata, the mother of Fatumanava-o-Upolu. Then Leifi waited for the council to be held at his meeting-place, Lalongafu'afu'a; but it was not held there, but at the meeting-place inland. Leifi was angry because the council was held in the wrong place,‡ and he sent a message to Fatumanava-o-Upolu that the troops should again assemble, and take sides with him. A battle was fought, and Aumua was routed. Then Aumua said to his hinder palankeen-bearers, "Who is it that is pursuing us?" The palankeen-bearers said it was Leifi. Then said the king, "That is Leifi-mou-loto.§ He is fighting on that side." This word of the king was the origin of the name Leifi-mou-loto. Aumua and his troops were routed, and then a council was held. Then Leifi said to the two chiefs, "You two are conquered. Let Aumua, who was appointed, be king, and you be kava-chewers|| to Fatumanava-o-Upolu. As to the taboo of Luafata, that you,

* "The chieftesses who had the right." Some of these ladies had great power, and the names of such descended with the title.

† "The sea and the earth were tabooed." Fishing and working were prohibited. This was often done on the death of a chief.

‡ "The meeting was held in the wrong place." On this point they were very particular. Some chiefs met in a private house at Manono to discuss the question of war. All the people from al parts of Samoa were collected in the malae, or proper meeting-place in the open air. A chief stood up, and in a loud voice asked if they were going to have a council in a cooking-house.

§ Leifi of many hearts.

|| A term applied to young men.

Aumua, took away, give all back to him; only the* herring† I will retain." This was agreed to. The taboo of Luafata gave origin to the name Saluafata‡; but the old name of that village was Evaloa.

Aumua married Leatealele, of Malaepongaponga. Their son

Moaitele married Leaponga, daughter of Vaetui, of Sanga. Their sons were Polailevao and Taumaoa.

Polailevao married Momoefuifatu. Their son was Fotuitama'i. That was the chief who gave the royal title by which Leteleipesenga had the privilege to help themselves to food. That was the chief who married Tele, daughter of Leifi. She bore Puepuemai and the girl Aliitasi. That was Fotuitama'i that had the taboo of Puepuemai. The royal title left Le-alataua from Leteleipesenga, and then

Samo became king. That was the chief to whom belonged the game of ti'a§ in Ti'asamo. All Atua went to build up the ground for that ti'a; but Leifi and Salei-aumua did not go. It was known that the ground for the game at Aleipata was not prepared. Samo was angry because Atua was not one in building this ground for ti'a. The title of Teleipesenga was given up, and

Faatufunga became king. That was the chief who was noted for his land, having been buried with stones carried in men's nostrils. Faatufuga was angry because Atua was not one in the work. Leifi did not go to it. He said that he did not go because of what the woman had said who had gone with her burden of thatch, and all the young men had burst out into a laugh at her leaf-girdle, which was bad. Then it was that she uttered the words, "Don't laugh at me; this is the consequence of your weak-handedness. We are going to fierce Tonga‖ with these burdens of thatch." Leifi heard her say this, and he told them to throw down the stones,¶ and come away to the east. Olapau then put down the stones and came away. These are the stones by the wall above Aufanga. The royal title departed from Faatufunga, and Toeta became king. That was the chief to whom belonged the swamp called the Swamp of Toeta; it is in Sataoa. That was the swamp at which Atua was beaten, because they were not all collected there, for Leifi and Saleaumua did not go. Toeta was angry because Atua did not all come to his work. Again the title was given to

Teleipesenga. Then the chief

Vaootui became king. This chief did not appoint some work to be done; but he said he would come and catch pigeons in Tuavao, in the mountain of chiefs, and would raise war against Leifi, because he

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* "Only the herring I will retain." These were caught in large quantities, and a portion of them was taken to chiefs even at a distant village, who had acquired the right to receive them. On one occasion the customary offering was omitted, and the aggrieved chiefs prepared for war, which was only averted by the submission of the offenders.

† When herring was caught a portion was taken to the king.

‡ Sa is used for taboo.

§ "The game of ti'a." The ground was made quite level, low places being filled up. The game consisted in casting light darts on the ground, so that they rebounded and flew along to a great distance.

‖ "We are going to fierce Tonga." This was a taunt to the young men for allowing themselves to be conquered and so submitting the females of their family to the degradation of preparing thatch, and carrying it a great distance to their conquerors. This is expressed by their taking it to Tonga.

¶ Stones with which to bury his land.

persisted in not going to any work of the king's. Leifi heard that the king had come to catch pigeons at Tuavao and to raise war against him; then he went to seek for troops. He was not received by the district of Maae; then he went down to Falealili, neither was he received there. He reached Salevalasi, and there he was at length received by Tongaulupuaa and Falepuavavemoe. The king and the conquering party, who were at Vaiugafa, heard that Leifi's request for troops had been granted at Salevalasi; then the war was directed towards them. They fought, and the king and conquering party were defeated by Leifi and Salevalasi; then they became the conquered party. Having again obtained the royal title, Mata'tia became king. He was the son of Lalovimama.

(3).—The Genealogy of Le-Samoa-Na-Ngalo.

Le-Samoa-na-ngalo married the daughter of the king of Tonga. Their son was Talapaitoitonga-na-mau, a second son, Lesanga-alala, and a daughter, Ekemaunga-a-tuitonga. That was the child, Le-sanga-alala, who came off in anger to Samoa, and lived in his mother's family at Safata.

Le-sanga-alala married the daughter of Malietoa. Their daughters were Vaeotamasamoa and Ekemaunga-a-tuitonga, and a son, Lalovimama.

Tonumaipea, of Satupaitea, married Ekemaunga-a-tuitonga, from Levalasifainga, of Faletai.

Le-langi-ngalo, the son of Tangaloa-faaofonuu, married Vaeotama-samoa. Their son was Tuiaana-tama-a-le-langi, the chief of Tutuila and Ape, who was stolen by Safata.

Lalovimama married Faatauemunga, of Fongaoloula. His son was Matau'tia, who raised up the royal title when he had obtained it. That was the chief who was also ill-used by Leifi and Tautoloia-le-Valasi-fainaa, of Faletai, the child of the daughter of his father. This chief soon died, but he left word that Leifi and Tautolo should take compassion and complete his reign in the son of Levalasi. The lady brought forth after the death of the chief, and she called her child Tuimavave. Lesi was the name of a Tonga man who took care of the boy Tuimavave while he was small. That was Lesi, from whom sprang Salelesi. Tuimavave soon died, and his successors were brought. First came

Siitu. He died, and then came

Silingatusa. These chiefs were called Mativa-i-lagi (Poor in praises). There they lie in the place of chiefs, because they had no family to take their place when they died. Next to Silingatusa was the lady Salamasina.

Fanga married To; they had one child, Sinatafua.

Tangatamatua married Sinatafua; their child was Fusialangi.

Onafanuatele married Fusiailangi; their child was Faasilialangi.

Tuiaana-le-uo-tele married Faasilialangi; their child was Faalulumanga

Maalomaivao married Faalulumanga; their child Fitimaula.

Tangaloa-faaofonuu married Fitimaula; their child Selangi-ngato. That was the chief to whom went the party seeking a chief.

Selangingato married Vaeotamasoa, the child of Lesangaalala, of Safata; their son was

Tui-Aana-tama-a-le-langi. He married Vaetoe, a Tongan lady. Their son

Salamasina. That was the king that first united the chieftainship of Atua and Aana, and the Tuamasanga. He was the king who held the united titles.

Tapumanaia married Salamasina; their child was Fofoaivaoese.

Tauatama, from Niulaita, married Fofoaivaose; their first child was Sina, their second Taufau, both girls.

(4).—The Genealogy of Sina.

Let the genealogy of Taufau come afterwards.

Toiaivao, from Saleaula, married Sina. Their son was Faumuina, who had all the royal titles.

Faumuina married Tuuama, the first chief of Sangana; their son Samalaulu. Faumuina married again to Atamulau, a Tongan lady. Their son was

Vaafusuanga. Faumuina married again to Falaleomalie, the daughter of Mata'utia, of Aleipata. Their son was Fonoti. These were the three wives of Faumuina. Their sons fought. It began with friends. Vaafusuanga and his friend, Fonoti, and their friends were constantly worsted. Then Fonoti saw that Samalaulu and Vaafusuanga were on the same side, and he fled to come to Atua. Then Misa and Aiono, and Taimalieutu and Fa'ifa'i followed to Manono. Then came Faleata, and found Veletaloola weeding taro. Fonoti laughed because the tulafale* weeded the taro in a stooping† posture. Veletaloola turned and saw Fonoti; then at once he abused him. Fonoti said, "Do you abuse me? Do you think you can assuage my anger?" Veletaloola asked what was the cause of his anger. He told him that he had run away, that he was going to be killed by his brothers and the conquering party. Veletalo said to him, "Go down towards the sea, to the house of the gods, until the town holds a council." Faleata held a council, and received Fonoti. Then a battle was fought. Faleata met the advanced guard of Samatau. Manoo asked, "Whence are these?" Veletaloola answered, "I am Faleata." Manoo said, "I have come here to search for the criminal. If he has run away down below I will dig down below; if he has run away to the horizon I will rend the heavens. You must be a brave man that you are about to receive the sand (=people as many as the sand) now coming. Look at the bush; its leaves are men. Look at the sea; it can no longer be seen for the men." Immediately Manoo was smitten by Veletaloola, and the troops were dispersed in the middle of the road. It was the same with the troops in the bush; there were Aiono and Misa and Taimalieutu. These were allotted to Fa'ifa'i. His road was the sea. That was the canoe of Fa'ifa'i; it was called the one canoe of Fonoti. Vaafusuanga and Samalaulu were conquered, and Fonoti was conqueror. Then

Fonoti became king, and Vaafusuanga was appointed by the king of Aana to be the guide of travelling parties, and to sit with the kava-chewers. That is the chief whose is the family of Salevalasi. He, too, is the chief to whom belongs the town of Falefa, which is called the town of Fonoti.

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* Head of a family. † Considered to be indecent.

Fonoti married Fuatino, of Fasitootai. Their son was

Muangututia. That was the chief whose is the family of Tuala. After this chief was named the family of Tuala and the family of Salevalasi in Lufilufi. The family of Tuala was expelled when the palankeen of Samataua came down towards the sea. Muangututia married Fenunuivao, the daughter of Leutele, of Falefa. Their son was

Tupua. That was the chief who was lifted down by Salangi, the child of Fuimaono. He is the chief whose is the family of Fuimaono. Tupua married Monofo-i-fale-ese. Their son was Afoa-fouvale. Tupua married again to Tualupetu, of Saleimoa, the daughter of Pula; their son was Ngalumalemana. Tupua married again Punipuao, the daughter of Alaiesa, of Falefa; their son was Luafalemana.

Afoa was king first. He was jealous because he saw the people were inclined to Ngalumalemana, as if he should be king. Afoa then raised troops to wage war with Ngalumalemana. He came seeking troops to Safata, but he was not received. Then was he dethroned, and so he was called Afoa-fouvale (Afoa the rebel).

Ngalumalemana then became king. This king also had all the royal titles. He was king of Aana, king of Atua, Tamasoalii, Gatoaitele. Ngalumalemana married Leteleasau; their son was Nofoasaefa. This was the chief who, while an untattooed lad, slew the kava-chewers of Mataafa at Amaile. Ngalumalemana also married Sapi-o-amoa, of Solosolo, the daughter of Leota Toomaata; their son was Tupolesava. That was the chief who was at variance with I'amafana. Tupo had to depart to Tutuila, because he could get no troops. Ngalumalemana again married Luafaletele, of Saluafata, the daughter of Sangapolutele; their son was Tualamasala. That was the chief who was heir to Pulumatau, and Mata'utia and Tangaloa, the father of Sangapolu, of Saluafata. Ngalumalemana married again to the daughter of Leleisuivao, of Palauli. Their son was Tualau, and his sister Samalaulu. Ngalumalemana married again to Sauimalae, the daughter of Lilomaiava, of Falelatai. Their first son was Putefua and their second I'amafana, also Taeoalii and Uaua, and a girl, Lanuola. These were the wives of Ngalumalemana.

Luafalemana married Galupuu, the daughter of Faleafanga, of Salani. Their son was

Paitomaleifi. That chief was king after Ngalumalemana, only he had not all the royal titles—only king of Atua.

Usufonoimanu married Taualaivaa, the daughter of Tango, of Lepa. Their son was

Leitufia-o-Atua, who married Tuioninimo, the daughter of Luatuao-atua-nuu, of Saleimoa; their sons Matui and Nauotuu. Ngalumalemana died, and Paitomaleifi became king. Then it was passed on to

Faasulumaleilii. He became king of Atua. At this time

Nofoasaefa came from Savaii, and they gave him the title of Aana. He was made king of Aana. But Atua was not of one mind concerning Mataafa. Matua and Tusa did not consent. Then came Nofoasaefa to fight with Mataafa, because a private messenger from Leifi and Tautolo had gone to him to say that Nofoasaefa should come and be king of Atua, because they did not desire Mataafa, who had disregarded their taboo, in that his canoes came and went with songs. Then Nofoasaefa raised war. Savaii and Aana and the Tuamasanga were united. Then they went to seek troops from Salefao and Falealili. Salefao was divided; some were with Mataafa and some divided to Matua, who sought for troops. Tafua stood up in Falealili, and said, "Manusamoa points to you as a destroyer, with whom dwell Matua and Alalamalae." Falealili had compassion, and favoured their application for troops; so also did Tusa. He sought troops, and was received by Solosolo and Saluafata, and all the fleet. The bulk of Atua were with Leifi, and Tautolo and Tusa; and but few were with Mataafa, only Falefa and Lufilufi and Samusu, and a part of Salefao and Salevalasi. A battle was fought. Mataafa and his troops were defeated, and Nofoasaefa was conqueror. That chief also had all the titles. Nofoasaefa soon died, on account of his rebellions. Again he raised war against Lealataua in Satupaitea, that he might seize on the title of Tonumaipi'a. They fought, and this chief died on Savaii. He was heir to Moengangongo. When Nofoasaefa was dead, then Lufilufi held a council about a king. They were unanimous for Tupo, but Tusa did not consent. Then they sent ambassadors to Atua to call a council that they might proclaim Tupo to be king of Atua. Tusa came journeying to the east. He said, "The council have decided to proclaim Tupo king of Atua, and I have agreed to it; but it is with you two to choose a chief, and he shall be my chief." Fuatanga and Tafua said, "Our chief is he who is in Tiavea, in Salefaavale, I'amafana." Tusa said, "That is good; we have got our chief." Then Tusa went away. A council was held, at which Atua was assembled. The mat* was thrown down in front of Lufilufi. Tupo went and sat on it. Manu'a stood up and said to Atua, "That is our king; such is the result of our consultation." Then a mat was thrown down in front of the council-seat of Saleaaumua. I'amafana went and sat on it. Then stood up Tafua, and said, "That is my chief; but let our people choose one of these two chiefs." Then stood up Tusa, and said, "That is also our chief." So Tusa distinguished as chief I'amafana. Leota, the first chief, then stood up, and proclaimed I'amafana. Molioo also stood up, and said, "That is our chief Leifi and Tautolu." So also said Saluafata. Each land in all Atua was divided between I'amafana and Tupo. Atua, however, leaned towards I'amafana, and but few were for Tupo. The council broke up in confusion. I'amafana went off at once with Faleapuna to seek troops. He was received by the Tuamasanga, so also by Aana and Manono and Savaii. Tupo followed after, but he was not received. Then the war passed on, and Tupo and his troops were swept away to Tutuila; so I'amafana became king. He had all the royal titles. He was the king to whom gods and men crowded. This chief died, and the war, with the sea† as a border, was fought. The carrying of this chief's‡ funeral bier was the cause of the war. This chief was next before Malietoa, the father of Mole. He was also next before Mataafa, the king of Atua. In the year of the Lord 1857 he was proclaimed. He was also next before the chief Sualauvi. He was king of Aana, Tamasoalii, and the Ngatoaitele. He also became king of Atua in the year 1869. If he gets all Atua and the Tuamasanga, then will he have all the royal titles like I'amafana.

* Answering to a throne.
† The sea between Upolu and Savaii divided the combatants.
‡ Living chiefs were offended by the dead chief being carried past them.

13.—NEW BRITAIN CUSTOMS.

By Rev. J. H. Rickard.

14.—THE PAPUAN RACE.

By Herr P. Wolff.

15.—THE PHYSIOLOGICAL BASIS OF MORALS.

By A. Sutherland, M.A.

Section H.

SANITARY SCIENCE AND HYGIENE.

President of the Section: J. Ashburton Thompson, Esq., M.D., D.P.H.

1.—SANITATION IN SCHOOLS.

By F. A. Nyulasy, M.B., Ch.B.

[*Abstract.*]

In the course of this paper the author indicated its great importance, especially with regard to the spread of infectious diseases, pointing out that no less than 74 State schools had to be closed last year in Victoria owing to the prevalence of these complaints; 33 being closed for diphtheria, 17 for hooping cough, 13 for typhoid, 6 for scarlatina, 4 for opthalmia, and 1 for croup. In addition to the ordinary measures of registration of affected pupils and their exclusion from school for definite periods, provision should also be made for their thorough disinfection by the aid of disinfecting chambers; and the construction of sanatoria in connection with large boarding-schools was recommended as a further aid to prevention. The architecture of schools was made the subject of special reference, improved methods of ventilation, lighting, and warming, and the better construction of seats and desks, being insisted upon. Defects in the ordinary methods of physical education were alluded to, and the annual medical inspection of all large schools by a competent Government officer was recommended.

2.—THE ETIOLOGY OF TYPHOID FEVER.

(With Chart).

By James Jamieson, M.D., Lecturer on Medicine, Melbourne University; Health Officer, City of Melbourne.

In spite of the attention which has long been given to questions about the causation of typhoid, and the substantial additions recently made to our knowledge of the subject, problems of fundamental importance still remain unsettled.

It must be assumed, I think, that typhoid belongs to the great class of diseases which owe their origin to minute organisms of bacterial nature. It has further been shown, with a large measure of probability at least, that the organism is a bacillus, capable of multiplying and forming spores, not only in the body, but on very varying media outside of it. So far, however, there has been no satisfactory proof that the disease can be produced in animals, either by the bacilli or their spores, whether they have been introduced into the stomach with food, inoculated below the skin, or injected into the blood. Till this link in the chain of evidence has been supplied, the proof of a causal relation between the organisms and the disease can hardly be looked on as perfect. Assuming that the *Bacillus typhosus*, of Eberth and Gaffky, is the true infecting agent, it is of importance to take note of its vital properties. It grows freely on suitable media at ordinary room temperatures, but has not been found to develop spores at a lower temperature than 68 deg. F. (20 deg. C.) Spore formation goes on most actively between 86 deg. and 104 deg. F. (30 deg.—40 deg. C.), and it ceases at temperatures over 107·6 deg. F. (42 deg. C.) Organisms which grow in diverse media, and at such varying temperatures, evidently possess a high degree of vitality. The spores, especially, have great power of resistance, and they have been kept in the dried condition for more than three months, and then found to germinate freely. The most recent researches, if they do not directly confirm, certainly do not contradict the view generally held by sanitary authorities, that the specific virus of typhoid grows and multiplies outside of the body, in drains and cesspits, and possibly also in the soil and in water. Whatever may be the case with the fully-developed bacilli, it may be taken as certain that the spores will survive for a considerable time, either in the moist or dry condition, and that on suitable media they will germinate and multiply rapidly at ordinary summer temperatures. That the spread of the disease is actually due, in large measure, to this multiplication of the virus outside of the body, and its conveyance in some way to susceptible persons, is further confirmed by the following facts. It is possible that the disease may spread directly from person to person, but all medical authorities are agreed that this is not the ordinary mode of infection ; the contrast, in this respect, between typhoid and such diseases as measles and small-pox being very marked. And further, the circumstance that typhoid is, in almost all countries, a disease most prevalent in the late summer and autumn, strongly suggests some affinity between it and the miasmatic diseases, like the malarial fevers. And if anything further were wanted to establish this, it would be found in the undoubted fact that the prevalence of typhoid in towns or districts is very largely dependent on their sanitary condition, accumulations of filth and defective drainage favouring its spread, and improvements in these respects tending greatly to keep it in check.

There is another point in connection with this question of varying prevalence which is of importance. All epidemic diseases have successive periods of greater and less degrees of severity, both as regards prevalence and fatality. In the case of purely contagious zymotics, like measles, the recurrence of severe outbreaks is generally supposed to be due chiefly to the accumulation, in the intervals, of susceptible persons. It is doubtful, however, whether this supplies a full explanation in the case, even, of diseases of the type referred to. And where we have to deal with a disease like typhoid, which attacks persons of all ages, without showing any preference for children, such an explanation is clearly quite inadequate.

About three years ago (*Australian Medical Journal*, January, 1887) I pointed out that through a long series of years there had been a very marked and regular periodicity in the rise and decline of the mortality from typhoid in Melbourne, severe outbreaks being separated by intervals of about four years. I was not aware at that time that any such peculiarity had previously been noted, and no mention is made of it by Hirsch in his "Handbook of Geographical and Historical Pathology." But in a lecture by Dr. Port, delivered in Munich in 1880, I find the following statement (Zur Aetiologie der Infections-Krankheiten, p. 129)—"In each of our barracks there appears to be a certain regular succession of good and bad years, which is different for the several barracks. For the new barrack on the Isar, about which recollections go somewhat further back than about the others, Dr. Anderl believes that a five-yearly cycle must be fixed." The regular succession, at intervals of about four years, of periods of rise and fall in the typhoid mortality of Melbourne, through a long series of years, is very clearly shown in the accompanying chart. On the same chart I have placed the curves of typhoid mortality for Sydney, unfortunately for a shorter period, but for as long a time as full information is obtainable. In the case of Sydney there are indications of periodicity, though not sufficiently distinct to ground any argument on. The remarkable parallelism of the curves for the two cities, during the period 1876-82, is suggestive of the operation of general conditions, of wide-reaching nature, perhaps resembling those which permit the spread of cholera, at particular periods, over great parts of the world. In more recent years there has been approach to parallelism in the curves for the two cities. In the last three years, too, there has not been the previously observed regularity of the curves for Melbourne. There has not been the anticipated decline after the acme reached in 1887, and instead of a continued fall in 1889 there has been a second rise. This irregularity may possibly be accounted for by a quite unprecedented amount of breaking-up of the surface in almost all parts of the metropolis, not only for building purposes, but in the construction of tramways, laying of wood-paving, &c. Outbreaks of typhoid have been supposed to be connected with similar causes in other cities. But supposing there is such periodicity of recurrence as is shown in the chart, there must be account taken of it in any inquiry into the general causation of the disease.

