REPORT

OF THE

NINTH MEETING

OF THE

AUSTRALASIAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE

HELD AT

HOBART, TASMANIA, 1902.

EDITED BY ALEX. MORTON.

Hobart:
PUBLISHED BY THE ASSOCIATION.

Please address all communications to—

THE PERMANENT HON. SECRETARY,
THE AUSTRALASIAN ASSOCIATION,
THE UNIVERSITY, GLEBE,
SYDNEY, NEW SOUTH WALES.

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Thursday, 9th January, 1902.

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OFFICERS FOR THE HOBART SESSION OF THE ASSOCIATION.

JANUARY, 1902.

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New Zealand : G. M. THOMSON, F.L.S., Dunedin.

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The Council consists of the following :—1. Present and former Presidents, Vice-Presidents, Treasurers, and Secretaries of the Association, and present and former Presidents, Vice-Presidents, and Secretaries of the Sections. 2. Authors of Reports or of papers published *in extenso* in the Annual Reports of the Association.

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H. C. RUSSELL, C.M.G. B.A., F.R.S., F.R.A.S., Sydney.

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Auditors:

R. TEECE, F.I.A. R. A. DALLEN.

Publication Committee:

The Hon. Local Treasurer, the Hon. Local Secretary, Secretaries of the Section, and Messrs. F. J. and F. M. YOUNG.

Recommendation Committee:

The past and present President, the General Treasurer, and the past and present General Secretaries.

Local Committee:

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Bennison, Thos.
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Clark, Hon. A. I.
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Hudspeth, F. W.
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Parker, A. C.
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Tenison, C. M.
Tabart, Thos.
Ward, W. F.
Woollnough, Rev. J. B. W.
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Wallace, W. H.
Watchorn, A. D.
Walch, C. E.
Young, Russell
Young, F. M
Young, F. J.

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Linnean Society of N.S.W.: Messrs. R. T. Baker, F.L.S., Chas. Hedley, F.L.S.

Royal Society, Queensland: J. Shirley, B.Sc., J. F. Bailey, F.L.S.

Royal Society, Victoria: Professor W. C. Kernot, M.A., M.C.E., Mr. Geo. Sweet, F.G.S.

Zoological Society of Victoria: Mr. J. R. Godfrey.

Aboriginal Board: Mr. J. R. Godfrey.

Field Naturalist Club, N.S.W.: W. A. H. Lucas, M.A.

Royal Society of South Australia: Messrs. S. Dixon and S. Smeaton.

OBJECTS AND RULES OF THE ASSOCIATION.

OBJECTS OF THE ASSOCIATION.

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

RULES OF THE ASSOCIATION.

Members.

1. Members shall be elected by the Council.

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

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

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

Sessions.

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

Council.

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

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

Local Committees.

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

Officers.

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

Reception Committee.

10. The Local Committee of the Colony in which the Session is to be held shall appoint a Reception Committee to assist in making arrangements for the reception and entertainment of the visitors. This Committee shall have power to add to its number.

Office.

11. The permanent Office of the Association will be held in Sydney.

Money Affairs of the Association.

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

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

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

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

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

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

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

Money Grants.

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

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

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

Sections of the Association.

22. The following Sections shall be constituted :—

A.—Astronomy, Mathematics, and Physics.
B.—Chemistry.
C.—Geology and Mineralogy.
D.—Biology.
E.—Geography.
F.—Ethnology and Anthropology.
G.—Economic Science and Agriculture.
H.—Engineering and Architecture.
I.—Sanitary Science and Hygiene.
J.—Mental Science and Education.

Sectional Committees.

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

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

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

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

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

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

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

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

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

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

33. In recommending the appointment of Research Committees, all members of such Committees shall be named, and

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

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

Official Journal.

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

Recommendation Committee.

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

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

Publication Committee.

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

Alteration of Rules.

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

40. Should an interim vacancy occur in any office appointed by the General Council, the vacancy shall be filled by a majority of votes recorded by correspondence by an Election Committee composed of the following officers :—The President, the President-Elect, the Vice-Presidents, the General Secretaries, the Treasurer, and the Local Secretaries.

INDEX TO RULES.

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

President.	Vice-Presidents.	Hon. Secretaries.	Hon. Treasurers.
Sydney, 1888.			
H. C. Russell, B.A., F.R.S., F.R.A.S. (Sydney).	The Hon. Dr. J. W. Agnew (Tasmania). The Hon. Sir Frederick Darley, Knt. (N.S.W.). C. W. De Vis, M.A. (Queensland). The Mayor of Sydney, Alderman John Harris. Sir James Hector, K.C.M.G., M.D., F.R.S. (New Zealand). The Hon. James Inglis, M.P. (N.S.W.). Professor W. C. Kernot, M.A., C.E. (Victoria). The Hon. Sir W. M. Manning, LL.D., M.L.C. (Sydney). The Hon. H. N. MacLaurin, M.A., M.D., LL.D. (Sydney). Professor E. H. Rennie, M.A., D.Sc. (South Australia). Sir Alfred Roberts, M.R.C.S. (N.S.W.).	Professor A. Liversidge, M.A., F.R.S., Permanent Hon. Sec. (N.S.W.). George Bennett, M.D., F.L.S., F.Z.S. (N.S.W.).	Sir Ed. Strickland, K.C.B., F.R.G.S. (New South Wales).