There being practical unanimity among authorities about the importance of local insanitary conditions, such as defective drainage, it is clearly of the utmost importance that there should be definite knowledge about the way in which these conditions operate. Direct contagion being relegated to a quite subordinate place, we have left as possibilities the following, as modes of conveyance of the virus :—

I. Contaminated water supply.

II. Accidental contamination of articles of food, and especially milk.

III. Inhalation of emanations from the soil, or from cess-pits, drains, &c.

That typhoid not infrequently spreads through the medium of contaminated water may be taken as proved. The most commonly recognised mode of contamination is by the washing, into wells, channels, or reservoirs, of the virus contained in the fæcal discharges of persons suffering from the disease. It is also probable enough that not fresh discharges, but virus which has been developed in the soil or in drains, soaks into wells or other receptacles; and by many it is held that it is only in this indirect way that an undrained, filth-saturated soil favours great prevalence of typhoid. This may readily enough be the case in small towns and rural districts, where the water supply is derived from streams or wells liable to impure soakage, and where the introduction of a single case may supply a source of infection to soil or water, or both, and so lead to quite an extensive outbreak. But it is evident that the conditions are altogether different in a town or city deriving its water supply from some outside source, from which it is conveyed in pipes. Even then, of course, there are two sources of danger—there may be contamination at the head-waters; or there may be occasional suction into the pipes locally, where the supply is intermittent. In the case of Melbourne it can be safely affirmed, I think, that the sources of its water supply are better guarded than those of most large cities. As the population in the gathering area is small, specific contamination could take place only in an accidental way, to a slight extent, and at comparatively long intervals.

Assuming the possibility, or even the probability, of this specific contamination at the sources, it is apparent, however, that its result would be a sudden outbreak of limited duration. The annual outbreaks of the disease, with their beginnings in November, their steady increase till February or March, and their regular decline during the late autumn and winter, are not explicable at all on this assumption. The regularity of the rise and fall is shown on the accompanying chart. The possibility of local contamination by the suction of foul matter into the pipes, from the soil or from the street channels, must also be admitted. But with such a constant high pressure in the pipes it is not easy to believe that this mode of contamination can go on to a large extent or that it can account for the regular recurrence and equally regular rise and decline of our annual outbreaks. There has been much controversy lately about the liability to contamination of the water in street mains from the fire-plug openings. About the possibility of this there need be no question, and about the grossness of the sanitary fault of placing fire-plugs in or close to street channels there can be no dispute. But that the great prevalence of typhoid in Melbourne is to be explained in this way is to me inconceivable. If there is any part of the metropolis in which fire-plugs abound, and one constantly used for street-watering purposes, it is the city proper. And yet, as I have repeatedly pointed out in my official reports, the mortality from typhoid in the city, year after year, is greatly below the average of the whole metropolis. In my report for the half-year ending 30th June, 1889, I was able to state that there had been no undue prevalence of the disease in the particular district (East Melbourne) whose water supply was specially declared to be contaminated. If, independently of introduction by the fire-plugs, we are to assume the probability of contamination of the water by entrance of infecting matter through the joints of pipes from the soil, equal difficulties have to be faced. The disease is so universally distributed over city and suburbs that it would be necessary to assume an almost continuous suction into the pipes going on in many places all over the metropolis. But this would imply an equally extensive system of leakage from the pipes while under ordinary pressure, and of that there is no evidence. Of course, we have had the statement made that typhoid bacilli have been found in the Yan Yean water, as it is drawn from the tap, just as the same bacilli have been reported as existing in drinking-water in various places in Europe. From equally competent authority we have had the statement, however, that careful and repeated investigation failed to discover them in water taken from various places, both at the sources and in the city (*vide* Final Report of the Sanitary Commission).

About the possible detection of typhoid bacilli in drinking-water there need be no dispute; but about the probability of their occurrence and detection in such water as that of Melbourne much may be said. It has been stated by Dr. H. Kowalsky, of Vienna, that among more than 2000 specimens of water which he had examined, these bacilli were found only in three, taken respectively from a well, from a cistern, and from the Danube water in Vienna. (*Schmidt's Jahrbücher*, No. 8—1889, from Wien Klin. Wehnschr., I. 10-16, 1888.) Without disputing the occurrence of outbreaks of typhoid due to the use of contaminated water, I have nevertheless to repeat the opinion that the probabilities against this mode of accounting for the prevalence of the disease in Melbourne are great, and the evidence in support of it unsatisfactory.

As to the part played by contaminated milk in spreading the disease, I do not propose to say much. Milk epidemics have often been reported, especially in England; though, in very many cases, the evidence that the milk was specifically contaminated, and that its use was the sole and efficient cause, was decidedly insufficient. If this mode of propagation is at all common in Melbourne there could hardly fail to be accumulation of evidence of its occurrence. As a matter of fact, however, there has been only one such outbreak investigated, and even in that instance there were great difficulties to be accounted for. (Transactions of the Intercolonial Medical Congress, Vol. II., p. 159.) After a good deal of careful inquiry, carried on for a series of years, I have been unable to discover a single instance of an outbreak produced in that way.

In how far typhoid may be caused by the inhalation of emanations from the soil, or from cesspits or drains, it is difficult to determine with certainty. Among English authorities generally there has always been a strong belief in the readiness with which the disease is produced by the inhalation of sewer-gas. I am not aware that the bacilli of typhoid have been found in the foul air escaping from drains or sewers, or in the exhalations from a filth-saturated soil. But it has been shown by Dr. J. D. Robertson (*British Medical Journal*, 15th December, 1888) not only that under particular conditions large numbers of bacteria escape from the openings of sewers, but that bacilli preponderate among them, as compared with the micro-organisms in the air of streets. In some ways, even more important was the observation of Dr. Henry Tomkins (*British Medical Journal*, 25th August, 1888), that in Leicester, which is notorious for the prevalence and fatality of summer diarrhœa, the air of the diarrhœa districts of the town contained three to six times as many micro-organisms or their germs as the air of the non-affected districts. Meteorological observations during the summer months of 1885, 1886, and 1887 showed that as soon as the earth, at a depth of one foot, reached about 62 deg. F. the disease broke out.

As to the influence of sewer air in producing typhoid, the observations of Dr. Alfred Carpenter, of Croydon, are of special interest. He states (*British Medical Journal*, 22nd June, 1889), that in three serious epidemics he became convinced that germs were conveyed from the sewers by aërial means. He quotes, also, the demonstration by Dr. Buchanan of the reason why fever existed on one side of two or three streets and not on the other, in which the water supply being the same and the sewer the same. In the one set of cases the air was admitted into the houses from the sewer, in the other it was not.

My own observations have led me to the conviction that, in most cases of localised outbreaks of typhoid in this city, there existed marked and special defects of drainage, and very often underground drains, which are too frequently badly laid, badly tapped, and with no means of ventilation, except by the inlets from yards or houses.

It is unnecessary to reiterate the proofs, so often supplied, that the introduction of an efficient system of underground drainage has almost with certainty the effect of lessening rapidly the prevalence of typhoid in a town or city. The effect may be produced in more ways than one: in some cases, perhaps, by diminished liability to contamination of the water supply; but in the case of large towns, with water conveyed by pipes from some distant source, the probability rather is that the great and continuous effect is due to purification of the soil, and consequent prevention of the formation and escape of foul emanations.

But although it may be sufficient, for some purposes or on some occasions, to determine that the medium for conveying the poison was milk, water, or air, there are other points in connection with the natural history of the disease which any such decision still leaves unsettled. Among the most important of these is that which concerns the periodical recurrence of the disease, whether it be the annual rise and fall, or the fluctuations in the degree of prevalence, as observed through a series of years. The annual fluctuations seem to occur in all parts of the world, and the rule is for the disease to become increasingly frequent during the late summer and autumn months. The tendency has always been to account for this mainly by the rise of temperature, and especially by the increased heat of the soil. This view is considered to derive support from the discovery of the specific bacillus, and the determination of the degree of heat at which spore-formation takes place. This might be a fairly satisfactory explanation if it were always true that the maximum prevalence is in the late summer and early autumn. But, as a matter of fact, this period of maximum intensity is not the same in all countries, even under approximately similar latitudes. Taking the continent of Europe, for instance, it has been found by Prof. J. Soyka (*Archiv. f. Hygiene*, 1887, quoted in *Schmidt's Jahrbücher*, Bd. 220, No. 2) that the maximum of mortality falls on the months of *August to October* in Berlin, Neufchatel, Lausanne, Breslau, Frankfort-on-the-Main; *September to November* in Hanover, Basel, Paris; *October to January* in Bern; *November to March* in Munich; *January to March* in Prague; *March to May* in Vienna. It is clear, therefore, that other considerations besides mere temperature of air and soil have to be taken into account. When it is also mentioned that in Christiana, with its severe winters, the maximum prevalence of typhoid falls in the months from November to January, it might be said, further, that mere temperature by itself is of very slight importance, whatever may be the case about the conditions necessary for the germination of the bacillus, investigated by Eberth and Gaffky.

The alternative has been to lay stress on the varying degree of dryness and dampness of the soil as being the real determining cause of the seasonal variations. This is the well-known *Grundwasser* theory, elaborated chiefly by the Munich school of epidemiologists, the position taken being that the prevalence of typhoid in a locality, at different periods, varies inversely with the high or low level of the subsoil water. This relation seems to be well established, at least for some places, whatever be the explanation. But the level of the subsoil water must depend on the amount of rainfall at the locality, or on the level of the water of a river on whose banks a town is built. In most places it will depend on the rainfall; and if the *Grundwasser* theory is correct, a maximum prevalence of typhoid should fall, not only in the dry season of the year, but epidemic periods should especially be in dry years. Facts in support of both of these points were collected by Prof. Soyka (loc. cit).

Another general condition that might be supposed to be of importance, at least on the supposition that the disease may be caused by emanations from the soil, is variation in the barometric pressure. Where that pressure is low, exhalations will rise more easily, and be more widely distributed.

The only other meteorological condition which has been supposed to have influence on the spread of epidemic disease is the presence or absence of ozone in the atmosphere. That, however, has not been made the subject of observation continuously enough, or on a sufficiently large scale, to allow of very reliable conclusions being based on it, and here there are no useful data available.

Rather contradictory opinions have been expressed as to the influence of meteorological conditions in determining the degree of prevalence of typhoid in Melbourne. There has also been some confusion, I think, caused by combining the terms "hot" and "dry," descriptive of the general peculiarities of particular seasons as compared with others spoken of cool and moist. Often, too, I fear that the opinions expressed have been based merely on general impressions, and not on adequate or carefully-sifted statistical data. As to the influence of temperature by itself, what has been already said seems to be sufficient to show that it can have little importance. If, in different towns in Europe, in about the same latitude, typhoid is most prevalent in one during the autumn, and in another in the depth of winter, it is hardly conceivable that a difference of one or two degrees in the average temperature of the summer months, or of the year, should be the determining cause of the marked fluctuations found in the mortality from it in Melbourne in successive years. Heat as a factor *per se* may therefore, I think, be disregarded.

Chart showing the Comparative Prevalence of Typhoid in Melbourne in different months.
Average of eight years, 1881-88.

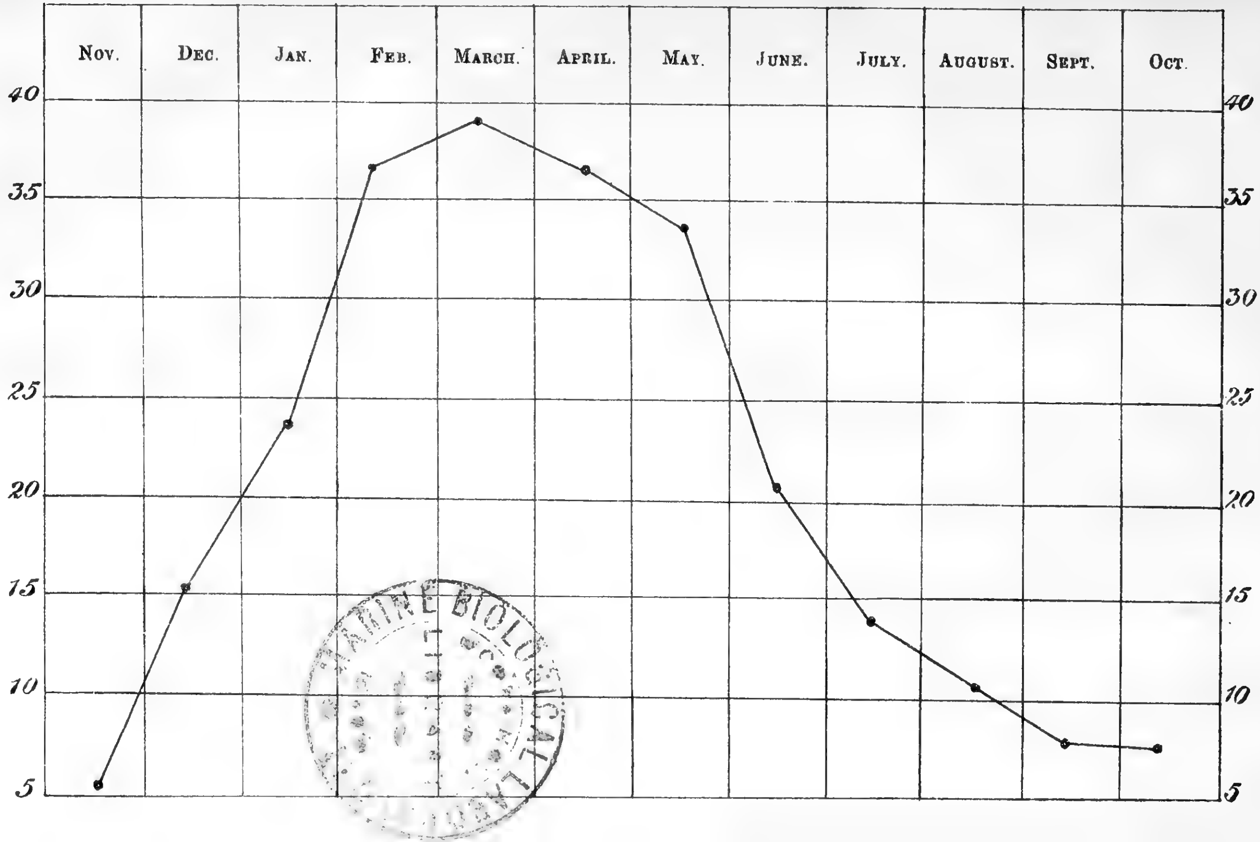
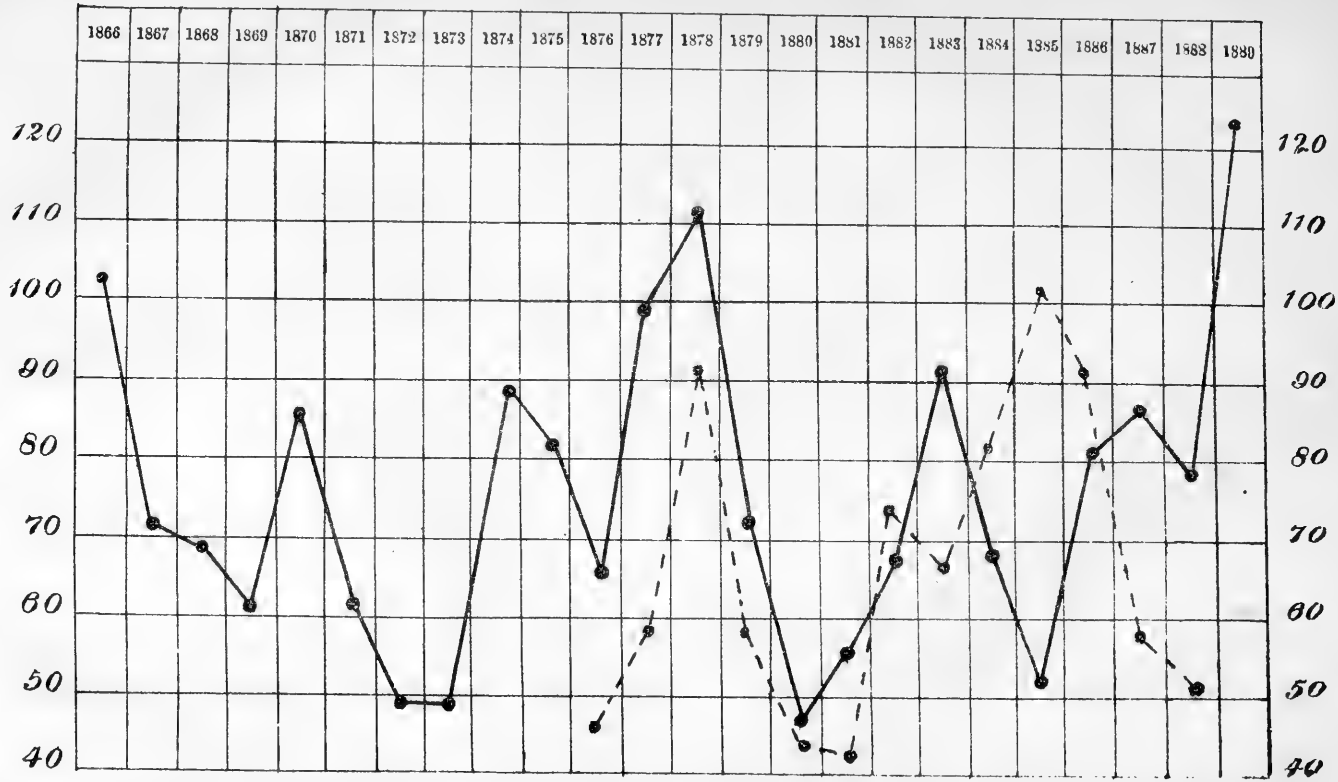


Chart showing the Rate of Mortality from Typhoid per 100,000 persons. In Melbourne and Suburbs for 24 years, 1866-89 (thus ———); and in Sydney and Suburbs for 13 years, 1876-88 (thus — — —).



On the other hand, it might be expected, from what was said about dampness of soil, that the influence of rainfall would be marked; and accordingly I have collected, in the following table, the data on which to found a judgment

TABLE I.

Showing the number of days in which rain fell, the amount of rainfall, and the mortality from typhoid per 100,000 persons in Melbourne, in each of the years 1866-88 :—

	Days of Rain.	Inches of Rain.	Mortality per 100,000 persons.
1866	107	22·41	102·7
1867	133	25·79	70·5
1868	120	18·27	69·2
1869	129	24·59	60·9
1870	129	33·76	85·8
1871	125	30·17	60.3
1872	136	32·52	49·7
1873	134	25·61	49·3
1874	134	28·10	89·6
1875	158	32·87	81·7
1876	134	24·04	64·7
1877	124	24·10	99·3
1878	116	25·36	111·9
1879	127	19·28	73·6
1880	147	28·48	46·1
1881	134	24·08	55·1
1882	131	22·39	67·5
1883	130	23·71	90·6
1884	128	25·85	68·1
1885	123	26·94	52·9
1886	128	24·00	80·0
1887	153	32·39	86·3
1888	123	19·42	77·7
1889	...	...	123·6

The general impression conveyed by a glance at this table is that dry years are by no means uniformly characterised by a high, or wet years by a low, mortality. A comparison of the three years 1870-72, and of the two last of the series, 1887-88, would by itself, indeed, suffice to show that, between the year's rain and the year's typhoid, there is no approach to uniformity of relation. It may be interesting, however, to analyse the data contained in the table, and in doing so I propose to give no further consideration to the number of days on which rain fell.

In each of three years of the period there was less than 20 inches of rain, and in each of five years there was more than 30 inches, and the following tables give the particulars of these dry and wet years respectively.

TABLE II.

Showing amount of rainfall and mortality in exceptionally dry years :—

	Inches of Rain.	Mortality per 100,000.
1868	18·27	69·2
1879	19·28	73·6
1888	19·42	77·7

TABLE III.

Showing amount of rainfall and mortality in exceptionally wet years :—

	Inches of Rain.	Mortality per 100,000.
1870	33·76	85·8
1871	30·17	60·3
1872	32·52	49·7
1875	32·87	81·7
1887	32·39	77·7

In the three dry years the average mortality was 73·5, and in the five wet years about 71, in neither case greatly different from the average of the whole period, which was about 74.

For further satisfaction, however, I have prepared the following tables, contrasting years of low mortality, less than 50 per 100,000, with years of high mortality over 90 per 100,000.

TABLE IV.

Showing amount of rainfall in years of low mortality :—

	Mortality per 100,000.	Inches of Rain.
1872	49·7	32·52
1873	49·3	25·61
1880	46·1	28·48

TABLE V.

Showing amount of rainfall in years of high mortality :—

	Mortality per 100,000.	Inches of Rain.
1866	102·7	22·41
1877	99·3	24·10
1878	111·9	25·36
1883	90·6	23·71

The years of exceptionally low mortality had thus, on the average, a rainfall of 28·17 inches, while in those marked by unusually high mortality the average was 23·89. The results obtained by these different methods of contrasting the conditions of different periods are not in very good account. Tables II. and III. apparently proving little or nothing either way, while tables IV. and V. rather support the view that a high mortality is associated with slight rainfall, and *vice versa.*

But the suggestion arises that there may be a fallacy in comparing the rainfall of the whole year with the mortality from typhoid, which is in large measure confined to less than one half of it. If the prevalence of typhoid is dependent on the amount of rain at all, it seems probable that it should be influenced specially by the summer rainfall, and less by that of the winter months. I have, therefore, in the following tables presented together the mortality of the year, along with the rainfall of its first four months, January to April, and of the months of November and December preceding. For the sake of contrast and comparison the four years of highest and lowest mortality are presented separately.

TABLE VI.

Showing amount of summer rainfall in years of low mortality :—

	Mortality per 100,000.	Inches of Rain, Nov. to April.
1872	49·7	16·53
1873	49·3	18·62
1879	46·1	14·29
1881	55·1	7·03

Table VII.

Showing amount of summer rainfall in years of high mortality:—

	Mortality per 100,000.	Inches of Rain, Nov. to April.
1866	102·7	6·73
1877	99·3	17·52
1878	111·9	15·66
1883	90·6	14·03

It is not easy to find, in these tables, any confirmation of the doctrine that the prevalence of typhoid stands related to the rainfall, very low mortality in different years being the accompaniment, either of an exceptionally wet or an exceptionally dry summer. In the same way, a very high mortality has fallen in snmmers which also exhibited both extremes as regards rainfall. In so far, therefore, as the level of the subsoil water can be considered to vary with the amount of rainfall, it must be taken as shown that the amount of typhoid in Melbourne does not depend on the rise and fall of that level. This must be regarded as proved in respect of successive years. It may almost be held to be true even of the seasonal variations, since, as is shown by the last tables VI. and VII., the summer rainfall of Melbourne is equal to the average of the whole year, the supply by pipes from without being much greater, quite a large proportion of it soaking into the ground.

In how far variations in the barometric pressure have any influence on the prevalence of typhoid remains to be shown. If it does exert an influence it must be by favouring or checking the escape of emanations from the soil; and the effect must be direct, *i.e.*, the barometric pressure, on this hypothesis, ought to be exceptionally low in epidemic years. For the purpose of discovering in how far this is the case, I have presented in two tables, to correspond with VI. and VII., the barometric pressure given, being the average of the mean pressures for the months November to April.

TABLE VIII.

Showing the average summer barometric pressure in years of low mortality :—

	Mortality per 100,000.	Average barometric pressure.
1872	49·7	29·929
1873	49·3	29·941
1880	46·1	29·922
1881	55·1	29·978

TABLE IX.

Showing the average summer barometric pressure in years of high mortality :—

	Mortality per 100,000.	Average barometric pressure.
1866	102·7	29·917
1877	99·3	30·026
1878	111·9	29·957
1883	90·6	29·915

Unpleasant as it may be to have an ingenious hypothesis exploded, it must be admitted that no support is to be derived from these tables for the suggestion that periods marked by low barometric pressure should correspond with periods of high typhoid mortality, the low pressure allowing free escape of emanations from the soil. The years of highest mortality were, of course, in two instances, 1869 and 1883, marked by a very low average of barometric pressure; but in another instance, 1877, that average was the highest of any of the years compared. And further, if the averages for the two groups are compared, it appears that for those in Table VIII. it was 29·942, and for those in Table IX. 29·953, practically the same, any difference existing being against, rather than in favour of, the hypothesis.

Though it is disappointing not to have been able to obtain positive results after this rather laborious inquiry into the causes of the annual and periodic fluctuations in the prevalence of typhoid fever in Melbourne, it does not follow that it has been without value. We always hear the hope, or even the positive opinion, expressed, that a good hot wind will check the prevalence of the disease; or, on the contrary, that heavy rains will have the same effect. It is well to know whether such opinions have any good foundation; and there may be positive gain in having the mind disabused of unfounded notions as to the beneficial or detrimental influence of general conditions, such as temperature, rainfall, or barometric pressure, over which we have no control. We are thrown back on the well-established facts that a filth-saturated soil supplies a condition eminently favourable to the spread of typhoid, and that a proper system of drainage, however it may operate, can be depended on to reduce, steadily and to a large extent, the prevalence of the disease. The best possible system of drainage cannot, of course, prevent danger arising from contamination of water or milk, or put an end to other possible modes of communication. But, judging from experience gained in the large cities of Europe, it may safely be said that no other measure of precaution, no other sanitary improvement, can be compared with this in certainty of effect. I do not believe that the difficult questions just discussed are incapable of solution, and if the varying prevalence of the disease, annual and periodic, is to be explained at all, I still think that it must be by meteorological considerations. The data at my disposal are insufficient, or are not analysed with sufficient care to allow of positive conclusions. But we know the direction in which to look for the remedy; and if we get the good result, we can afford to wait for the explanation.

3.—COOL HOUSES.

By James W. Barrett, M.D.

[*Abstract.*]

The author said that the object of the paper was to describe simple methods by which Melbourne houses might be kept cool during the summer. The cause of heating of the house was two-fold; the heating of the roof and walls by the sun, and the entrance into the house of hot air. A temperature of 70 with the ordinary degree of humidity was not unpleasant, and he found from Mr. Ellery that on only fourteen nights during December, January, and February did the temperature of the air between 8 p.m. and 12 p.m. exceed 70. Therefore, we might conclude that on the great majority of nights cool fresh air could be

obtained by opening windows, doors, fireplaces, and ventilators. But the unpleasant nights passed were largely due to the heating of the roof and walls by the sun, and it was this heating which it was essential to avoid. This he had done by painting the roof and exposed walls with a white paint. Simple experiments undertaken to show the difference caused by painting the slates resulted as follows:—The temperature of a painted slate at mid-day on a bright summer's day was about 30 deg. lower than an unpainted one. The interior of flower-pots and boxes covered by slates exposed to the sun at the same time of day differed by from 10 to 18 deg. A house with roof and walls painted was probably 10 deg. cooler than an unpainted one. Consequently, to keep a house cool it was simply necessary to paint the roof and walls, to keep all doors, ventilators, fireplaces, and windows shut in the warm part of the day, and to open them at night. The use of the electric light would greatly assist. If coolness was desired on the few nights on which the air was hot, special ventilating apparatus must be provided. In the house in which he (Dr. Barrett) lived, when the directions had been followed, the temperature had not exceeded 76 deg. F., and was rarely above 70 deg.

4.—PURIFICATION OF SEWAGE.

By J. M. SMAIL, M.Inst.C.E., and W. L. DE L. ROBERTS, C.E.

IN his work on "Health and Life" B. W. Richardson, M.D., F.R.S., states that "An ancient ruler, no less ancient and no less cunning a ruler than Cambyses himself, taught his son Cyrus certain lessons in sanitary science, which he then considered much needed, and instructed him as to his chief anxiety in connection with his army, which should be the preservation of health; for, says Cambyses, he should prevent the army falling into sickness at all." In addition to the above advice, he adds other observations, which shows to us that in Cambyses' day (529 B.C.), in the midst of a very high ancient civilisation, there was no special exemption from the thousand natural ills that flesh is heir to.

The advice given by Cambyses to his son can well form a subject worthy of serious consideration by those in authority and charged with the well-being of communities forming a State. The ancient law-giver (and no less a sanitarian) Moses enjoined upon the Hebrews the "necessity of disposing of the excretions of the human body and other organic filth by burying the same in the earth at places remote from habitations, without the camp." "Under the Mosaic dispensation sanitary laws were religiously observed, and recent discoveries clearly show that the ancient Jews possessed a clear knowledge of the necessity of removal of all decomposing matter as expeditiously as possible to a place outside their city, and that when so removed they knew how to dispose of it."—*Baldwin Latham.*

The question which appears to have occupied the attention of the ancients is more intensified at the present day, owing to changes of condition and other obvious causes. Notwithstanding the numerous enquiries and scientific investigations, the general opinion is that sewage and other organic filth is troublesome, and should be got rid of as quickly as possible, and without endangering the public health.

The question of disposal is very often surrounded with difficulties and complications, and severely taxes the minds of the authorities and pockets of the ratepayers.

Where a seaboard discharge, accompanied with favourable circumstances, can be obtained, the problem is easily solved, but where such facilities are not available other means of disposal have to be obtained. Notwithstanding years of trials, investigation, and large expenditure, the authorities on the subject are at variance as to the best means of overcoming the difficulty. Every system has its enthusiastic advocates, each considering their particular system as the only remedy for the evil.

In former years considerable value was attached to the sewage as a manure, but experience has demonstrated the fallacy of such value from a commercial standpoint.

The various systems which have been tried for purifying sewage may be classified as under :—

I. Filtration.
II. Chemical treatment.
III. Irrigation.

I. The removal of impurities from crude sewage by means of artificial filters has not been attended with such success as to lead to its general adoption. The glutinous character of the sludge entirely clogs the interstices of the filtering material and renders it inoperative, and a nuisance is set up by the accumulation and decomposition of the foul matter in the filter. The disposal of the offensive solid is surrounded with difficulty, and the cost of constantly cleansing and renewing the filtering material has led to the system being regarded as impracticable and expensive.

II. *Purification by Chemical Treatment* has been practically tried in various ways, as well as chemically investigated. Numerous patents have been taken out, but few have stood when put to a practical test, and in many instances this result has not been arrived at except by a large monetary expenditure.

The various chemicals used for precipitating and purifying sewage are :—Lime ; lime, with addition of magnesium chloride and tar, known as Hille's process ; milk of lime, with sulphate of alumina, Anderson's process ; lime, with iron sulphate ; also a process combining crude cake alum, blood, and clay, generally known as the A.B.C. system. More recently experiments have been made with a process combining milk of lime and herring-brine. Of the various processes enumerated, lime, in conjunction with sulphates of iron and alumina, has, according to latest accounts, given good results as far as a precipitating agent, but no claim has been set up as a purifying agent; it has, however, been claimed by the patentees of the process known as lime combined with herring-brine, that a high standard of purity, as well as efficient precipitation, has been obtained.

In a paper* read by W. J. Dibden, Esq., F.C.S., of the Metropolitan Board of Works, on the disposal of sewage sludge, he states that "the use of an excessive quantity of lime, whilst having a temporary antiseptic action, is objectionable, by increasing the quantity of putrescible matters in solution in the effluent. One object claimed for the use of an excessive quantity of lime, and also for some other substances, is that they destroy the living organised bodies, such as bacteria, &c., which give rise to the phenomena known as putrefaction." Mr. Dibden considers this question of such importance that he discusses it at some length; and as it opens up fruitful ground for consideration, his opinions are given as recorded. Mr. Dibden states the researches of Warrington† have demonstrated that the process known as nitrification of the complex nitrogenous bodies existing in sewage during its filtration through land is brought about by definite organisms, who in their life processes feed upon the sewage matters and evolve the nitrogen in the form of nitric acid. As with the nitrogen, so it is with the carbon, which is absorbed as food and evolved as carbonic acid. Without these life processes, whether they be of an animal or of vegetable nature, no destruction of the objectionable matters can take place. As the very essence of sewage purification is the ultimate destruction or resolution into other combinations of the undesirable matters, it is evident that an antiseptic process is the very reverse of the object to be aimed at. If a preservative process be required, a receptacle should be provided for the preserved matters, and in order to ensure that the antiseptic process should be a continuous one any subsequent treatment or method of disposal must avoid the destruction of the antiseptic employed. In the case of lime, which in strong solutions is a solvent of organic structures, what time will elapse before its neutralization by absorption of carbonic acid, and consequent loss of antiseptic properties, after the discharge of the effluent into running water? Obviously, only a very limited period, after which the growth of organisms so zealously destroyed will recommence, by reason of the numerous spores in the water of the river and with the air

* Volume LXXXVIII.; Minutes of Proceedings of the Institution of Civil Engineers.
† Journal of the Chemical Society, Vol. XLV., 1884. Transactions, p. 637.

with which it is constantly in contact, and there will thus be an end to the antiseptic properties of the system.

Mr. Dibden further states that where it is advisable to increase the effect of the lime, experience has shown that either sulphate of alumina or sulphate of iron in various proportions are best adapted for the purpose. The actual result of the combination of lime and either of the salts of alumina or iron depends in a great measure to the manner in which the lime is applied. Experiments have shown the lime is best applied in the form of "milk of lime."

The discussion on the paper, from which the foregoing statements have been quoted, is remarkable for the diversity of opinion of the chemical experts as to the efficiency of chemicals in connection with purification and precipitation of sewage. The general opinion, however, tends towards the fact that the question is capable of more extended investigation. Whatever difference of opinion may exist among chemists on the matter, sanitary engineers are decidedly of opinion that before the effluent can be considered up to a standard of purity to admit of it passing into fresh-water streams, it should, subsequent to chemical treatment, be passed over and filtered through land.

Mr. Dibden, when investigating the question for the Metropolitan Board of Works, London, made over 500 different analyses with 23 samples of London sewage, and treated them 25 different ways, and the results of the investigation show that the use of a larger quantity of chemicals would, independently of the expense of dealing with the increased quantity of sludge—an important consideration—have cost a great deal more than their worth. The table accompanying Mr. Dibden's paper shows that whether he added 4·7 grains of chemicals, or 108 grains per gallon, at costs respectively of $1\frac{1}{4}$d. per head and 4s. per head, it did not make more than 20 per cent. difference in the amount of organic matter removed.

The quality of sewage dealt with at an outfall varies considerably during the twenty-four hours, and the difficulty with chemical treatment is to apply the chemicals at all times so as to obtain the desired result.

A few experiments were made at the Botany Sewage Works in connection with the Sydney main drainage. The quantity of chemicals used in the first instance was the same recommended by Mr. Dibden for treating the London sewage, viz., 3·7 grains of lime per gallon. This amount of chemicals, when mixed with the sewage, had no visible effect in precipitation, and with regard to purification the liquid was to all appearances as foul as it was before the chemicals were put in. When it is considered that there are 70,000 grains in a gallon, it is obvious that the homœopathic dose of 4·7 grains would be useless for either clarification or purification.

Further tests were made with increased quantities of lime alone in the form of milk of lime. The precipitating action was good, but the quantity used to obtain this result was so large in proportion to the sewage dealt with, that the cost of the material and machinery for mixing and agitating together, with the increased bulk of the sludge, would far outweigh any advantage obtained in clarification or purification.

A further trial was made with milk of lime and sulphate of iron in the proportion of two of the former to one of the latter. In this case the quantity of chemicals used was such as would make it expensive, and preclude its use on a large scale. The result, however, as to a high standard of purification and clarification was disappointing. It was found that the effluent could not be let into a river, especially one from which a water supply would be drawn, without danger.

In vol. XIII. of the Proceedings of the Association of Municipal and Sanitary Engineers, Sir Robert Rawlinson, in speaking on the chemical treatment of sewage, stated that "to purify sewage by any known chemical process you must leave the word purify out. When, again, as regards precipitation, whatever action the precipitants may have in throwing down the floating and floculent matter in sewage, seven-eighths of the salts of sewage still remain. You may clarify sewage until it is as bright as spring-water, and yet seven-eighths of the salts which act injuriously when turned out into a water-course remain in the clarified effluent."

"At Coventry, England, where £60,000 had been lost in attempting to purify sewage, it was found, after a second company had been formed, with a subsidy of £1200 per annum from the corporation, that it would have failed if they had not procured a portion of valuable land over which the clarified sewage could pass before it passed into the watercourse."

In all the towns that have, in the past, attempted to purify the sewage by chemical treatment, the greater number have abandoned the process for one of disposal and filtration over land, and in the light of experience which has been obtained in other lands, as well as the successful issue of the experiments at Adelaide and Sydney, the question of purification of sewage should be easily solved. Where, however, suitable land is not available, the question becomes narrowed down to the choice of chemical treatment—*Aeration* process and by *electrolysis*.

III. *Filtration through land* is carried out by disposing of the sewage, after screening off coarser matters, directly over land specially prepared for it, or in combination with chemical or mechanical precipitation. Except in special cases the latter system is not resorted to.

In the case of the Sydney main drainage works the sewage has to be screened, and the suspended matter precipitated in specially-designed basins, on account of the sewage having to pass under the bed of a navigable river by a syphon. The sludge is dredged from these basins, and together with extraneous matter, which is caught on the screens, is taken to the farm and dug in.

The farm is situated on a neck of land at the junction of Cook's River with Botany Bay. The formation is drift sand overlying clay, which is at a considerable depth.

The sewage, after passing under the bed of the river, is conveyed across the farm by a concrete carrier, on each side of which is laid out the storm-water tanks and irrigation areas.

The irrigation areas lie between the main carrier and Cook's River. They are formed in terraces, and the sewage is applied to the land by sluices in the main carrier and ordinary earth channels, with subsidiary sluices made of timber. The daily sewage is applied to the irrigation areas, the tanks on the opposite side being reserved for storm-water.

The irrigation plots have been planted with sorghum, barley, cabbages, swede turnips, and other vegetables, all of which thrive very well and find a ready sale. Some of the storm-water tanks have been planted with lucerne, the crop being watered with the storm-water, which is turned into the tanks; the growth has been beyond expectation, considering the nature of the soil prior to being irrigated, the crop being capable of being cut once a month.

From a sanitary standpoint, the disposal of the sewage has proved successful, the effluent water being analysed by the Government Analyist every quarter. Appended hereto are reports of Mr. Hamlet for July and September, 1889.

The question of disposal of sludge has to be considered in any system of sewage disposal. This difficulty has been met in many ways, viz.—1. By allowing the matter in suspension to precipitate in specially-designed tanks, drawing off the supernatant water, and allowing the sludge to dry, and afterwards dealt with; 2. To precipitate the suspended matter by chemicals and sludge, dealt with as above; 3. To carry out precipitation by either of the above processes, and treat the sludge by "filter presses," the resultant being sludge cake. This has the advantage of the sludge being easily handled if there is any demand for this description of manure by farmers, market gardeners, or other agriculturists. The simplest and best means of disposal of sludge is to dig it into the ground if the land is available; where such cannot be obtained the question of disposal becomes more expensive, and the cost has to be faced, as experience has demonstrated that no laboratory value of the sludge can be obtained from those who are likely to use it.

The mode of disposal adopted at the Botany Sewage Works is to precipitate the suspended matter by lime, the supernatant water being lifted from the tanks to the syphon-well by an "ejector." The sludge is dredged out by a dam-dredger, and deposited in trucks and conveyed to the farm and used as a top-dressing and manure.

The sewage was turned on to the farm in August, 1887, and at the present time the character of the soil does not indicate any great change, notwithstanding the quantity of sewage which it has received.

The area cultivated and irrigated with liquid sewage was little over two acres, the population draining into the main sewer being estimated at 7000, so that each acre of land was absorbing the sewage of about 3500 persons.

As before stated, the question of disposal has been solved favourably from a sanitary point of view, and it accords with the opinion of sanitary engineers who have had any experience in the matter, that notwithstanding any prior treatment the sewage should, as a final measure, be disposed over and filtered through land.

The question of treatment of sewage by "*electrolysis*" is dealt with by Mr. Roberts, who is the patentee in the colonies for the process. In connection with this system I merely wish to state an opinion that the system is destined to supersede chemical treatment, but where suitable land and circumstances are favourable it will not hold good against land filtration.

Government Laboratory,
Sydney, 8th July, 1889.

Analysis of a sample of sewage effluent received from the Medical Adviser, 21-6-89. Labelled No. 1. Well 79 feet from tank.

—	Results expressed in	
	Grains per gallon.	Parts per 100,000.
Appearance in two-foot tube	Brown peaty colour	
Odour on heating to 100 deg. Fahr.	Slight	
Chlorine as Chlorides	12·5	17·8
Phosphoric Acid in Phosphates	Trace	
Nitrogen in Nitrates and Nitrites	—	—
Do. equivalent in Nitric Acid	—	—
Do. existing as free Ammonia	·653	·934
Organic Nitrogen, or Albuminoid Ammonia..	·070	·100
Oxygen absorbed in 15 min. at 80 deg. Fahr.	—	—
Do. do. 4 hours do.	3·29	4·70
Hardness in degrees, Clark's scale, before boiling	—	—
Loss on ignition	4·7	6·8
Poisonous metals	None	
Total solid residue, dried at 220 deg. Fahr.	38·9	55·6

General observations on the character of the water: The effluent is of such composition as may be passed into tidal rivers without causing a nuisance.

(Signed) WILLIAM M. HAMLET,
Government Analyst.

Government Laboratory,
Sydney, 8th July, 1889.

Analysis of a sample of sewage effluent received from the Medical Adviser, 21-6-89. Labelled No. 2. Well 20 feet from tank.

—	Results expressed in	
	Grains per gallon.	Parts per 100,000.
Appearance in two-foot tube	Brown peaty tint	
Odour on heating to 100 deg. Fahr.	Slight	
Chlorine as Chlorides	9·7	13·80
Phosphoric Acid in Phosphates	Traces	
Nitrogen in Nitrates and Nitrites	—	—
Do. equivalent in Nitric Acid	—	—
Do. existing as free Ammonia	·560	·80
Organic Nitrogen, or Albuminoid Ammonia..	·098	·14
Oxygen absorbed in 15 min. at 80 deg. Fahr.	—	—
Do. do. 4 hours do.	3·566	5·08
Hardness in degrees, Clark's scale, before boiling	—	—
Loss on ignition	10·36	14·8
Poisonous metals	None	
Total solid residue, dried at 220 deg. Fahr.	30·52	43·6

General observations on the character of the water: The composition is such as to allow it to be passed into tidal rivers without causing a nuisance.

(Signed) WILLIAM M. HAMLET, F.I.C.,
Government Analyst.

Government Laboratory,
Sydney, 16th September, 1889.

Analysis of a sample of water received from the Sewerage Farm, Webb's Grant, Botany, 4-9-89. Labelled Effluent marked "A."

—	Results expressed in	
	Grains per gallon.	Parts per 100,000.
Appearance in two-foot tube	Clear	
Odour on heating to 100 deg. Fahr.	None	
Chlorine as Chlorides	6·8	9·71
Phosphoric Acid in Phosphates	Traces	
Nitrogen in Nitrates and Nitrites	None	
Do. equivalent in Nitric Acid	None	
Do. existing as free Ammonia	·210	·30
Organic Nitrogen or Albuminoid Ammonia..	·035	·05
Oxygen absorbed in 15 min. at 80 deg. Fahr.	—	—
Do. do. 4 hours do.	·56	·80
Hardness in degrees, Clark's scale, before boiling	—	—
Hardness in degrees, Clark's scale, after boiling	—	—
Poisonous metals	None	
Total solid residue at 220 deg. Fahr. ...	31·36	44·8

General observations on the character of the water: The analysis indicates that the effluent is undergoing the natural process of purification by oxidation, and may be safely discharged into rivers without causing a nuisance.

(Initd.) W. M. H.,
Government Analyst.

Government Laboratory,
Sydney, 16th September, 1889.

Analysis of a sample of water received from Sewerage Farm, Botany, 4-9-89. Labelled Effluent marked "B."

	Results expressed in	
	Grains per gallon.	Parts per 100,000.
Appearance in two-foot tube	Clear	
Odour on heating to 100 deg. Fahr.	None	
Chlorine as Chlorides	4·3	6·14
Phosphoric Acid in Phosphates	Traces	
Nitrogen in Nitrates and Nitrites	None	
Do. equivalent in Nitric Acid	None	
Do. existing as free Ammonia	·021	·030
Organic Nitrogen, or Albuminoid Ammonia..	·035	·050
Oxygen absorbed in 15 min. at 80 deg. Fahr.	—	—
Do. do. 4 hours do.	·84	1·20
Hardness in degrees, Clark's scale, before boiling	—	—
Hardness in degrees, Clark's scale, after boiling	—	—
Poisonous metals	None	
Total solid residue, dried at 220 deg. Fahr...	33·6	48·0

General observations on the character of the water: The analysis indicates that the effluent is undergoing the natural process of purification by oxidation, and may be safely discharged into rivers without causing a nuisance.

(Initd.) W. M. H.,
Government Analyst.

5.—HEALTH LEGISLATION IN VICTORIA.

By A. P. Akehurst.

6.—DUTIES OF SANITARY INSPECTORS.

By C. J. Eassie.

7.—HOUSEHOLD SANITATION.

By George Gordon, M.Inst.C.E.

[*Abstract.*]

The requirements for a wholesome dwelling are—1st, a good site and correct construction of the house; 2nd, plenty of fresh air; 3rd, a pure water supply; and 4th, the speedy, and as far as practicable, automatic removal of all refuse.

Under the three first heads, which are not entirely in the control of individuals, it is urged that where the ground-water level, or a clay subsoil, is near the surface, the whole area occupied by the house should be covered with a layer of concrete or asphalt, and the space intervening between this layer and the floor joists should be thoroughly ventilated. Hollow walls are recommended, and when practicable such an aspect that the morning sun shall shine into as many bedrooms and livingrooms as possible. Thorough ventilation is insisted on, but no special arrangements for artificial ventilation are needed, except in the case of buildings inhabited by a great number of persons. It is pointed out that where there is no town water supply a moderately roomy house will generally, where the rainfall is 22 in. per annum, yield from the roof sufficient water for drinking and cooking, and partly for washing purposes, and that an equal additional supply of inferior water would suffice for other purposes. Iron tanks above ground are preferable to underground brick tanks, as being more easily cleaned, and not liable to have the water contaminated by infiltration from surrounding soil. If the latter are used, they should be at some distance from, and at a higher level, than the house and outbuildings, the water being led in by a cast-iron pipe into which the down pipes are fixed.

The special subject of the paper is the removal of all kinds of refuse liquid, which can easily be removed by water without manual labour, and solid, which it would be impossible so to remove. The first is practically all the water used in the establishment and fouled in the using, and coming from the kitchen or scullery, bedrooms, water-closets, washhouse, and from the scrubbing of floors.

The principles on which the house drainage should be designed are simple, viz., these:—There should be no stagnant fluids; they should be discharged into the sewers as quickly as possible, and there should be no possibility of foul air from the pipes or sewers entering the houses, that is to say, there should be no cesspits, and all drains should be trapped. The use of water-closets is advocated for town houses, wherever there is an underground system of sewers, because they are the only unobjectionable means of removing fæcal matter, and their use adds little to the liquid refuse that has in any case to be disposed of—about one-sixth—and the proportion to the quantity of water used becomes less as this increases, which is the observed tendency in most town supplies. When it can be conveniently arranged, the closets should be against an outside wall, and the soil-pipe should be outside the wall, and should, in all cases, be carried up above the roof, the connections with it and the closets being trapped. Alongside the soil-pipe there should be a smaller ventilating-pipe, into which the closet-traps are ventilated. The horizontal part of the soil-pipe, called the "house drain," should be carried by the most direct line to the street sewer, but it should not pass under the house. If this is unavoidable it should be of cast iron, laid on a solid foundation. There should be an "air disconnection" between the sewer and the house-drain, near their junction. The waste-pipe, which disposes of the sewage from sinks, &c., should be treated in the same way; but at the foot of the pipe, and near the wall of the house, there should be a disconnecting trapped chamber, into which all the foul drainage from outhouses, &c. (except closets), should also be led, preferably by open drains of half-round glazed tiles, which are easily cleaned. Various kinds of traps are described and illustrated by diagrams, and it is pointed out that it is essential they should be ventilated in order to prevent unsealing. Each trap should have a separate connection with the waste-pipe, as, if several traps are on pipes joined together below the trap, the action of one may unseal the other.

The second kind of refuse, the solid waste, consisting of ashes, cinders, bones, small rubbish, tins, sweepings, and such kitchen waste as is intercepted by the strainers, should, in towns, be placed in covered receptacles, and removed daily by the dustman in a covered cart, and it is best disposed of by burning. Where the water-closet system is inapplicable, either from want of a proper water supply or of underground drainage, as in some villages, barracks, country houses, &c., probably the best substitute is the dry-earth closet, or the "Goux" pail system. Closets should be detached from the house, and the pans should be made so that the urine is carried off separately and led by pipes into the drains carrying the other waste water or liquid sewage, and conveyed to a distance from the house by a rapid current. Unless this be done the so-called dry-earth system is little better than the ordinary pail system, which has the great fault of keeping the excreta for a considerable time, whereas they ought to be instantly removed.

A system of house drainage, however well designed, may be made worse than useless by bad construction or workmanship, and it is suggested that only such plumbers as have been examined on the principles of sanitary work, and have certificates of competency and experience, should be allowed to carry out such works, and in case of negligence they should be liable to prosecution. In New York and other principal cities of the United States of America the plans of the plumbing have to be approved by an officer of the Board of Health, specially appointed for this purpose. It is thought, what with these checks on defective design and workmanship, the sanitary condition of dwellings would be much improved.

8.—SCHOOL HYGIENE.

By E. G. Leger Erson, L.R.C.P.

9.—HOUSEHOLD DRAINAGE: ITS PRINCIPLES.

By A. M. Henderson, C.E.

[*Abstract.*]

Household drainage, regulated in Victoria by local municipal officers, who are, as a rule, untrained in the work—result unsatisfactory. Open drains insisted on, but great carelessness as to quality of materials and permeability of the joints, which soon get saturated with grease, urine, and filth. Interceptors not allowed at junction of pipes and open drains, and hence fouling of the pipes and return of bad gases. Unfortunate that architects, being in business competition, too often have to consider economy, and often ignorant work being cheaper triumphs. Suggest regulations compelling uniform work; and as there will be underground system in Melbourne within the next five years, regulations and trained inspectors should be adopted now, and all new wastes and drains for houses made on sanitary principles and suitable for new system. New Health Act provides for registration of plumbers, but training in sanitary principles first necessary.

Necessary to have good maintenance as well as good construction. Maintenance of house drains entirely neglected here; often clogged with years' deposits. Cause of great part of typhoid.

Waste waters of two classes—continuous and intermittent. *Continuous* include (*a*) bath and lavatory water, with no solid matter, and often used for irrigation; (*b*) pantry, scullery, and laundry water, containing solid and greasy matter; (*c*) water from slop-sinks and urinals, with no solid matter; (*d*) from water-closets, containing solid matter.

Intermittent include (*e*) pure water from roofs and tank overflows; (*f*) fairly pure water from balconies, towers, flats, and tank-flushes; (*g*) overflows of trays under baths and lavatories; (*h*) trays under slop-sinks and closets.

Greatest dangers arise from intermittent wastes. Upper ends generally open. Difficulty in securing interception.

Good drainage requires—

I.—Proper conductors to convey away the waste products made with non-absorbent, non-corrosible material, and joints—of sufficient (not too great) size and fall, and self-cleansing form and easily accessible.

II.—Proper interceptors to prevent dangerous matter entering or leaving the conductors. Made with non-absorbent, non-corrosible materials and joints. Two classes. Self-cleansing form as small as practicable for (*a*), (*c*), (*d*), where gases only require interception, but not so self-cleansing as to empty by momentum or suction. Non-self-cleansing and of full size for (*b*) where solids and gases require interception. As interception is generally maintained by water, the surface should be as small as possible to lessen evaporation.

III.—Proper disconnection to prevent pressure in the conductor and aid in ventilation—consists in leaving outlet end of each section of conductors open to the air—generally discharging over open drains or over interceptors.

IV.—Proper ventilation to maintain interception, which might be destroyed by suction where conductors unite or strong flushes are used—and to oxygenise the inner surface of conductors and render products of decomposition innocuous. Upcasts should be carried well above roofs and chimneys.

It is characteristic of intermittent drainage that the inlets are open, so that interceptors must be fixed at outlets or at junction with continuous drainage. In continuous drainage interceptors should be fixed as near the inlets as possible.

Foregoing classification and notes especially useful as a basis of criticism, and for instructions to inspectors.

10.—FACTS AND FIGURES RELATING TO VACCINATION.

By A. J. Taylor.

11.—PREVENTIVE INOCULATION AGAINST ANIMAL PLAGUES.

By O. Katz, Ph.D.

12.—MICRO-ORGANISMS AND HYGIENE.

By A. Shields, M.D.

13.—CREMATION A SANITARY NECESSITY.

By H. K. Rusden.

REPORT OF COMMITTEE No. 9.

Town Sanitation.

MEMBERS OF COMMITTEE :—Dr. BANCROFT, W. M. HAMLET, Sir JAMES HECTOR, Professor LIVERSIDGE, Professor THRELFALL, Dr. SPRINGTHORPE, Dr. SYME, Professor THOMAS, Professor WARREN, and Hon. Dr. CAMPBELL (*Secretary*).

AT the close of the last annual meeting, on the motion of Professor Liversidge, the following gentlemen were appointed a committee to report on "Town Sanitation," viz. :—Dr. Bancroft, Hon. Dr. Campbell, Mr. W. M. Hamlet, Sir James Hector, Professor Liversidge, Professor Thomas, Professor Threlfall, and Professor Warren. Subsequently the names of Dr. Syme and Dr. Springthorpe were added. In December Dr. Campbell agreed to act as hon secretary.

On the 1st of February, after consultation with various members of the committee, the secretary issued a letter to upwards of 200 medical practitioners and health officers in Australia and New Zealand. The letter asked for information respecting the sanitary condition of the towns in which they either practised or held health appointments. It was suggested that for the purpose of classification the information should be given upon the following lines, viz. :—

1. Site and soil.
2. Houses, their arrangement, material of construction; regulations respecting houses unfit for occupation, over-crowding, and lodging-houses.
3. The water supply.
4. The removal of refuse water, and of dry refuse.
5. The removal of excreta.
6. The conservancy of the surface.
7. The food supply—regulations respecting milk, slaughter-houses and bake-houses.
8. The regulation of offensive or noxious trades, and the overcrowding of factories.

9. The arrest of infectious diseases. State views on the compulsory notification of infectious diseases.
10. Disposal of the dead.
11. The supervision of nuisances.
12. Liability to outbreaks of special diseases, and their connection with any insanitary condition.
13. State suggestions as to the most suitable means of improving the sanitation of your town, or, in your opinion, the best system to be adopted to place it in a reasonably sanitary condition.
14. Statistics as to population, death-rate, and general character of the diseases which prevail.

The following gentlemen courteously favoured the committee with replies:—Dr. Coppeadge (Roma), Dr. Vivian (Rockhampton), Queensland; Dr. W. C. Aild (Kiama), Dr. W. J. Bassett (Bathurst), Dr. W. Asher (Lithgow), New South Wales; Dr. D. F. Fleetwood (Warrnambool), Dr. H. H. Radcliffe (Ballarat), Dr. H. H. Gordon (Clunes), Victoria; Dr. Markham (Port Augusta), Dr. Mitchell (Port Adelaide), T. Farrell, Esq. (Adelaide), South Australia; Dr. S. H. Beard (Masterton), Dr. Neil (Wellington), New Zealand; J. G. Bushman, Esq. (Launceston), Tasmania.

Communications from other sources, in the shape of Health Acts and reports of health boards, have also been received. The committee desire to acknowledge their indebtedness to Dr. Mitchell, Dr. Vivian, Dr. Neil, Dr. Radcliffe, Mr. Farrell, and Mr. Bushman, for their admirable reports.

The paucity of the replies received, as well as the heavy labour involved in an attempt to bring all the colonies under one report, induces the committee to make the suggestion that in future the work of any similar "town sanitation" committee should for the year be restricted to one colony, and, if possible, the colony in which the annual meeting of the Association for that year shall be held. It is further suggested that the honorary secretary should be a resident of the same colony.

This suggestion, combined with the fact that the present honorary secretary had before him ampler information respecting the colony of South Australia than any other, the report has been limited to the "town sanitation" of that colony.

It may briefly be stated that the Health Acts of South Australia are under the administration of a Central Board of Health, the president being a Government officer. Appointments upon the board are in the hands of the Cabinet. By a recent enactment, all civic corporations and district councils are local boards of health. Corporations have power to raise a special sanitary rate, while both corporations and district councils may appoint health officers, and may take proceedings against infringements of their regulations.

The Act requires each local board to forward annually a report to the Central Board. Any corporation, as a local health board, failing to impose a health rate, or to appoint a medical health officer when called upon by the Central Board, or failing to carry out any instruction of the Central Board, may be summoned to appear at the Supreme Court. In the case of district councils as local health boards, if they refuse or neglect to comply with any instruction of the Central Board, that board may do the thing required to be done, and recover the expenses incurred from the district council.

The administration, then, of the Health Acts is greatly subdivided, and is proportionately less effective. In proof of this inference, it may be stated that the report of the Central Board for 1888-9 says that, out of 173 local boards, no less than 112 had failed to comply with the Act in the simple matter of sending an annual report. In the same document it is further intimated that several local boards had been guilty during the year of so far neglecting to carry into effect their own regulations that the Central Board was under the unpleasant necessity of issuing peremptory orders upon them.

The sanitary condition of all the towns, whether under corporate jurisdiction or under district councils, is therefore in the hands of their respective local boards. Leaving out of view in this report the city of Adelaide, which, with its numerous and populous suburbs and its distinct deep drainage system, certainly merits an exclusive report, the towns of South Australia range in population from 8000 to 500. The committee consider that a fair estimate of their sanitary condition may be arrived at by dividing them into two classes—those situated on the sea-board and those inland. Of the first, Port Adelaide, Port Pirie, and Port Augusta may be taken; while, of the second, Gawler, Burra and Clare may be selected to illustrate the position. The respective sanitary conditions of these towns will give a fair notion of the "town sanitation" of the province.

Port Adelaide.

Port Adelaide was laid out in 1840, four years subsequent to the founding of the colony. It lies about seven miles west of the City of Adelaide, on an estuary of the Gulf of St. Vincent, called the "Port River." It is the chief seaport. The river is subject to tidal action. The "Port" may be regarded as consisting of Port Adelaide proper, lying east of the river, and the Semaphore lying on the west side. The population is about 8500. The site is low, and in many places damp, much of the eastern portion having been at one time covered by the tides. The river is now banked off, and the land behind is being gradually levelled up. Port Adelaide proper has a honeycomb clay bottom, through which the tides ebb and flow. Above is a layer of sand, rubbish of various descriptions, and limestone silt, deposited from the dredgings of the harbour. The western side has a hard clay bottom, with a varying thickness of sand overlaid. Fresh water is easily obtained in this sand. The eastern portion is the old section of the town, and still retains among its modern and substantial stone erections some of the primitive structures, consisting of wood and galvanised iron. Some of these are highly insanitary, being on the original swamp level, and now below the surrounding street level. On the western site, while one portion is unsatisfactory from very imperfect drainage and damp, the houses on the whole are modern and substantially built, and free from the unwholesome surroundings which affect the Port proper.

The water supply is mainly derived from the same source as the City of Adelaide, viz., the reservoirs at the Torrens and Hope valleys. The supply is very pure. The reticulation area, however, does not extend to many of the more distant houses. These obtain their supplies either from the roofs or surface wells. The water in these wells being secured by soakage, is liable to contamination. Outbreaks of typhoid or bowel derangement have been traced to them.

The refuse water is conveyed in open water-tables to the harbour. Sludge boxes, 2ft. x 1ft. 6in. x 2ft., are placed in the course of these water-tables at the entrance to all culverts and drains, and are periodically cleaned out. It is estimated that at least 12 miles of these open drains has been constructed. The site of the town being very little over the sea level, the carrying out of a system of deep drainage would be very costly. On the Semaphore, or western side, few streets, and consequently few water-tables, have been fully constructed. The refuse water is here allowed to pass into the sand, which, in view of the wells above referred to, as well as the pollution of the soil, constitutes a highly objectionable practice. It is a happy circumstance for the health of the residents, as well as an attractive feature of the locality, that a large number of trees and shrubs are planted every year. They thrive well, and absorb the accumulated foul soakage which lies on the clay bottom underneath the surface.

Dry refuse is removed weekly by itinerating carts, under a contract with the local board. It is employed to fill up low-lying levels alongside of the swampy ground to the north. The Corporation have at times allowed it to be used for filling up hollow sites in the town itself. The Health Officer states that in 1888 he attributed an outbreak of 15 cases of typhoid fever to this cause

Cesspits are chiefly used. In about 50 instances earth-closets have superseded the cesspit, and where properly attended to have given satisfaction. According to the provisions of the Health Act, all cesspits must be water-tight, but the law is perfunctorily enforced by the local board. In numerous cases the pits are glaringly defective, being visibly influenced by the tides. In this leaky condition they thoroughly saturate the surrounding soil. The cost of emptying the pits seems to be the chief obstacle to an efficient administration of the law, and the local board does not appear to attach sufficient importance to this matter to induce them to establish an organised system for the complete and frequent removal of excreta. The contents of these cesspits are cleared away at intervals much as the residents choose, although by regulation it should be done at stated intervals. In several parts of the town the pepper-tree is again a friend of the public health, preventing many from reaping the harvest of their indifference and ignorance.

It may be said with regard to the inspection of food that it is only nominal so far as the local board are concerned. In the case of imported meat or other food it is different. This has to pass an inspection by the Customs officers, a service of great moment not merely to Port Adelaide, but to the whole colony.

Port Adelaide has no public abattoirs; small cattle are allowed to be slaughtered inside the limits of the town. Slaughtering-places and butchers' premises are subject to inspection. It must, however, be admitted that not a few of them are left, particularly in the summer months, to become sources of annoyance to the neighbourhood.

The regulation of trades and trade premises seems to be conducted on very general principles. Bakehouses are seldom looked at; noxious trades are occasionally inspected, and where a glaring instance is found of workmen being employed in ill-ventilated or otherwise unhealthy buildings interference may take place.

No provision is made under the Health Acts for the early or compulsory notification of infectious diseases, except smallpox, cholera, plague, yellow fever, and leprosy. The speedy discovery of infectious cases is therefore very difficult. When such cases do become known to the local board, steps are promptly taken to disinfect the premises and remove any known or suspected cause. Isolation, except in the case of smallpox, cannot be enforced, as there is no legal power and no accommodation to receive patients. No doubt, in the event of any serious epidemic arising, temporary premises would speedily be made available.

The ordinary practice of interment is followed. There are two cemeteries, one almost disused, inside the Corporation boundary, and another on the outskirts. The latter has a dry clay soil. The water level is reached at a depth of 10 to 12 feet.

The general work of inspection is carried out by a medical health officer and two inspectors. The latter have too many duties to perform to be able to give the requisite attention to sanitary work. Other duties as those of Town Surveyor, Inspector of weights and measures, of lights on vehicles, of widths of tires, of public conveyances, of lodging-houses, of storage of kerosene, the registration of dogs, etc., are laid upon them. Efficiency under such circumstances cannot be secured.

Port Pirie.

Port Pirie is situated about 150 miles north of Adelaide and 50 miles south of Port Augusta. It lies on a small estuary of Germein Bay, itself a part of Spencer's Gulf. The population is well over 1000, and from its business connection with the Barrier silver mines, is rapidly on the increase. The site is only a few feet above high-water level; it is consequently defective in natural drainage. The buildings are nearly all of recent erection, and fairly substantial. Its water supply is good; originally it was supplied from an expensively-constructed reservoir at Nelshaby, some miles off; but latterly it has formed a connection with the splendid Beetaloo Water Supply. Scavenging is carried out effectively, and the disposal of refuse is strictly regulated. No means are adopted by which foul water can be satisfactorily disposed of. The primitive cesspit is well-nigh superseded by the earth-closet, quite two-thirds of the residents using the latter. The scavenging contractor attends to the pans. The regulations bearing upon slaughter-houses, trades, lodging-houses, &c., are fairly enforced. The sanitary staff consists of a medical health officer and an inspector.

What must be regarded as a retrograde step was taken by this corporation a short time ago. It indicates decisively how the worthier interest of the public health is set aside by such local bodies when confronted with the chances of material progress. The Amended Health Act of 1882 admits of the creation of manufacturing districts, the object being to free certain manufactories from the strict application of the Health Act of 1873 in several respects. These districts are proclaimed at the instance of the Government on petition of the residents and the local governing body. In this instance a petition was presented, asking two things in addition to that of the formation of a manufacturing district. The first was that the clause in the Health Act providing that corporations or local health boards shall have power to order the removal of waste and foul water, and the second, that clause 45, providing for a simple and inexpensive legal process for securing compliance with the previously-mentioned clause, should not apply to this manufacturing district. The Central Board of Health, in the future interests of Port Pirie, strongly remonstrated against granting these two concessions. The prospect of having smelting and other works established prevailed against every other consideration, not merely with the local authority, but with the Government also, and the full petition was granted. Under such circumstances, all nuisances created by this manufacturing district are absolutely without control. It may be urged that the power of inspection remains to the Central Board ; but without the power of enforcing its orders, inspection is to little purpose.

Port Augusta.

This town is situated (on the map) at the apex of Spencer's Gulf. It is distant about 240 miles from Adelaide. It possesses a fine harbour, and is regarded as the coming metropolis of the north. On the completion of the railway system, which will connect South Australia with every colony, all the lines will converge to it. The population is just under 2000. The site is low and difficult to drain. It has a sandy soil, with a sub-layer of clay. It is laid out rectangularly, and the streets are mostly formed and well-paved, with properly-constructed water-tables. The buildings generally are substantial. The water supply is fair, being obtained from a reservoir some 14 miles off. An attempt is made to dispose of the foul water by leading it into a number of deep subsidence wells. This is said to answer fairly. Until recently these wells were not ventilated. In numerous parts of the town the people are still permitted to throw refuse water on the surrounding soil, which being of a sandy nature allows the water to disappear readily. In hot weather, however, the state of the soil brought about by this practice is unquestionably the cause of numerous cases of intestinal inflammation among children. A moderately efficient system of scavenging is in operation, but the objectionable custom of filling up hollows with dry rubbish is still followed. Privy-cesspools are practically abolished in favour of the dry-earth system. No organised supervision of the system by the corporation exists as yet, and consequently it is attended with nothing more than partial success. The excreta are removed weekly, and buried outside the town in trenches. Notwithstanding the large possibilities that exist for improvement, the town is remarkably healthy, having a death-rate of 13 to the 1000.

Gawler.

Gawler is situated 25 miles north of Adelaide, in close proximity to the main northern line. Its population numbers 2000, and its houses 400. It occupies partly the face of a hill and partly a flat. The arrangement of the streets is rectangular. It is the centre of an agricultural district and the seat of the famous foundry and machine-shop of Messrs. James Martin and Co. The natural drainage is good. The soil is limestone in character. The principal streets are macadamised, the footpaths are properly kerbed, and the water-tables well paved. The water supply is derived from a well, sunk by the Government, on a rising ground near the town, from whence reticulations are carried over the greater portion of the town. Except in a few instances on the west side, where a few soakage-wells are sunk, the waste water is allowed to run into the water-tables, and thence into the Para River. The ordinary cesspit and privy is in use, and many of them possess the usual defects of being too large and full of leaks, and of remaining too long a time unemptied. In a few cases the earth-system is adopted, as at Messrs. James Martin and Co.'s yard, where over 300 men and boys are employed. In this instance the system is supervised by the company with care and attention, and the best results are said to follow. Slaughtering is not permitted within the boundary. There is a medical health officer and an inspector of nuisances.

Burra.

The Burra township is distant 100 miles north of Adelaide. When the famous "Burra Burra" copper mines were in operation it was the scene of great activity. Since their cessation the population has greatly diminished. It now numbers some 2600 inhabitants. It is the centre of an agricultural district, and a depôt for cattle going to the far north, or southwards to the Adelaide market. It has had railway communication with the metropolis for many years. The town comprises several settlements, each going by a different name. The site is, on the whole, good. The soil is hard and stoney, very unfavourable for absorption or percolation. The houses are fairly built and arranged. In Kooringa they are closely packed, while at Redruth and Aberdeen they are scattered. The water supply is from an old mine called the "Bon Accord," and is considered to be good. A supplementary supply has to be secured for the residents on what is known as "The Flat," where, unfortunately, the houses are numerous and the cesspits, in many cases, nothing more than large holes in the ground. A licensed nightman attends to the cleaning of the cesspits, but as each resident has to pay the cost, not as a rate, but directly to the nightman, he employs him as seldom as possible. The waste water is allowed to pass into the street water-tables, and thence into the "Burra" Creek. Dry refuse is removed periodically by an authorised scavenger, and the excreta is deposited and trenched on a farm at some distance. This part of the work is well done. Butchers' premises are, on the whole, well looked after. There is no medical health officer. All sanitary work is done by an inspector under the direction of the local health board.

Clare.

Clare is some 80 miles northward of Adelaide, and about 20 miles westward of the northern main line of railway. It is the centre of an agricultural and pastoral district, and contains 1100 inhabitants. It is regarded as the handsomest township in the colony. The site is favourable, and the houses are, for the most part, well-built stone structures, surrounded by gardens. The soil is clayey, mixed with stones. Good natural drainage exists, except for the main street. The water supply is obtained from shallow wells, which, from the contiguity of numerous cesspits, run great risk of contamination. Till recently, these cesspits were mere holes in the ground. Within the last two years the Central Board of Health has had to issue an order upon the local board, requiring the immediate construction of all cesspits in accordance with the provisions of the Health Act. Scavenging is only partially attended to. Dry refuse is deposited outside the boundary, and excreta upon an adjacent farm. No slaughtering is permitted. An interesting convenience in the shape of a bath, some 80 feet by 25 feet, exists for the public. The sanitary work is in the hands of an inspector, who has a hundred and one other duties besides.

The following facts indicate the extent to which the sanitary schoolmaster has been abroad in some of these townships since the passing of the Health Act of 1873. The Central Board of Health report that, in 1888, a resident of Clare made a formal complaint that the local board had failed to carry out their sanitary duties, inasmuch as—1, nightsoil was allowed to be carried through the street in the daytime; 2, that the so-called earth-closets were defective; 3, that scavenging was limited to the main street; and 4, that the removal of nightsoil was made unnecessarily difficult and expensive. The chief inspector of the Central Board confirmed these charges, and added that since his previous visit no steps had been taken to rectify the condition of the cesspits and protect the wells from contamination. In reply to the Central Board, the local board forwarded the local inspector's denial of the complaint, and his views on the requirements of the situation. The Central Board issued a peremptory order requiring immediate compliance with the Health Act, not only in respect of the complaints made, but also in respect to the construction of cesspits. The local board immediately carried out the order, and promised to continue its efforts to secure a good sanitary condition of the town.

In connection with the natural history of the sanitary state of the foregoing towns, a word or two is needful on the existence of infectious diseases during the year ending March, 1889. The following table shows the fatal cases of enteric fever and diptheria, the usual residences of the deceased being the towns named :—

Towns.	Enteric Fever.	Diphtheria.
Port Adelaide ...	1	8
Port Pirie ...	1	1
Port Augusta ...	1	1
Gawler	2	1
Burra	5	—
Clare	—	1

It is unfortunate that no returns exist which would enable a tabulated statement to be made of the number of persons attacked in these localities. It is, however, useless to offer a surmise on the basis of the death-rate; that is, to give a general average. The main cause assigned for the presence of enteric fever in most of these towns was the return from Broken Hill of residents who had either visited the silver mines or had been employed as workmen, and had contracted the disease there. Broken Hill, at that time, was in a highly insanitary condition, and quite an epidemic of typhoid prevailed. The Central Board of Health supports this statement of the origin of numerous cases by communications from medical health officers who had carefully traced their courses. The large number at the Burra was doubtless due to the fact that this town is the first on the way from Silverton to Adelaide which possessed hospital accommodation for the treatment of enteric fever.

DEATH RATE PER 1000 INHABITANTS.

Towns.	1884.	1885.	1886.	1887.	1888.	Average of Five Years.
Port Adelaide ...	15·9	15·6	15·6	13·6	12·8	14·5
Port Pirie ...	33·0	22·1	24·4	22·7	24·6	25·3
Port Augusta ...	39·5	30·5	31·8	36·2	34·2	34·4
Gawler	18·3	14·3	17·6	11·3	10·8	14·4
Burra	16·5	25·6	24·1	12·6	18·4	19·4
Clare	14·8	17·6	14·1	11·1	10·2	13·5

The towns above described are fairly typical of every township of moderate size in South Australia. The facts stated concerning them raise almost every question of a general character that is touched upon in public hygiene. To utilise these facts it will be needful to present a summarised review of them. This may be done under the five following divisions :—

1. The work already accomplished.
2. Natural difficulties.
3. Obvious defects.
4. Local Health Boards.
5. The Health Acts.

1.—THE WORK ALREADY ACCOMPLISHED.

The leading Health Act upon which all sanitary progress has rested was passed in 1873, that is, 16 years ago. In that Act civic bodies formed the local sanitary authorities. Two years ago the Act was amended so as to include district councils as local health boards. The territorial jurisdiction of the Central Board by this extension to district councils became greatly circumscribed. Sufficient time has not elapsed to declare the wisdom or otherwise by the Central and local boards of this step. The work done during these 16 years has been most varied and beneficial. The existence in itself of an active and fairly-organised system of sanitary inspection has had a valuable educational influence upon the public mind. In this connection the Central Board of Health must be credited with a large amount of steady perseverance and real tact.

The record of facts already presented in this report shows that local sanitary authorities have pushed on the filling-in of all swampy and low-lying portions of their respective towns. Old land-marks, around which only too frequently converge insanitary conditions, have been taken out of the way. Streets of good width have been systematically laid out. They have been well macadamised, and finished with water-tables and kerbing of a substantial nature. Buildings consisting chiefly of stone, or of brick, have been erected, and all with more or less regard to hygienic conditions.

A considerable amount of attention has been given to supplying pure water for domestic purposes. Large and expensive reservoirs have been constructed at Hope Valley and Thornden Park, which, while furnishing a supply for the city of Adelaide, also serves Port Adelaide. Smaller reservoirs have been formed for Port Pirie and Port Augusta, and a deep well and a large tank have been made to meet the requirements of Gawler. The Burra authorities have taken advantage of an old mine from which to draw a wholesome and ample supply.

An attempt has been made in a few places to get rid of foul water in a simple and inexpensive way. Wells have been sunk to considerable depths, into which the foul water drains and passes away by soakage. Where due attention is paid to the ventilation of these wells, they are credited with a fair degree of success.

In no town has dry refuse been allowed to accumulate. Regulations controlling this matter have been strictly enforced.

So far as the employment of cesspits as part of a system for the disposal of excreta can be brought under hygienic conditions, fair efforts have been made to do so. They are small in size, and water-tight. In some instances, as at Port Pirie and Gawler, earth-closets have been substituted for many of the cesspits. When the requirements of the dry-earth system, as at Gawler, are carefully met, such as a good supply of dry earth, and regular and frequent removal, it has proved a success.

Less disposition exists in the community now than formerly to oppose sanitary work, and a freer readiness prevails among local sanitary bodies to appoint inspectors, and even medical health officers, when required by the Central Board.

Without, perhaps, having directly in view the beneficial more than the artistic effects of tree-growth, several towns have planted along their streets, and elsewhere, large numbers of pepper and other varieties of trees and shrubs, with the happy result of minimising the serious evils which arise from the saturation of the soil with foul water.

2.—NATURAL DIFFICULTIES.

It is hardly necessary to say that towns placed near the sea level are exceedingly difficult to drain. It is well known that the rivers on which many towns similarly situated to Port Adelaide and Port Pirie are generally only open sewers. But this is not so in the case of either of these towns. The reason for this may possibly be found in the two facts, that the population has not reached such dimensions as to bring about this undesirable state of things, and that further, as the rivers are really arms of the sea, all sewage passing into them is immediately subject to the chemical action of sea-water. All the ports referred to are undrained, beyond what ordinary surface drainage and a few subsidiary soakage wells can effect. At Port Adelaide traps are constructed at points on the course of the water-tables, to arrest the more solid portion of the fluid refuse, but beyond this no attempt has been made to carry out any complete system of drainage. The deep drainage of Port Adelaide has been reported upon by engineers, and frequently discussed by the town council, but only to be laid aside again. The full supply of water which each of the ports and some other towns receives points strongly to the necessity of a system of efficient deep drainage.

3.—OBVIOUS DEFECTS.

In some towns, as Clare and the Burra, water-supplies for domestic purposes are, in a number of instances, taken from wells exposed to contamination. Cesspits of old standing, badly constructed originally, and permitting soakage, have been found in close proximity to these wells. It is needless to say that the contiguity of cesspits and wells under any circumstances is extremely dangerous, and where, as in every instance in these towns, supplies can be secured by the conservation of roof-water, the practice of drawing water from such suspected wells is simply criminal.

In the similar fact of preserving the air that is breathed from pollution, we see the serious outrage that is committed against the public health, in the habit of running filthy water into the soil or throwing it persistently upon the surface. It is a matter of regret that this practice should prevail so largely, and be overlooked by all sanitary local bodies. Numerous cases of enteric fever—the scourge of Australia—intestinal inflammation and diptheria are undoubtedly traceable to this source. In this connection the reflection thrusts itself upon us, that a critical examination of the towns of South Australia reveals the fact that the local authorities have yet much to learn and more to accomplish in the direction of sanitation. Tree-planting, it is true, modifies the insalubrity arising from this cause, but the fact is indisputable that no real protection exists against some of the most fatal and severe diseases that attack both old and young, but especially the young, apart from a clean and wholesome soil.

In this connection another most subtle conspirator against the public weal is the cesspit. Sanitary regulations may be all that are desirable, but where cesspits are used, through invisible rents, decay of structure and neglect, the soil may every day be becoming more impregnated with filth. The only safeguard, where the system cannot be supplemented by a better, is to place the entire management, control and inspection in the hands of the local authority. This is the position taken by an independent authority where the water carriage system exists, and no reason is at hand to show why the same authoritative control should not extend to any other system. To leave to the unquickened mind and biassed judgment of the ordinary householder the management of so important a branch of public hygiene is simply, from his point of view, to put within his reach the opportunity of saving himself from a rate, which he would otherwise have to pay, for he allows his cesspit to go uncleaned for an indefinite period; and, further, it is to permit failure to step in where success is imperative. Small cesspits soundly constructed and maintained, frequent cleansing and disinfection, a proper disposition of the excreta, and all carried into effect by the local sanitary authority, constitute the elements of a good system. This, however, most of the towns in South Australia have not yet attained to.

Another obvious defect is, that food supplies, such as milk, meat and bread, are largely allowed to go without inspection. By this indifference a subtle source of disease is left uncontrolled. When once the importance of recent investigations in the connection between tubercular disease and the ingestion of diseased meat has been clearly realised by the public, we may see more vigilance in this direction than at present exists.

The same indifference applies to trades and trade premises, except such as are not within the scope of this report, viz., those in the city of Adelaide and suburbs. It must, however, be said that the manufacturing industries outside of this centre of population are very limited in number, and not generally of an obnoxious character.

4.—LOCAL BOARDS.

The circumstance that local boards change their *personnel* more or less every year is a serious obstacle to sanitary progress. The members are elected primarily as civic or district councillors, and mostly for reasons which have no direct relation to sanitary matters. The most attractive quality which a candidate can present to a local constituency is a profession of rigid economy, and that simply means that neither increased taxation nor new-fangled notions, as they are called, will be indulged in. The broader principles and larger necessities of good government, which certainly include systematic sanitation, have no place in such men s programmes of progress. Hence the prospect of any rapid expansion in sanitary efficiency is not to be looked for. Short of local health boards being constituted on an independent basis, only the rougher phases of sanitary work will be carried on. Members of these boards should surely possess some acquaintance with the elementary principles of sanitation, and certainly their freedom of action should be secured to them on the basis of a special sanitary rate. When we find local boards, such as Port Pirie and Clare, disputing the authority of the Central Board on matters which were patent to any tyro in sanitary knowledge, the difficulties which bar the way to advancement are very evident. The difficulties to be overcome then in the case of these boards lie at the root. Their constitution must be changed. It is not an ungenerous criticism to say that when material or monetary interests conflict with even the crudest necessities of the public health, these boards invariably lend the weight of their influence to the material. They have yet to prove that they can act from motives which spring from an intelligent apprehension of those principles which lie at the foundation of a true providence over the people.

5.—THE HEALTH ACTS.

The health acts of the colony consist of the Drain Act of 1873, two minor amending acts, and the District Councils Act of 1887. Prior to the passing of the latter act, the Central Board had direct jurisdiction outside the limits of all corporations. This jurisdiction has been transferred by the act of 1887 almost entirely to the district councils.

The existence of the Central Board began with the act of 1873, and although it has been undoubtedly hampered in many important directions by insufficient legal powers, it has overcome numerous difficulties, and done a great deal of good work. It cannot be questioned that it has been the means of sweeping away the grosser and more palpable dangers to health, while it has educated the people to believe in some degree in the real necessity of public cleanliness.

The health acts are in several respects too tentative, notably the District Councils Act just referred to. It may fairly be doubted whether any colony, such as South Australia, should commit the administration of its health acts so unreservedly to a host of small and practically independent local bodies. Sanitary knowledge is special and always in advance of public opinion, and it would, therefore, seem to be more reasonable that a body of men, fitted for the duty and free from popular influences, should administer its laws.

This position leads to other prejudicial results, and among them we may refer to the delay in the removal of nuisances. Many of these boards meet only at intervals of a month, and as the inspector must first report to his board, and receive his instructions to serve an order for abatement, weeks must sometimes pass over before the removal takes place. Meanwhile, it can be honestly said that the law is at work for its abatement. This position of things can only be met by investing the inspector with power to proceed at once on his own judgment against certain infringements of the acts.

It may as well be noted here that the office of sanitary inspector to these local boards would be materially strengthened, and the work be more heartily and effectively done, if the appointment and removal of these officers were made subject to confirmation by the Central Board, as in the case of medical health officers.

The law is further in need of amendment in two other directions. First, with respect to the notification of infectious diseases, and in the second place with regard to the possession by the Central Board of the necessary legal power to deal with outbreaks of such diseases. The compulsory notification of infectious diseases formed part of an amending health act recently before the Legislature, but the clauses having this object were struck out. The purpose of all sanitary work is doubtless to bring about the extinction of preventible diseases, and if this point is ever to be reached, then immediate, correct, and systematic information as to the place where and when any outbreak has arisen must be forthcoming. It is self-evident that unless the information is speedily transmitted to the proper authority, the opportunity is lost for the limitation or suppression of the epidemic. This information cannot, however, be secured without legislation. The committee admit that they are aware of the difficulties that seem at present to surround the practical working of the principle, but they are none the less strongly impressed with the conviction that there exists a real necessity for compulsory notification being brought into operation.

Jointly with compulsory notification, the importance of legal power being vested in the Central Board to deal with any outbreak is likewise self-evident. The Central Board has power now to deal with smallpox, cholera, plague, yellow fever, and leprosy. Seeing, however, that but one of these diseases, viz., smallpox, and that in a single instance only, has appeared in the colony, while other preventible diseases are permitted to stalk abroad, it is not an unfair inference to say, that with the appearance of having some legislation, nothing is in reality laid down by the law having the object of preventing the extension of infectious diseases. It is to be feared that the indifference that prevails on this point is due to the misconception that heavy expenses would be entailed by carrying out stringent regulations of isolation and quarantine. The actual outlay could not be large, while the saving effected by the prevention of disease would be very great.

It is very desirable that the central authority should have a full opportunity of demonstrating to the public the advantages of checking outbreaks of infectious diseases in their initial stage. If this could be done, assuredly the public interest in sanitary work would be stimulated, and with every repetition of such evidence the public mind would come to appreciate more keenly the labours of sanitarians in seeking to secure to every member of the community health and longevity.

It now only remains for the committee to state that the following documents are on hand for reference should any future committee, following up the "Town Sanitation" of the other colonies, desire to do so on the lines suggested in the early part of this report :—Reports on the towns of Roma, Rockhampton, Queensland ; Kiama, Bathurst, Lithgow, New South Wales ; Warrnambool, Ballarat, Clunes, Victoria ; Masterton, Wellington, New Zealand ; Launceston, Tasmania. Also able reports from Messrs. W. A. Billing, Esq., F.V.I.A., and Lloyd Taylor, Esq., F.R.I.B.A., architects of Melbourne, and George McRue, Esq., City Building Surveyor of Sydney, on the Building Acts of Victoria and New South Wales respectively.

SECTION I.

LITERATURE AND FINE ARTS.

President of the Section: Hon. J. W. Agnew, M.D., M.E.C.

1.—ART IN DAILY LIFE.

By THOMAS A. SISLEY.

[*Abstract.*]

THE primary meaning of the word Art appears to be "trained skill guided by intelligence;" and it is also applied in a general sense to the various crafts which require trained skill, as well as to the results produced. Thus we speak of the art of the goldsmith or of the ironworker, of the art of painting, and of Japanese art. But the term has also acquired a special meaning, so that it is now commonly understood as referring to painting or sculpture, unless modifying words are used. Indeed, the notion is generally entertained in the present day that art has nothing to do with utility, being concerned only with embellishment. The phrase, "useful as well as ornamental," shows the prevalence of this mischievous and quite erroneous idea. We hear also a good deal about art-furniture and art-fabrics—terms which imply the assumption that art is a thing to be super-added, and that we ought not to expect it unless named in the specification.

Now, it is my purpose to show, in the first place, that art not only can, but should be associated with utility—nay, more, that useful things will be all the more useful in proportion as they are truly artistic. The principle may be formulated in three canons, as follows:—

1. The first artistic necessity is fitness. The beauty of an object will always depend on suitability to its right purpose or function.

2. All ornament that interferes with fitness, or is inconsistent with it, is relatively bad, however beautiful in itself.

3. Nothing, however beautiful, can be artistic unless when put to its right use amid its right surroundings.

To which may be added the corollary that shams must always be wrong.

It will, of course, be understood that I do not claim originality for the ideas involved in these three canons; they are familiar to all students of art. Nor do I pretend to lay down dogmatic rules; my object is merely to indicate the principles on which my remarks are based. "Beauty," says Lessing, "of which we derive our first notions from material objects, has universal laws, which apply to many things—to actions and thoughts, as well as to forms." And I venture to assert that by applying the rules here suggested we may all know whether our dwellings and furniture, our gardens, our costumes, and even our manners and speech, are in good taste, otherwise artistic, otherwise—for it is the same thing—rightly pleasing.

Let us first give some attention to architecture, for two reasons—because it is the oldest, the most important, and the most universal of the fine arts, and because all other arts of design are ancillary to it. In the introduction to his great work, Mr. Fergusson points out that "two wholly different systems of architecture have prevailed at different periods of the world's history. The first is that which prevailed everywhere down to the time of the Reformation in the 16th century, and still prevails in remote corners of the globe wherever European civilisation and its influences have not yet penetrated. The other is that which was introduced with the revival of classic literature, and still prevades all Europe, and wherever European influence has established itself. In the first period the art consisted in designing a building so as to be most suitable and convenient for the purpose it was wanted for, in arranging the parts so as to produce the most stately and ornamental effect consistent with its uses, and applying to it such ornament as should express and harmonise with the construction, and be appropriate to the purposes of the building. No race, however rude or remote, has failed, when working on this system, to produce buildings which are admired by all who behold them, and are well worthy of the most attentive consideration. The result of the other system is widely different. From St. Peter's at Rome to our own Parliament Houses, not one building has been produced that is admitted to have been entirely satisfactory, or which retains a hold on general admiration." And the reason of this, according to Mr. Fergusson, lies in the fact "that no sham was ever permanently successful, and that the attempt to reproduce any style which belongs to a state of society totally different from anything that now exists can never be a real or an earnest form of art."

The classic temple was built with one definite object, namely, to contain the image of a god. We know not precisely how these temples were lighted; but certainly they had no windows. In modern application, therefore, the whole thing is falsified and the design debased. Gothic architecture belongs properly to Catholicism; the high altar was the leading motive in the construction. Protestantism, which threw down the altar, abandoned the Gothic style, quite logically and consistently. We have returned to it, through the influence, I believe, of the High Church movement, which gave some cause for the revival by restoring the altar. But, whatever may be said of churches, nothing can be more incongruous than the false classical or pseudo-Gothic forms used for banks, law-courts, or town-halls, the internal arrangements of which have little or no relation to their external aspect. We see ringhieras from which no one ever addresses the populace, balconies on which no one can sit or walk, turrets from whose narrow loop-holes no watchman spies the approaching enemy.

Coming now to private houses, we shall very commonly find that the smaller are best in design, however infamous in construction. Here cost and convenience are prime considerations; hence their style is more consistent with common sense, and therefore with true art. But when something superior is contemplated people too often go astray. Half-imitations of an Italian villa, a French château, or an Elizabethan house, though possibly handsome enough in themselves, are sure to be uncomfortable or to look pretentious and out of place, being more or less unsuited to our climate and habits. And, since the style must be modified so as to make the house habitable by modern people, the result will be a mere counterfeit that cannot be pleasing to good taste. We shall see such bad solecisms as flights of stairs crossing casements, and, still worse, that shocking device of sham windows or blank window-spaces in the walls. Now, the weather-board cottage is good in so far as it is a naturally evolved style. And as the temple grew from the hollowed-out trunk of a tree through the intermediate stage of the wooden hut, so might a grand, appropriate, and harmonious order of colonial domestic architecture proceed from the germ of the weather-board shanty, by a series of simple, rational improvements and extensions. In forming such a style, the bath-room and the verandah, which are of especial importance in this climate, ought, perhaps, to be first considered.

Let us now look at the interior of the ordinary modern house. The diningroom, being constructed and furnished with one well-defined, easily comprehended object, will generally be the best apartment in the house. Men are in earnest about their meals; therefore we may expect to find a good solid table, chairs to correspond, a convenient sideboard—and not much else, because nothing else is wanted. Therein lies the secret why the dining-room is usually a pleasant room. It has one distinct function, and it is actually designed and furnished in strict accordance with that function, because it is too important to be slighted. But in the drawingroom we see what is achieved when something more ethereal is aimed at, when considerations of adornment prevail over considerations of utility. In a room the eye goes to the hearth as it goes to a dwelling in a landscape. And there, in the average house, we see scarce anything that is not false or absurd. First the grate, of which there are three degrees—blacked iron, bright steel, and iron framework with tiles inserted. The steel grate is rare enough now, which is a good thing; for it would be hard to imagine anything more unsuitable to the purpose than such a material, involving, as it does, constant care and labour, and presenting, at its best, a cold and most unpleasant appearance. The common iron grate, which has to be blacked and polished with infinite pains, is an abomination of lower degree. Then there is the superior fireplace, with tiles let in to an iron framework. This appears to me the worst of all, because it is the most pretentious and insincere. Like the others, it represents the art of the furnishing ironmonger. For when he saw that folk were disposed to revive the good old fashion of the tiled hearth with the grate standing in it, as properly distinct, he said, "Why go to so much trouble and expense? I can supply the whole article in one piece, with the tiles all stuck on; you have only to clap it in." And the public was delighted, because it always prefers elaborate combinations and curious devices to what is natural and simple.

The mantelpiece, in its present form, is a modern innovation, poorly imitated from the slab forming the top of the French stove. But that is a natural, inevitable thing, and therefore does not cry loudly for concealment or adornment, while our imperfect imitation is nothing if not a receptacle for ornaments. Drape and arrange it as we may, it will never look anything better than a quite unnecessary shelf for holding superfluous knick-knacks. The overmantel hardly helps us out of the difficulty. This pigeon-hole arrangement is at once thrown out of gear if a single article is wanting in its place; and it seems far too elaborate and formal for the trifles that are usually displayed upon it, each in its own compartment, as if they were of the highest value and importance. In any case, detached ornaments are far more effective if placed about with apparent carelessness; too great a regard for orderly arrangement suggests the museum or fine-art repository. Nevertheless, the overmantel is an improvement on the old chimney-glass.

The excessive desire for ornament causes many mistakes. Results would be far better if the principles of fitness, harmony, simplicity, and truthfulness were constantly borne in mind. But these are continually violated. For instance, few people with any pretension to taste will put a plant growing in an ordinary garden-pot in their rooms; the common, ugly garden-pot must be placed inside one of porcelain—something pretty, with flowers painted on it. Now, note the absurdity of this practice. The designs on the china vase, if good enough to be noticed, will confuse the eye or else attract it quite away from the natural flower, which is the real ornament; if inferior, as they usually are, they are worse than redundant. And is the plain garden-pot, simple in design, unobtrusive and certainly not unpleasing in colour, such a hideous object after all? In any case, we can substitute a somewhat similar article in terra-cotta more elegant in form. There cannot be harmony between the tints of the natural flowers, so pure, soft, and brilliant, and the comparatively harsh and impure colours of the porcelain-painter. Lastly, a pot for use inside a pot for show is an arrangement that cannot be justified.

Among other notable examples of the tawdry effect produced by undue striving after prettiness are the clocks which have for their dial a willow-pattern plate, or a sham palette stuck on a sham easel. Even if the form of the plate or the palette were convenient for the purpose, it ought to be made clear that adaptation was intended, not imitation. Jugs representing wicker-work are very bad; and china porcupines with crocuses growing out of them instead of quills are still worse. Everything must be made to resemble something else—a pepper-pot like an owl with perforated cranium, salt-cellars like toy coal-scuttles, with little shovels, and cruets like perambulators. All this is puerile, and utterly futile. Then there is the favourite device of a little picture on a little easel, with a coloured silk handkerchief thrown over the corner. Surely that is not the proper place for the handkerchief; and it would be removed at once if the picture were worth anything. But you may be quite sure it is not, for the whole arrangement is a piece of of ridiculous affectation, impossible for anyone having a right feeling for art.

The rage for drapery is not altogether surprising when we consider what beautiful designs and colours are now used in dyeing the most inexpensive textures; but it requires much moderation. A draped flower-pot, for example, giving the impression of a plant growing out of a silk bag, is the height of inartistic absurdity—fit only for a conjuror's table. As to window-hangings, it is not creditable to upholsterers that they should have returned of late years to those very artificial arrangements, cut in stiff and awkward imitation of natural folds. Here, again, we perceive the passion for concealment. What need for hiding the curtain-pole? It need not be unsightly; while the cumbrous apparatus used for concealing it accumulates dust and obstructs the light and air.

Ideas of comfort and convenience, when carried to excess, are inimical to good taste; and some hideous designs in furniture are attributable to this source. The very worst example, perhaps, is the *tête-à-tête* ottoman or arm-chair. The modern practice of nailing carpets all over the floor is probably due to the notion that a loose carpet not extending to the walls on each side was mean and incomplete. It is not immediately apparent how principles of good taste apply here. But, bearing in mind that the carpet is not a permanent feature, that it requires to be frequently taken up for the sake of cleanliness, and that the process of nailing and unnailing it is very laborious, we may recognise that it is more consistent with fitness and simplicity that the carpet should be merely laid down. And, that being so, it is neither necessary nor desirable to cover the floor-space with painful exactness.

Among other manifest faults in furnishing, I may mention the application of unsuitable materials and the excessive use of patterns. Brazen rods for supporting delicate sash-blinds, and chains of brass or steel for looping up curtains, are as appropriate as a two-inch cable for mooring a cock-boat. In ordinary rooms you will find that wall-paper, curtains, carpet, upholstery, mats, table-covers, drapery and other accessories, present, perhaps, a dozen different patterns, or more. It would be wonderful if half of them could be harmonious; and the effect would be far more pleasing and soothing to the eye if self-colours were used wherever possible—for table-covers and curtains, at all events.

This excessive use of patterns arises from the notion that plain things are not pleasing. The sense of form, which was paramount with the Greeks and other artistic peoples, is now well-nigh lost; and the eye must be tickled with ornament. Thus we see spindle-work applied at random to all articles of furniture, showing woeful poverty of constructive design. Patterns and other ornamental devices are also extensively used in order to conceal or disguise inferiority of material.

The number of false contrivances and elaborate combinations goes on increasing daily, in spite of pretended æsthetic feeling. It would almost appear that shams are loved for their own sweet sake, as well as because they are considered more elegant than plain reality. Many of them are mere survivals, portions of complex constructions retained long after they have lost their use or significance, like the heavy leather plastron, representing the reverse of the old coat, which the French grenadiers and voltigeurs used to button over their chests. Such things are continued in a falsified form because people cannot bear to give up anything in the nature of ornament; although, rightly regarded, whatever has become redundant is a disfigurement.

In our time the old national and local styles have almost all died out; so that we have to rely on thought and fancy instead of habit, on selection instead of sound and wholesome tradition. Therefore, we scour the earth and ransack antiquity to find what will serve the turn, perhaps with violent modification; and the inordinate love of novelty prompts the selection of what is new and striking, rather than of what is fit and harmonious. We shall never do any good in this way, nor, indeed, until we first consider our climate and other peculiar conditions, our social state and our daily needs. Domestic art will never flourish until it is founded on these and thoroughly in accordance with them, nor until it abandons ignoble shams and foolish imitations, keeping constantly in view simplicity, fitness, harmony, and truth.

2.—THE MIDDLE VERB IN LATIN.

By HENRY BELCHER, M.A., LL.D.

SECTION J.

ARCHITECTURE AND ENGINEERING.

President of the Section: Professor W. H. Warren, M.Inst.C.E., University of Sydney.

1.—GAS-LIGHTING AND ITS FITTINGS.

By A. U. LEWIS, B.A.

[*Abstract.*]

THE paper commenced by describing and explaining gas itself, and went on to show how the mysterious heavy gas bills are caused. The writer pointed out that, owing to the different altitudes to which the various gas companies have to supply gas, it is impossible for them to give consumers the pressure as it should be—namely, half-inch, and that it rests, consequently, with every individual consumer to regulate the supply for himself by means of an automatic governor attached to the meter. The author condemned the custom of employing plumbers for work in connection with gas, and said that gasfitters only should be entrusted with such work, as plumbers, taken as a whole, knew little or nothing about the scientific principles of gas. A suggestion was made that architects should specify in every case size of pipes and burners, etc., and that tenders be opened for gasfitting as distinct from plumbing. Another matter of interest broached was the vexed question of patent burners. Mr. Lewis explained several of the best, more especially "Stott's" governor, which he said met with most favour as being the cheapest and most economical. He illustrated his remarks by several interesting experiments with gas-lighting and trials of economical appliances.

2.—NOTES ON TESTS AND SPECIFICATIONS OF CAST AND WROUGHT IRON.

By Professor KERNOT, M.A., C.E.

THESE materials are in such general use for engineering purposes, and such great reliance is placed upon them in cases when failure would involve disastrous consequences to life and property, that a proper system of specifications and tests becomes a matter of the very highest practical moment. On the one hand, it is most important that bad material should be rigorously excluded, while on the other it is very desirable that the contractor or manufacturer should not be harassed by unreasonable and impracticable requirements.

Anyone unacquainted with the details of engineering practice might naturally suppose that this question had been threshed out and standard specifications universally adopted long since. Such, however, is not the case. The most inconsistent and various tests have been, and are still in not a few cases, employed—some, for example, so exacting that the very best and costliest qualities can hardly reach the standard; and others so lenient that none but the most outrageously bad will be rejected.

In the hope of arousing discussion on this very important question, and in some small measure helping to establish and promote the general adoption of tests that shall be at once consistent in themselves, reliable as securing the public safety, and not unduly oppressive in their effect on the manufacturer, I have in the present paper collected and commented upon such specifications as have come under my own notice, and shall conclude by proposing rules for general adoption.

First, as to cast-iron. This material is usually tested as a beam, the test-piece being made either 1 inch square, or 2 inches deep and 1 inch wide, and slightly over 3 feet long, supported on knife edges 3 feet apart, and loaded at the centre. Such a test-piece is easily made, and the load required for fracture is so moderate that, in the absence of a proper testing-machine, extemporised appliances of a simple and inexpensive nature will suffice —a practical convenience, as tests are often neglected which need elaborate apparatus.

Now let us enquire what would be a reasonable central load for a beam 1 inch square and 3 feet span to carry. Rankine, in his "Civil Engineering," gives data from which I compute it at from 470 to 1036 lbs. for different qualities, the former result being hot blast-iron that had been melted no less than eighteen times, while the latter was for the same at its twelfth melting. Good cold blast-iron gave 871 lbs.

Trautwine gives from 500 to 900 lbs. as the strength of a similar beam, 700 being a fair average.

Stoney, in his work on "Strains," gives 847 lbs.; and a standard specification adopted by thirteen of the leading bridge manufacturers of the United States takes 500 lbs. as the test load of a bar 4 feet 6 inches span, which is equivalent to 750 lbs. on 3 feet.

The South Australian Railway Department, in several specifications of comparatively recent date, makes 7 cwt., or 784 lbs., the standard; while the Victorian Water Supply Department, in their specification for the Loddon Weir, are satisfied with 6 cwt., or 672 lbs. Some years ago I had the opportunity of testing a large number of such bars of iron from four different Melbourne foundries, using different brands of pig, and in one case old American railway wheels. More than 60 bars were broken, half being sand-castings and half chilled, and the results were very uniform. In no case did a sound bar carry less than 700 lbs., while in only five cases did a sand-casting carry more than 900, and in only two more than 1000 lbs., and but one chilled bar reached 900 lbs. These experiments correspond well with the South Australian specification, only six bars out of thirty-one falling below it, and five of these being only a few pounds deficient. If the test had been reduced from 7 cwt. to 750 lbs., the American figure, only one bar that was not visibly defective would have failed to pass, and this test I would suggest as a reasonable one to adopt in practice.

Some engineers prefer a larger test bar, and specify one 2 inches deep by 1 inch wide. I am inclined, on the whole, to join in this preference, on the ground that such a bar approaches more nearly to the dimensions of the objects for which the iron is intended. The Victorian Railway Department for many years has employed this size, and fixes 30 cwt. as the load, and so does the Victorian Water Supply in their Goulburn Weir specification, while the New South Wales Railway Department in the case of Penrith Bridge asked for 27 cwt.. Now, all my experience leads me to regard a 30 cwt. test as impracticably high. Theory would lead us to conclude that bars of this latter size would be four times as strong as the inch bars previously referred to, in which case 28 cwt. or 3136 lbs. would be a fair test, corresponding to that used in South Australia. All my experience with colonial castings, however, leads me to the conclusion that a 2-inch by 1-inch bar is far from being four times as strong as one an inch square, a conclusion that is not very astonishing when one considers the nature of the material and the hardening effect of the rapid cooling of the external skin. The results I have so far obtained range for sound sand-castings from 2116 to 2850 lbs., and I do not think the standard should be fixed higher than 2450 lbs., or say 22 cwt., which is barely 3·3 times as much as the smaller bars endure. Our president, Professor Warren, informs me that he has never known such a bar to carry more than 28 cwt., or 3136 lbs., and that 25 cwt. is a good test. My own experience, as above stated, leads me to a still lower figure.

Some engineers specify not only a test load, but also a deflection that must be reached before fracture, arguing that a very hard iron might carry a large weight gradually applied, but at the same time be so deficient in resilience as to be very easily fractured by a blow. This view is, I think, reasonable, and from my own experience I would suggest a $\frac{5}{8}$-inch as the least allowable deflection, when on the point of fracture, for a bar 1-inch square and 3 feet span, and $\frac{5}{16}$ for a bar 2-inches deep and the same span. It is to be noted that the best results are obtained from a test-bar when so placed that the side in tension is that which was lowest in the mould during casting.

The test for wrought-iron is usually by direct tension, and, unless the test-piece be made most undesirably small, requires comparatively powerful appliances, such as are usually found only in a well-equipped engineering laboratory. Such a laboratory exists at the best engineering colleges, and also at important arsenals and the works of some of the leading manufacturers in Europe and America. The Universities of Sydney and Melbourne are provided with these appliances, and are frequently resorted to by the colonial Governments and private engineers.

What, then, should be the specified tenacity of iron for bridge and boiler work? The various authorities, English and American, give from 44,800lbs., or 20 tons, to 60,000, or nearly 27 tons, per square inch in various cases, the lower values being usual in plate and the higher in bar iron, as is to be expected when the mode of manufacture is considered. Further, with the same quality of iron the tenacity of large masses is always somewhat less than that of smaller or thinner portions, so that the same requirements cannot be fairly made in the case of large and thick as in that of smaller or thinner rods and plates. Again, mere tenacity, apart from other properties, is not a sufficient criterion of quality, for, as was pointed out by Kirkaldy about twenty years ago, a high tenacity may be exhibited by a hard, brittle iron, utterly untrustworthy for bridge or boiler work; consequently, the ductility must be carefully observed and numerically determined.

Let us now, therefore, consider and compare a number of actual specifications of iron. Those which merely state in vague terms that the material shall be of the best quality and subject to the approval of the engineer may be at once dismissed as belonging to a bygone chaotic era in engineering, and so may those others which simply name the material supplied by some particular manufacturer, followed by the words, "or of equal quality."

The specification under which the majority of the railway bridges in this country have been built reads as follows:—"The whole of the wrought iron used shall be of good quality, capable of bearing compression equal to 16 tons per square inch, or a tensile strain of 20 tons per square inch, without decreasing or increasing more than 1-625th part of the length of any bar or plate tested. Plates and bars will be selected by the superintending officer, which must be cut to the required form, and submitted to the above-mentioned tests. The contractor will have to find all labour, machines, and instruments required for these experiments, and every lot of iron will be rejected the specimen of which will not bear the prescribed compressive or tensile strain." Now, with reference to this specification, I have to say that I have never tested, seen, or even heard of any kind of iron that would comply with it, and I do not believe that such a material has any existence. An English engineer of the highest eminence, whose opinion upon it I sought, replied as follows:— "There is one comfort about the specification you refer to giving 1-625th extension for 20 tons, namely, that no such iron could have been manufactured, and therefore the bridges must have been built of something else; let us hope good Staffordshire iron." What the bridges are made of I have no means of knowing; but this I do know, that of all the iron I have tested, that which approached most nearly to this specification was hard, brittle, and utterly unsuited for the construction of works upon which the security of human life depends. All fairly good iron extends more than thirty times as much as this extraordinary specification permits.

About four years ago the construction branch of the Railway Department gave up the preceding specification, and in lieu thereof required the metal to endure a tension of 20 tons per square inch, and to elongate *at least* 7 per cent. Now, while the old specification excluded all iron known to me, this, by a strange contrast, includes almost all. I have never yet met with a specimen of bar-iron that would not carry 20 tons per square inch, and that did not elongate at least 7 per cent before fracturing, and only two of plate-iron, and one of these was cut from an exploded boiler of considerable age. The specification is, in fact, absurdly lenient, and consequently affords no real protection to the public.

The earlier specifications of the New South Wales Railway Department were on the same lines as the first-mentioned Victorian specification, requiring a hard, unyielding iron, and expressly forbidding that quality of ductility which is now recognised by all competent authorities as being so highly desirable. At the Penrith Bridge, which was one of the earliest, test-pieces, two inches wide and half an inch thick, were to be cut from the plates, and when tested were not to stretch more than one-eighth of an inch in seven inches with 18 tons, quarter of an inch with 21 tons, half an inch with 23 tons, and three-quarters of an inch with 24 tons, and were not to break with less than 25 tons. (See Maw and Dredge, Road and Railway Bridges, p. 9.) Now, whether this specification was enforced or not I cannot say, but I think probably not, as plate-iron of 25 tons, or 56,000 lbs. per square inch tenacity, is a thing I know of only by reading, and even that was accompanied by a ductility far above what this specification permits. Still, this test is not so utterly impracticable as the earlier Victorian one, as it permits at 20 tons per square inch about twenty times as much elongation.

A more recent New South Wales railway specification gives 50,000 lbs. as the required tenacity of tee and angle iron, and 45,000 lbs. as that of plates along the grain, the contraction of area at point of fracture being 15 per cent. in the first, and 10 per cent. in the second, and the elongation not less than nine or more than 12½ per cent. on a length of eight inches. It is also demanded that no permanent set shall take place with 24,000 lbs. per square inch. Now, this is a reasonable specification, showing some knowledge of the properties and behaviour under stress of the material. It also takes into account, as it should, the difference of tenacity of bars and plates owing to the different mode of manufacture. In these respects it contrasts most favourably with those preceding.

The South Australian Railway specifications for bridge iron also bear evidence of careful consideration, and of progressive modification with accumulating experience. That of the Terowie and Pichi-Richi Railway, dated 1880, requires a tenacity of 22 tons, or 49,280 lbs., for general purpose iron, 21 tons, or 47,040 lbs., for plates, and 22 tons, or 49,280 lbs. for angle irons for girder making, with 8·3 per cent. elongation, and 24 tons, or 53,760 lbs., for rivets and bolts, with 16·7 per cent. elongation; while that of the Palmerston and Pine Creek Railway, dated 1885, is still more precise, requiring 21 tons, or 47,040 lbs., with 10 per cent. contraction for plates along the grain; 18 tons, or 40,320 lbs., with 5 per cent. contraction for plates across the grain; 22 tons, or 49,280 lbs., with 15 per cent. contraction for angle, channel, tee and girder iron and flats over six inches wide; and 24 tons, or 53,760 lbs., with 20 per cent. contraction for round and square iron and flats under six inches wide; while for general purpose iron the requirement of the former specification is repeated. In both these specifications there is a list of names of recognised makers, from one or other of whom the material must be obtained.

The most complete and elaborate specifications I have so far met with are those agreed upon by thirteen of the leading American bridge-building firms or companies, and which represents the result of an experience of bridge-building infinitely beyond what any other body of men can claim. They read as follows :—

1. All wrought iron must be tough, ductile, fibrous, and of uniform quality for each class, free from cinder pockets or injurious flaws, buckles, blisters, or cracks. As the thickness of the bars approaches the maximum that the rolls will produce, the same perfection of finish will not be required as in the thinner ones.

2. No specific process or provision of manufacture will be demanded, provided the material fulfils the requirements of the specification.

3. The tensile strength, limit of elasticity, and ductility shall be determined from a standard test-piece, not less than one-quarter of an inch in thickness, cut from the full-size bar, and planed or turned parallel if the cross-section is reduced; the tangent between shoulders shall be at least twelve times its shortest dimension, and the area of minimum cross-section in either case shall not be less than one-quarter of a square inch, or more than one square inch. Whenever practicable, two opposite sides of the piece are to be left as they come from the rolls, but the finish of the opposite sides must be the same in this respect. A full-size bar, when not exceeding the above limitations, may be used as its own test-piece. In determining the ductility, the elongation shall be measured, after breaking, on an original length the nearest multiple of a quarter of an inch to ten times the shortest dimension of the test-piece (in which length must occur the curve of reduction from stretch on both sides of the point of fracture), but in no case on a shorter length than 5 inches.

4. All iron to be used in the tensile members of open trusses, laterals, pins and bolts, except plate-iron over 8 inches wide and shaped iron, must show by the standard test-pieces a tensile strength in pounds per square inch of

$$52{,}000 - \frac{7000 \times \text{area of original bar}}{\text{circumference of original bar}} \text{ (all in inches).}$$

with an elastic limit not less than one-half the strength given by this formula and an elongation of 20 per cent.

5. Plate-iron 24 inches wide and under, and more than 8 inches wide, must show by the standard test-pieces a tensile strength of 48,000 pounds per square inch, with an elastic limit of not less than 26,000 pounds per square inch, and an elongation of not less than 12 per cent. All plates over 24 inches in width must have a tensile strength not less than 46,000 pounds per square inch, with an elastic limit of not less than 26,000 pounds per square inch. Plates from 24 inches to 36 inches in width must have an elongation of not less than 10 per cent.; those from 36 inches to 48 inches in width, 8 per cent.; over 48 inches in width, 5 per cent.

6. All shaped iron, and other iron not hereinbefore specified, must show by the standard test-pieces a tensile strength in pounds per square inch of

$$50{,}000 - \frac{7000 \times \text{area of original bar}}{\text{circumference of original bar}}$$

with an elastic limit of not less than one-half the strength given by this formula, and an elongation of 15 per cent. for bars five-eighths of an inch and less in thickness, and of 12 per cent. for bars of greater thickness.

7. All plates, angles, &c., which are to be bent hot in the manufacture must, in addition to the above requirements, be

capable of bending sharply to a right angle at a working heat without sign of fracture.

8. All rivet-iron must be tough and soft, and pieces the full diameter of the rivet must be capable of bending cold until the sides are in close contact without sign of fracture on the convex side of the curve.

9. All iron specified in clause 4 must bend cold 180 degrees, without sign of fracture, to a curve, the inner radius of which equals the thickness of the piece tested.

10. Specimens of full thickness, cut from plate-iron, or from flanges or webs of shaped-iron, must stand bending cold through 90 degrees to a curve, the inner radius of which is one and a half times its thickness, without sign of fracture.

11. For each contract four standard test-pieces, and one additional for each 50,000 lbs. of wrought-iron, will, if required, be furnished and tested by the contractor without charge, and if any additional tests are required by the purchaser they will be made for him at the rate of five dollars each; or, if the contractor desires additional tests, they shall be made at his own expense, under the supervision of the purchaser, the quality of the material to be determined by the result of all the tests in the manner set forth in the following clause.

12. The respective requirements stated are for an average of the tests for each, and the lot of bars or plates from which samples were selected shall be accepted if the tests give such average results; but if any test-piece gives results more than 4 per cent. below the requirements, the particular bar from which it was taken may be rejected, but such test shall be included in making the average. If any test-piece has a manifest flaw its test shall not be considered. For each bar thus giving results more than 4 per cent. below the requirements, tests from two additional bars shall be furnished by the contractor without charge, and if in a total of not more than ten tests, two bars (or for a larger number of tests a proportionately greater number of bars) show results more than 4 per cent. below the requirements, it shall be cause for rejecting the lot from which the sample-bars were taken. Such lots shall not exceed 20 tons in weight, and bars of a single pattern, plates rolled in universal-mill or in grooves, and sheared-plates, shall each constitute a separate lot.

13. The inspection and tests of the material will be made promptly on its being rolled, and the quality determined before it leaves the rolling-mill. All necessary facilities for this purpose shall be afforded by the manufacturer; but if the inspector is not present to make the necessary tests, after due notice given him, then the contractor shall proceed to make such number of tests of the iron then being rolled as may have been agreed upon; or, in absence of any special agreement, the number provided for in clause 11, and the quality of such material shall be determined thereby.

14. A variation in cross-section or weight of rolled material of more than $2\frac{1}{2}$ % from that specified may be cause for rejection.

Agreed to by the Keystone Bridge Co., Phœnix Bridge Co., Union Bridge Co., Edge Moor Iron Co., New Jersey Steel and Iron Co., Passaic Rolling Mill Co., Detroit Bridge and Iron Works, Morse Bridge Co., Massilon Bridge Co., Cofrode and Saylor, John F. Alden, C. J. Schutz, and D. H. Andrews.*

This American specification is most admirable in its completeness, and deserving of the highest regard. Next in merit to it I place the South Australian and recent New South Wales specifications, and the rest, in racing parlance, nowhere. Could the American specification be generally introduced into Australian practice it would be a very great advantage. I fear, however, its elaboration and complication would be objected to by contractors. As a concession, therefore, I would suggest a specification more on the lines of the late South Australian ones, as follows :—

For Iron Bridges, Roofs and Similar Structures.

	Tenacity.	Least elongation on 8 in. test-piece.
Round, square and flat iron, of not more than 4 sq. in. section	50,000 lbs.	18 per cent.
Angle channel, tee and girder, also flats of more than 4 sq. in. tection	47,000 lbs.	12 per cent.
Plates under 24 in. wide along grain	45,000 lbs.	8 per cent.
Plates under 24 in. wide across grain	40,000 lbs.	4 per cent.
Plates above 24 in. wide along grain	45,000 lbs.	6 per cent.
Plates above 24 in. wide across grain	40,000 lbs.	3 per cent.

In compiling this proposed set of standards, I have followed particulars given by all good authorities accessible to me, checked by a number of original experiments of my own, made by means of the University testing machine. In adopting elongation rather than contraction of area as a measure of ductility, I have been guided by the American practice, and also by my own experience, which is that elongation can be measured with greater ease and

* Extracted from "General Specifications for Highway Bridges in Iron and Steel." By J. A. L. Waddell, Consulting Bridge Engineer, Kansas City, Mo., United States.

certainty than contraction of area. I have left out the requirement as to elastic limit which occurs in the American specifications, because I fear it would be perplexing to the majority of those that have to use the specifications, and further, because I have never yet found an iron good in respect to tenacity and elongation that was not also up to the American standard as to elastic limit.

In actually testing the material certain precautions are necessary. If possible, recourse should be had to a proper testing machine, such as exists at the Sydney or Melbourne University. Failing this, extemporised machines may be used, but in this case great care must be taken to ensure absence of friction, accuracy of leverage, and gradual application of load without shock or vibration. The preparation of the test-pieces also requires care, and my own experience of the difficulty of getting proper test-pieces made, especially in the case of flat bars or plate-iron, has induced me to have a special milling machine constructed, whereby the test-pieces can be properly prepared under my own supervision. Specimens of the work of this machine are upon the table.

Tabular Statement of Specified Tests of Cast and Wrought Iron.

1.—Cast Iron.

	Span.	Transverse dimensions.	Test Load.
Rankine	3 ft.	1 in. sq.	470 to 1036
Trautwine	3 ft.	1 in. sq.	500 to 900
Stoney	3 ft.	1 in. sq.	847
Victorian Water Supply ...	3 ft.	1 in. sq.	672
South Australian Railways	3 ft.	1 in. sq.	784
American Bridge Companies	4ft. 6in.	1 in. sq.	500
Author's own tests ...	3 ft.	1 in. sq.	700 to 1050
N.S.W. Railways—Penrith Bridge ...	3 ft.	2 in. x 1 in.	3024
Victorian Water Supply ...	3 ft.	2 in. x. 1 in.	3360
Prof. Warren's highest ...	3 ft.	2 in. x 1 in.	3136
Author's own tests	3 ft.	2 in. x 1 in.	2116 to 2850

2.—WROUGHT IRON.

	Tenacity.	Elongation.	Contraction of Area.
Victorian Railways—1st specification ...	44,800	·16 per cent.	—
Victorian Railways—2nd specification ...	44,800	7 ,,	—
N.S.W. Railways—Penrith Bridge ...	56,000	10 ,,	—
N.S.W. Railways—Recent specification, tee and angle ...	50,000	9 to 12½ ,,	15 per cent.
Plate	45,000	9 to 12½ ,,	10 ,,
South Australian Railways—Earlier specification, general purpose iron	49,280	—	—
Plates	47,040	8·3 ,,	—
Angle irons	49,280	8·3 ,,	—
Rivets and bolts ...	53,760	16·7 ,,	—
Recent specification, general purpose iron	49,280	—	—
Plates along grain ...	47,040	—	10 per cent.
Plates across grain ...	40,320	—	5 ,,
Angle channel, tee girder & flats over 6in.	49,280	—	15 ,,
Round, square & flats under 6 in.	53,760	—	20 ,,

For American tests, see body of paper.

3.—NOTES ON THE SUBJECT OF TOWN DRAINAGE.

By WILLIAM PARKER, Assoc. M.Inst.C.E.

[*Abstract.*]

THE author points out that, while in the near future a proper system for the conveyance and purification of sewage will be adopted by all towns of any size in the colony, yet a considerable time must elapse before this is done. In the meantime, a great deal of work will have to be carried out by the municipalities in the extension and improvement of their present arrangements. If this work is carried out piecemeal, as at present, it will be almost impossible to incorporate it afterwards in general schemes for applying the separate system. The author advocates an intelligent foresight being now exercised, and, where possible, complete schemes for sewerage being prepared, so that, as far as possible, all future work could be carried out on permanent lines. By this means it would be possible to avoid, in a great measure, the heavy loss experienced at home in carrying out new sewerage works, of having either to discard or radically alter existing sewers. As the methods of purification best suited to this colony are those of treatment upon land, preparations for the future should include the early acquisition of sites for sewage farms. In England enormous sums have had to be paid by some towns to landowners holding the monopoly of land on which the sewage of towns could be treated by gravitation, and in this colony sites for sewage farms might now be obtained at prices much short of those which will have to be paid in ten, or even five, years from the present time.

4.—GAUGING OF RIVERS.

By George Gordon, M.Inst.C.E.

[*Abstract.*]

The object of the paper was to draw the attention of engineers specially to some possible disturbing elements in the observations from which the volume of discharge of large rivers is reckoned. After describing the difficulty of obtaining accurate measurements of the velocity by means of floats, and the superiority in most cases of measurements made by current meters, notwithstanding some difficulties inseparable from use of the latter, the paper touched on the selection of such a site for the observations as would reduce the errors to a minimum, and then proceeded to treat of the disturbances in the gaugings caused by the curve of the flood-wave, as well as by freshes in the tributaries and by outflows from the main river into ana-branches and swamps, and of the means of applying the necessary corrections, as well as of some methods by which the observations are facilitated. The author pointed out the necessity of frequently repeated measurements of the sectional area and velocity owing to the frequent changes of the river-bed during floods, and expressed the opinion that bodies who had the control of rivers should be required to furnish reliable returns of the discharge of rivers at all times. A hope was also expressed that the Governments of the colonies would in time be induced to establish such recording stations on all the principal rivers as would furnish results of observations that would be of use not only for practical but also for scientific purposes.

5.—IRRIGATION WORKS IN AUSTRALIA: HOW THEY MAY BE MADE REMUNERATIVE.

By W. W. Culcheth, M.Inst.C.E.

[*Abstract.*]

1. The main deductions on the points dealt with in this paper may be briefly summarised as follows:—

(*a*) If irrigation is entirely optional, the landowners being quite free to take the water or not as they like, the revenue derived from water-rates is not likely to be sufficient to pay interest as well as working expenses for very many years to come.

(*b*) If irrigation be made in a measure compulsory, by the landowners having to pay a general rate to enable the Trusts to meet their engagements with the Government, a speedy extension of irrigation may be expected.

(*c*) The general rate for the payment of interest should be levied from the commencement of operations. It would usually be a low rate at first, owing to payment of part of the interest only being then required.

(*d*) The instalments of interest payable should increase yearly by equal increments, and should not depend in any way on the area irrigated.

(*e*) The landowners must agree to pay two charges—one, a general rate to meet interest on loan, to be paid by all; and the other to defray working expenses, to be paid by those only to whom water is supplied.

(*f*) Further concessions regarding payment of interest should be made only on condition that a general rate is levied to meet the charge.

(*g*) The appointment by the Government of experts, one to advise the Trusts which are in difficulties how to regulate their operations, and the other to advise the farmers how to use the water, would probably do much good.

2. An endeavour was made in the paper to show how the Trusts may carry out the task which they undertook to perform, and for which they have been constituted, in a manner that is likely to result satisfactorily to all concerned. The works should be managed on commercial principles, and not as ordinary municipal institutions. A competent manager should be appointed, and interfered with as little as possible. An Irrigation Trust, formed under the Act, is really a company, the liability of which is unlimited. All the landowners in the district are shareholders,

and a general rate is merely a call made by the directors (who are, in this case, termed commissioners) to meet certain liabilities. The profits are obtained in the increased value of all property in the district.

3. The points that the Trusts need to bear in mind to enable them to meet their liabilities, or, at least to put them in the best position to do so, are—

(*a*) All the landowners should be prepared either to take the water, or to dispose of their share to those who may wish to take it.

(*b*) Water should be taken by the landowners in turn as arranged by the Trust. All should take their chance of any deficiency occurring on the dates fixed for them.

(*c*) Payment should be made for the water for the season, whether used or not.

(*d*) In any case of special hardship, owing to a short supply, the Trust might remit the whole or part of the water-rates, but not the general rate to meet charges for interest.

4. For adoption by the Trusts, the following suggestions are made with a view of obtaining the best results :—

(*a*) All outlets to be designed to deliver, as nearly as possible, the same quantity of water in a given time.

(*b*) The whole district to be subdivided into areas of a convenient size, say for instance 80 acres, each to have its own outlet. The large selections would then have several outlets, while two or three of the small selections could have one outlet between them.

(*c*) Lists should be prepared at the commencement of a season showing the dates on which each outlet could be opened.

(*d*) Each outlet to be kept open (if required) for a certain time only, say 24 hours, on the dates mentioned in the list, and at all other times to remain closed.

5. The Victorian Irrigation Trusts were started on a system that was likely to lead to the best results. The Trusts seem, however, to have failed to realise the magnitude of the task that lay before them, and finding themselves in difficulties are now asking for concessions from the Government, which, if granted unconditionally, will not assist in improving matters. They are more likely to induce greater laxity, and render further concessions necessary at no distant period. Before concessions are thought of in the case of any Trust, a special enquiry might well be instituted with a view of ascertaining the causes of the Trust's inability to carry out its engagements.

6.—THE LAYING OUT OF TOWNS.

By John Sulman, F.R.I.B.A.

A typical Australian town is made up, like a chessboard, of a number of co-equal squares or rectangles. The chief merit of such a plan is its simplicity, and the ease with which the work of the surveyor can be performed. The defects are, however, many, and it is a thousand pities that a work of such great importance to the future millions of Australia should be performed with so little thought and care. Unfortunately, the plans of most of our existing towns are fixed beyond the possibility of radical alteration, but there are many more yet to be located where now the gum-tree grows, and suburbs to be formed on sites at present innocent of the surveyor's peg. In these, at least, we may avoid past errors, and make some attempt at a more rational system. How such a desirable end is to be attained I hope to point out very briefly under the five headings of "Location," "Utilisation," "Decoration," "Legislation," and "Realisation."

Location.

In the first place a town should only be laid out where the conditions for its growth are present, such as a considerable area of surrounding agricultural land, subterranean mineral wealth, or at points suitable for trade, like the convergence of highways, an important railway junction, or a point of shipment. Too often these conditions are wanting, and then (if of Government origin) it is a direct loss to the community; if privately promoted it is still a loss, but indirectly through individuals. A comparison of the country maps with the country itself will show many an apparently extensive town still covered with thick brush from which even the surveyor's pegs have totally disappeared. Granted, however, the necessary conditions for growth, the natural healthiness of the site is the next point to consider. Much may, no doubt, be done by the skill of engineers to improve an unhealthy site; but in a new country, where the land is practically unlimited, it is little short of a crime to permit any town to be formed which, from its location, will encourage disease. The most patent evils to guard against are swampy or flooded land and an impervious sub-soil. Of the former there are by far too many examples. I will describe one. In a rich, agricultural district of the parent colony a Government township was laid out many years ago on rising ground near the banks of a river. The upset price was low, but just on the other side of the stream a large area of land was possessed by a drunken old settler, which was, however, flooded in wet seasons. So far as position was concerned either bank would serve, as the river was bridged.

Cheapness, however, won the day, and the flooded land was purchased in blocks at the price of a bottle of rum, by ignorant new chums, and on it the town was built. Every few years the river comes down a banker, covers the town several feet deep in mud and water, and leaves behind a legacy of who can say how much suffering and death. Now the inhabitants are petitioning for extensive works of embankment, and in course of time will, no doubt, obtain a large grant of public money for the purpose. If surface unsuitability is thus ignored, what may we expect when the subsoil is in question? Its importance as bearing on the health of a town can scarcely be exaggerated, but it rarely receives a thought. As a flagrant example, I will describe a noted health resort. Picturesque hills surround a green valley on almost every side The surface soil is loamy and fairly pervious, but at eight to twelve feet in depth an impervious bed of clay underlies the whole of the valley. At any point water may be reached by digging to that depth, and above this clay bed the town is laid out. At present it is little more than a large village, but when its vacant lots are filled up, and the surface soil is choked by impurities, what will be the death-rate of that place? An expensive system of land drainage at the public cost will be an absolute necessity to palliate the evil of wrong selection, though it can never be a cure, and the worst of it is that a few miles away, on the most direct route, there is land possessing all the requisites of a healthy site, except that of railway communication, which was engineered on to the inferior land by political influence. Assuming, however, the natural healthiness of the site, its artificial preservation when occupied by a large population is the next point to consider. Three conditions are essential viz.:—An abundant supply of good water, at a sufficient elevation and within a reasonable distance, adequate surface drainage for storm waters, and levels that will permit of a system of underground sewers with a suitable outlet and area of land for the disposal of the effluents. How few of our towns possess all these, and how many lack them?

Utilisation.

The typical mode of sub-division I have already alluded to, and it is very useful from the "pay your money, take your choice," and "do as you like" point of view. Blind chance in such a case determines the future of each street or block, and the game of "beggar my neighbour" is too often played by adjoining owners with opposing views or interests in the buildings they erect. It is a case of individualism run mad. And with no better result than that in the course of years, and after many rebuildings, some kind of order and classification will have been evolved out of the chaos of the commencement. Whereas it should not be forgotten a modern town is an organism with distinct functions for its different members requiring separate treatment, and it is just as easy to allot these to suitable positions at first, as to allow them to be shaken with more or less difficulty into place, while the final result obtained under the latter system is not to be compared with that of the first—either on the score of convenience, utility, or beauty. It will be conceded without dispute that the centre round which town life revolves is the seat of its government, hence the town-hall should be allotted the best and most central position. Closely adjoining it sites should be reserved for other public buildings, such as the post-office, court-house, and district land office, and near by opportunities should be given for the erection of semi-public buildings, such as banks, offices of public companies, theatres, and places of amusement, hotels, clubs, and possibly one or two churches, though the latter are best located in the residential districts. The buildings most used by the population would thus be grouped together, and a great saving in traffic effected, as compared with the present plan of haphazard distribution. To prevent congestion, the absolute centre should form an open reserve, and from this broad and direct roads, or boulevards, should radiate to the surrounding country, the railway station, or navigable river. The exact lines these should take can only be determined after careful study of each specific case. Now fill in between these radiating boulevards with ordinary streets, and with the addition of a few diagonal lines we shall obtain a plan far more useful for inter-communication than any arranged on a rectangular basis. In fact, it will resemble that marvel of ingenuity, a spider's web, than which nothing could be better devised for rapid access to all parts of its surface. Immediately around the central nucleus the business quarters would be located, while retail trade would naturally extend for some distance along the main arteries of traffic; and farther out, as the spaces between the main lines became wider, the residental quarters would find their place. But these should not be extended too far without a break, and if the admirable example of Adelaide could be followed by introducing a belt of parklands, the gain to the health of the town or city would be great. Beyond this belt of open ground, as the town increased in size, suburbs would naturally spring up, and these, according to local conditions of soil, elevation and accessibility to rail or water communication, would naturally subdivide themselves into residential or manufacturing. One of the latter should, in all cases, be restricted to the use of noxious trades. The question how far the heart of the town should be placed from the railway or river is an open one, and it would probably result, in many cases, that rail or river would form a chord, cutting off a considerable part of the complete circle. The foregoing ideal sketch assumes a fairly level site, but where this condition is absent the gradients should be most carefully considered. And here, again, the cast-iron uniformity of the chess-board type shows its entire unsuitability to varying natural conditions. I have in my mind's eye ludicrous examples of this. For instance, there is a fairly level cathedral city in New South Wales, possessing towards one corner a steep hill from which there is a beautiful view. This would have formed a most admirable reserve, but it so happens that two streets intersect exactly at the top of the hill. They are too steep for traffic, and hence the town council is compelled to laboriously cut away the very boon which nature had provided the city with. Again, at a health resort on the Blue Mountains, most irregular and diversified in contour, the chess-board plan has produced streets up and down which it is difficult even to walk, and for horse traffic they are practically impassable, whereas by the use of curved roads following the natural configuration of the hills, easy gradients could have been obtained at a tithe of the cost for construction, and they would also have been immeasurably more useful to the inhabitants.

Decoration.

The beauty, or otherwise, of town or city must have an effect on its inhabitants. The long, unlovely street pictured by our poet laureate could not but depress even the least sensitive of its residents, and the evil is aggravated when, as in a chess-board city, the streets are all alike. Now, the "spider's web" plan possesses not only the advantage of convenience, but also of variety, and we all know that "variety is charming." Scarcely any two of the blocks would be exactly the same size, the angles made by the streets with each other would differ, and these together with the trapezoidal allotments, would call for special treatment. In the hands of an architect who knows how to use it, an irregular site is a godsend. Such a site enables him to get out of the beaten track, and design something fresh and original, while even the tyro cannot make his structure absolutely like everything else. Then as to the streets—their width should be ample, both on the score of health and beauty, but they should not be all the same. Taking one chain as a minimum for side streets, three chains are not too great for the main arteries or boulevards. This width would allow of their subdivision into three roads, with intervening footpaths and rows of trees, the central road being paved for heavy traffic and tram lines. There are some examples of this type in Melbourne, and their manifold advantages will be more and more appreciated as population increases. And, in passing, let me pay a tribute of praise to the vigorous way in which the municipal councils of Victoria have carried out tree-planting in the streets, and in that respect Ballarat may, I think, be awarded the place of honour. In comparison, the attempts made in the other colonies are but half hearted, though I hope the time will soon come when they will emulate the good example set by Victoria. Moreover, the introduction of trees in large numbers in the heart of cities is a wise sanitary precaution, for the carbonic acid gas human beings exhale is absorbed by vegetation, which in turn gives off the oxygen we need. Hitherto I have only referred to straight streets set at irregular angles, let me now put in a word as to the advantages of curved lines. It is said that "Nature abhors a straight line," and so does art unless relieved by curves. As a source of beauty the curved line is of inestimable value. Imagine what Collins Street would be without its undulation of surface! It is that which gives it the charm it possesses. On a level or nearly level site a curve in plan may often be introduced with the greatest advantage. It may be defined formally and regularly as in a quadrant or circus, or so gentle in its sweep as to be scarcely perceptible at the first glance. Of the former I may instance the quadrant in Regent Street, London, and the latter that exquisite example the High Street at Oxford. To carry the principle still farther, a sinuous line may occasionally be found serviceable where local conditions permit, and of this there is no finer specimen in the world than the Grand Canal at Venice, though to be sure it is a water-way, but for all that is the chief street of the city of the sea. The Strand in London is another example, and even in this southern hemisphere I may refer with satisfaction to the irregular lines of George and King Streets in Sydney. In all these the continual unfolding of fresh views is the great charm, and for my part I am devoutly thankful that one or two at least of the old Sydney streets were formed by bullock-waggons rather than by the surveyor's chain. Their narrowness I do not defend, but that is quite another matter. In planning a new town, however, it should never be forgotten that a curve ought only to be laid down when it serves a practical purpose, and in more cases than at first appear likely it will be found to serve the purposes of communication better than a straight line, especially in easing off the connections of one street with another. I have already alluded to reserves, and on this point there is usually little fault to be found with Australian towns, as far as the mere amount of them is concerned, but their shape is nearly always the prosaic square or rectangle, in which there is no beauty. Furthermore, the worst is made of them by running roads along the four sides, instead of leading up to them. Now, instead of this, in the spider's web plan there is the possibility of introducing reserves of all shapes and sizes, and so securing variety of form. Again, wherever a number of streets converge there should be an enlargement of the area, with a refuge in the centre. What this means in the future can only be realised by those who have seen and observed the planning of the new quarters in the continental cities of Europe. It is of the greatest value for traffic, and of inestimable worth for architectural effect. And of these enlargements the central square or reserve would of necessity be the finest. Such a grouping of public buildings around it as I have suggested would give importance to even a small town, and form another example of the value of combination as opposed to separation. Together, their effect would be doubled; separated, it would be halved.

Legislation.

Where a new town is laid out on Government land it would be easy to adopt a new system of planning, but I have little hope in this direction. The bonds of routine are too strong. In those laid out by private enterprise, the principal and, I may almost say, only aim is to produce the greatest cash return at the lowest outlay. At present it is believed this may be done by the rectangular system. On the ground of the public health and well-being, I think it is perfectly legitimate that the almost absolute freedom to lay out a town anywhere, and in any fashion, should be somewhat limited, and such limitation would prove in the end a gain to the promoters as well as to the public. I would therefore suggest the following regulations as reasonable:—1. That the erection of buildings for human occupation be absolutely prohibited on flooded land; 2. That no town be laid out on soil of unhealthy character, such as a morass or over an impervious subsoil; 3. That no title be registered for any allotment less than 1-20th of an acre in area, and that no lease containing a building covenant be valid for any site of less area (the object of this clause is to limit density of population and insanitary conditions); 4. That the area of streets and reserves be equal to one-third the area leased or sold for occupation; 5. That no town or suburb contain a greater area than one square mile, with a belt of reserved land at least $\frac{1}{8}$th of a mile in width between the same and the adjoining suburb; 6. That before any land is sold or leased in allotments, if less than one acre in area, official sanction to the plans be obtained, and that this sanction be withheld unless a satisfactory scheme of drainage and water supply be submitted at the same time, but for future realisation. At the present time, when it is beginning to be understood that the land is the heritage of the whole people, and its absolute ownership is permitted to individuals only as a matter of convenience, the right of the community to enforce provisions against misuse is, I think, undoubted; and when this misuse takes so glaring a form as originating conditions that must inevitably tend to produce diseases it is the absolute duty of the State to interfere. As in medicine, so in legislation, " Prevention is better than cure."

Realisation.

The scheme I have propounded is no ideal one; it is quite within the sphere of practical politics, and if anything is to be done a commencement should be made at once. It is a matter not only affecting one colony, but all, and the meeting of this Association affords the opportunity to take action. A recommendation to the Government of each colony from such a body as the General Council, backed up by the personal influence of its members, would at least secure attention. And if, at the same time, the general public could be instructed through the Press, a great advance would become possible, more especially as I believe the time is ripe for a change. The evils of the old "happy-go-lucky" system are beginning to be felt, and already, in at least two instances, private corporations are taking the initiative. I refer to the well-arranged suburb of Kensington, near Sydney, the plan of which I have carefully examined and can highly recommend; and to that of Hopetoun, near Melbourne, of which I know less. The plans of Kensington were designed by an architect, laid out by a surveyor, and checked by an engineer. This is as it should be. The architect is the one man who by training and experience combines in himself a knowledge of all the conditions of town-planning, and to him should be entrusted the task of initiation. He is, or should be, conversant with all kinds of buildings and their requirements, the general principles of form and beauty, the devising of good lines of access and communication, and the requirements of sanitary science. At the same time, the surveyor should be jointly associated with the architect, as he has a practical acquaintance with the details of laying-out, and would naturally carry forward the scheme to completion in the field; while the engineer comes in as a valued and necessary specialist on the questions of drainage and water supply, &c. I therefore claim, on behalf of my profession, the honoured position we once occupied, but from which we have been too long excluded, viz., that of chief designers of our towns and cities, and this claim is being recognised. Those shrewd business men, the auctioneers and land agents of Melbourne and Sydney, are beginning to appreciate the aid we can give, as they find that it *pays*. The field thus opening is one that will require the highest skill, and may well satisfy the ambition of the most talented among us; and if, at the same time, we can secure the aid of such legislation as I have indicated, we may indulge in the hope that the towns of the future will far surpass those of the present in convenience, healthfulness, and beauty.

7.—ILLUMINATING PUBLIC CLOCKS.

By Sydney Gibbons, F.C.S.

8.—SAFETY APPLIANCES ON STEAM BOILERS.

By A. O. Sachse, C.E., M.E., M.S.E., London, F.R.G.S.

[*Abstract.*]

The paper refers particularly to the perfunctory manner and "*penny-wise pound-foolish*" policy in which steam boilers are mounted with safety appliances. Mountings are sometimes used, sometimes not (just in accordance with specifications), irrespective, in most instances, of the exact capacity or requirements of the special pattern of the boiler, its method of setting, quality, or kind of fuel to be used, and other local peculiarities; and thus it is that the same sized mountings of orthodox patterns are placed on boilers of different sizes and peculiarities.

The writer refers at length to the many defects in the design and adjustment of such apparatus as are now in use, dilating particularly on the unreliability of low water metallic plugs and whistle alarms, and strongly deprecates the crass inattention to the safety valves, and the unsuitability of some of the materials of their construction. He, moreover, advocates a dual system of pressure gauge dials and water glasses; and expresses a high opinion of the value of a late invention of an automatic safety apparatus, which, by means of a float appliance, ingeniously connected with a battery, an alarm is given to the attendant when a "low" or "high" level of water or undue pressure of steam is attained, and if required registering in a manager's office, or other convenient position, an undeniable record of the height or pressure which the water or steam had attained; the probability of oxidation to contact points being obviated in this invention by the use of diminutive mercury baths.

Such a system as the latter, he predicts, will be found very valuable, as not only does its use call the immediate attention of the stoker to a sense of his duty, by the alarm (which is sounded at low water level, or undue pressure limit,) but, if this is disregarded, a second alarm commences, and at the same time records against him to his superior officer, thus bringing the culprit immediately under the notice of his employer. Finally, the author emphasises the importance of a strict care in specifying all steam boiler safety fittings, and a close periodical scrutiny of their adjustment and condition, and, in conclusion, advises all intending users of steam to erect boilers of *larger* capacity than is actually requisite at the time, so that easy stoking, a thorough combustion (and consequently an economy) of fuel will be obtained over those steam boilers which have to be driven to their utmost, and strained in being made to give forth their maximum power.

9.—COMPRESSED AIR AS A MECHANICAL MEDIUM IN THE EVAPORATION OF LIQUIDS.

By A. O. SACHSE, C.E., M.E., M.S.E. Lond., F.R.G.S., &c.

[*Abstract.*]

IN dealing with this subject, the author of the paper pointed out that there was no thoroughly satisfactory system of evaporating liquids at low temperatures yet engineered. In the present method of boiling by open heat at a minimum temperature of 212 deg. F., he explained that many liquids of commercial manufacture were seriously damaged, principally by caramelisation, such as in the manufacture of sugar, the concentration of milk, meat extracts, and similar substances requiring condensation. After giving a careful consideration to the vacuum-pan systems, the author referred to extensive experiments conducted by him during the past 12 years, in which he made use of compressed air, injected into the body of a liquid (which was kept at a temperature of 150 to 170 deg.), to produce a mechanical or artificial ebullition.

The paper dwelt upon the success of these trials over the vacuum process, and called attention to the advantage of this system in regard to the liquid under treatment, being at all times exposed to view, and skimming could be freely practised; whilst in existing vacuum "double" and "triple" effects the removal of impurities was a matter of impossibility, which was most injurious to the successful manufacture of many articles of food, and that in some districts large quantities of cold water for vacuum maintenance were unobtainable.

But whilst giving the compressed-air process much praise, he stated that the mechanisms now to be obtained for delivering dry air under pressure were unsatisfactory; and as air-pumps were inefficacious for supplying large quantities of air, resort had to be made to rotary blowers, which latter exhibited many disadvantages, principally on account of the great noise produced by them when working. Contrary to his expectations, he found that *hot* air when used produced less evaporative results than that taken in from the ordinary atmosphere. He advocated a careful research into the working of this peculiar system of evaporation, and demonstrated what a boon its successful application would prove to manufacturers dealing with liquid products requiring condensation, and especially so to proprietors of small installations, where the heavy cost of purchase and working rendered the adoption of the vacuum process prohibitive.

10.—CONSTRUCTION AND MAINTENANCE OF METALLED ROADS.

By William Bage, M.C.E.

[*Abstract.*]

In deciding what construction to adopt, one must consider the nature and extent of the traffic upon a road. What is required, in addition to a good route and easy gradients, is a smooth surface, sound enough to carry the traffic, and one that can be made and maintained at the least ultimate cost. Where traffic is light the natural surface may answer, or by small expense in drainage and formation may be made to answer; as the traffic increases, it may be necessary to use selected local materials to cover the formation; and, where this is not sufficient, to metal.

As traffic becomes heavier, repairs and renewals become more frequent, until the metalled surface no longer satisfies the requirement of a smooth surface, the traffic being frequently harassed during the progress of repairs, and the ultimate cost comes to exceed that of a more permanent road, such as stone, hardwood, or asphalt paving upon a concrete foundation.

In constructing a metalled road, the bed below the road should be sufficiently sound to bear the traffic without sinking, and can generally be made so by draining and consolidating with roller, or otherwise, before putting on the bed-metal. Where soft clay or sand is met with, a layer of loam or turf, or even cut scrub, is often sufficient to prevent it working up into the metal bed. It is not an uncommon practice to cover sand with clay, but it makes a very objectionable foundation. Sand itself is a good foundation. It should be prevented from working up into the metal from below, and the borders should be covered to prevent it drifting on to the surface of the metal. The same curvature should be given to the bed as you give to the finished surface of the roadway; a slope of about 1 in 30 from the edges is generally sufficient, and the same slope should be given to the border, if any, between the metal and the channel or water-table.

The bed-metal, when properly laid and consolidated, should be permanent and require no maintenance; its duty is to act as a foundation to bear and distribute the weight of the traffic. It need not be of so hard a stone as the surface-metal, and is usually broken to a larger gauge—3½-inch and 4-inch metal is very commonly used, but a smaller size is better. It should be well rolled when spread. The depth depends upon the nature of the traffic and the soundness of the bed, but 5 inches is deep enough in most cases. If schist or other soft stone be used it consolidates more rapidly. Good schist metal is being extensively used for bed-metal in many of our suburban streets, and gives very good results, being cheaper than bluestone, more elastic, and quite strong enough as a bearing surface. Occasionally pitching is necessary where, with heavy traffic, the bed is too soft to bear broken metal, but, if resorted to, should be proper Telford pitching, wedge-shaped stones on edge, with the narrow edge uppermost, laid in regular courses across the road, breaking bond, and carefully hammer-packed with spalls. Rough-pitching is a good deal used, but I cannot reconcile it with my notions of good road-making.

The surface-metal should be of a hard and durable material, and requires renewal from time to time as it is worn away by the traffic. How to reduce this wear to a minimum is one of the important problems of road-making, and can best be studied by observing the chief causes of wear, especially those due to faulty construction or insufficient care in maintenance. Until a road is consolidated, the metal below the surface, as it is disturbed by traffic, is being crushed and injured; after consolidation this wear ceases as long as the upper surface or skin of the road remains unbroken. Any loose stones, sand, mud, or water, lying on the surface increase wear, and should not be allowed to remain. Loose stones, projections and hollows also cause concussion from wheels passing over them, and tend to wear and break the surface.

The surface-metal should be broken to a small guage, 2-inch, or at the most, 2½-inch. Opinions differ as to the relative advantages of machine-broken and hand-broken metal; the advantage of the former is that it costs less and consolidates more rapidly; on the other hand, it is claimed that it is not so cubical or durable as the latter, being injured by crushing in being broken by machine. The hand-broken metal has to be crushed by traffic or roller before it consolidates, and I doubt if it is then any more durable.

The surface-metal should be spread and raked to its proper section, the same transverse slope being given as to the bed; large stones should be broken down with the hammer; the road should then be rolled until consolidated, all hollows must be filled up as they appear, and after partial consolidation, blinding added in sufficient quantity to fill all interstices in the surface; but care should be taken in the selection of blinding-material. Screenings from the stone crusher answer the purpose well, and so do some loams and marls; but one often sees most objectionable material used, such as sand, clay, or even the sweepings of gutters. During rolling in dry weather it is often necessary to water. Want of sufficient rolling is the cause of many of our bad roads; a steam-roller is much more rapid and effectual than a horse-roller, and is an economical investment for any municipality spending much money upon metalled roads, if the bridges and roads are good enough for it to travel upon.

Roads require constant care and attention to keep the surface smooth. Remove loose stones, mud and dust, attend to hollows, never allow water to stand on the surface, and by careful attention to drains and culverts, keep the subsoil well drained and the surface-water off the metal. Maintenance-metal should be of small gauge, certainly not more than 2-inch, and is added either by patching and darning, or by sheeting the whole surface; in either case the surface to be treated should be disturbed by picking, and the patches of new metal should be frequently attended to until they have consolidated. Autumn and winter are the seasons for systematic renewal and repair of road surface, spring and summer best for construction.

The borders between the metal track and the water-tables or channels should be kept in good order, to encourage light traffic upon them. On many roads they cannot be used, owing to the mitre drains not being covered.

In conclusion, I wish to draw special attention to the advantage of using metal of small gauge, and of consolidating rapidly by rolling and blinding, continuing the rolling until the road is thoroughly consolidated, and not attempting to roll too great a thickness of metal at once; and to the great economy of constant instead of periodic maintenance, and the employment of careful and well-trained maintenance men.

11.—THE UTILISATION OF TIDAL ENERGY AS A CONTINUOUS MOTIVE POWER.

By I. Diamant, C.E.

[*Abstract.*]

Various methods have been invented to utilise tidal energy as a motive power, but up to the present time no great practical utility has been obtained. There are two prominent difficulties in utilising the power of the tides. 1. The development of motive power out of tidal energy is only possible in certain localities. 2. We depend on the fluctuations as well as on the variable periodical returns of the tides. With regard to the first point, we know that the progress made in using electricity modifies these conditions gradually, because the comparatively costless water-power may be employed to generate electricity, which may be conveniently conveyed or stored for consumption.

With regard to the second point, we know that whatever means have been adopted, it was always necessary to allow a certain period of rest for the motors in order to obtain any effective head between the restrained and free waters. On the other

hand, the tides have their own variable times, which do not conform with the ordinary hours of everyday work. The object of this invention is to overcome the last difficulties, and its peculiar feature is that the motors do their work continuously without interruption, consequently we become independent of the daily variations of the tides. This method consists essentially in the employment of a pair of reservoirs formed by *tidal dams*, constructed of shutters for the principal tidal dam to open and close automatically at will, an arrangement proposed for the turbines (similar to that adopted for accumulators), in forcing water beneath their bearings so that they may be able to follow the changing level or the sea either gradually or at intervals. Each dam is connected with turbines or other water motors arranged to work; when the water is flowing into as well as flowing out of the said reservoirs.

Through gradual and alternate emptying and filling of these two reservoirs the motors are kept in motion in a continuous and uninterrupted manner. Both reservoirs are able to produce a certain number of horsepower during thirty-six working hours.

The general remarks made by Mr. Diamant concern the construction of the reservoirs, installation of motors, and the construction of a temporary bridge along the breech of the principal tidal dam in order to lower the caissons in an easy and convenient manner.

12.—DEVELOPMENT OF ARCHITECTURE AND ENGINEERING.

By F. C. Jarrett.

[*Abstract.*]

As science is simply knowledge, the more lucidly that knowledge is conveyed the more clearly does the writer evidence the mental process by which he has worked. The advance of science has been so rapid that we are apt to under-estimate the undiscovered field still before us. Thomas Carlyle says, "The eye sees what it brings the power to see." This must be applied not only to the work of the specialist who devotes a lifetime to the pursuit of one study, but to the simplest forms of education which we know. The power to see is, after all, the power which education gives us to see. There is no practical end to discovery or study. Nature is not exhausted. Discovery has recently given us gutta-percha, asphaltum, and natural gas. Study has made iron trebly valuable as steel in various forms. The whole history of the past, written in stone, repeats to us ever the one lesson. Art is greater than

science, for science discovers while art creates. What is man without his shoes, his house, his clothing? Nature enables him to adapt what she provides, and the development of this adaptation is higher and higher refinement, and refinement is the threshold of all discovery. The history of architecture and engineering, written in the records of stone, and brick, and cement, from whatever part of the world we select our study, tells us that the advance from barbarism to civilisation was recorded in the building and engineering work itself just as it progressed. Greece has handed us down the purest examples of her refinement, Rome of her grasp of sanitary science in the noble aqueducts, and of the energy and commercial progress of her people in the causeways to the city. The Hindoo, in his temples of massive and solemn design, speaks of his estimate of nature which surrounded him. The decadence and ruin of the Roman Empire is shown in the almost complete loss of her architectural and engineering greatness, and by the long period of semi-barbarous rule which followed, and of the generations which came and went before the skilled mason again left his almost indelible record upon stone. Though the present teems with importance, in the past we have cause and effect sketched out before us in undeniable portraiture; and while in the present we are creating further illustrations for the ages to come, we are all too slavishly following some of the lessons of the past, while we disregard the more important altogether. Almost every man is guided by the opinion of others. Opinion is generally a matter of education, and we are constantly experiencing the fact that we have to unlearn much, and that this is a harder process than to go from absolute ignorance to knowledge. There is much which we have to alter and adapt, and which on that account we neglect. We slavishly copy "styles;" we are not free to create. Education is at fault here. Progress in the past shows that excellent work was the outcome of the increasing intelligence or knowledge of the people. Art was generally understood, the youth of the times were educated carefully, and among those nations where the masses of the people remained in ignorance the class of work produced was inferior. We have, in some measure, recognised the principle thus taught us in the compulsory education of children for a certain number of years, and we can find a modern instance of a nation having proved a nation of soldiers, since every man is trained to service for a certain number of years. We do not properly apply the lessons which thus surround us; we copy "styles" slavishly, and disfigure our streets with inappropriate monuments of our wealth, and deaf to the history which those styles repeat to us, we do not avail ourselves of the methods by which those high states of architecture were reached. The people reared the temples and churches and cathedrals of the past because their religious teaching showed them that this was required of them. The work displayed the fervency of the workers—the fervency was the work of education. While the old world surpassed us in the beauty and magnificence of its temples and public buildings, its inhabitants knew nothing of the pleasures and comforts of homes such as we enjoy. Athens, with its Parthenon and its temples, had no house for prince or merchant which could compare in comfort and convenience with the cottage of the artisan, which lets to-day in and around this city for 10s. to 15s. per week. This is called the iron age, because we have adapted iron and steel to all forms of building construction in place of the more massive and enduring works of stone of the ages in which the very roofs were built of stone. Venice, with its splendid public and private buildings, speaks to us of the wealth of its inhabitants, and the foundations rising out of the water itself are a marvel of the skill of builders whose stone temples, resting upon them, are to-day almost untouched by time. We have scarcely anything that is new. We find records of a patent fire-proof wire lathing, dated 1797, and the page of history has yet to be written which shall tell of the absolutely successful application of fire-proof building materials. The worthy president of this section, in a recent speech in Sydney, referred to the registration of architects and engineers as a desirable thing, and I make that remark the basis of an application of some thoughts which this paper suggests. We require to make the knowledge of these sciences of architecture and engineering a greater power in our land. Can we do that by registration? I doubt it. Enactments which constrain men in their occupations, or which make it more difficult for them to develop such talents as they feel themselves to possess in practising any avocation, are so un-English that the public, whose will makes these enactments, are slow to consent to them, or, in consenting to them, run to another extreme, and create a greater evil. Registration may come by-and-bye, and I hope it will; but the true basis of such a development must be the education of the masses, the thorough training of the artisans, and the introduction of building acts which will compel the use, in the interests of health and happiness, of these discoveries which science has handed down to us, or is still opening to us day by day. Let it be made impossible for any man to construct a building, however insignificant or wherever situated, which shall be deficient in ample provision for lighting, drainage, heating, and ventilation, or which is constructively deficient in strength or in provisions in case of fire, and the owners who need the services of architects will speedily discover that their best interests lie in the employment of the highest skill which is available. The processes which will lead to amendment will be slow of achievement; our people must be educated. A great work was inaugurated in this city by the late Francis Ormond, but the proper education of the artisan is of itself insufficient; the men who direct the labours of these artisans will need to be educated to a higher standard. The work must commence at the bottom of the tree, and go steadily upward; there will always be plenty of room at the top. The chair of architecture at our universities, and the professorship of engineering, must denote the nationally recognised importance of the education of these professions. It must become imperative, from the irresistible force of custom, for the would-be architect or engineer to pass a course of study, and come forth to the world certificated as competent. This result cannot be achieved in a day or a year, or a decade, but a generation may see much accomplished. It must be achieved by the higher education of the masses. Our public State schools should be the mediums through which every boy and girl would be made acquainted with the laws which govern health, and those which provide sufficient ventilation, of others which guard against the dangers of inefficient drainage and general sanitary provisions. They should be made to understand that a non-observance of these laws which will be treated as a misdemeanour and offence against society, which cannot with impunity be disregarded. These are the only steps by which the people of this great nation, the future federated Australia, will be enabled to write a page in the world's history which will tell how science advanced, and how that advance improved the building and engineering work of the twentieth century. Much more may presently be done towards this in the establishment of national institutes, of which this Association is the type and, we hope, the parent of all. There should be one institute of architects, with its provincial chapters, numerous builders' exchanges, with one national association holding an annual convention; an engineering institute which should be Australasian, with vigorous offshoots in every city in the country —and for an example we need only look to Newcastle in New South Wales to-day—and a determined purpose in all these to make the national spirit of their work the predominant idea in their discussions, and their central and, perhaps, annual gatherings, the notches by which the next hundred years may record the fact in stone and iron that Australasia was abreast and even ahead of the rest of the world in its vigour, intelligence, and scientific knowledge.

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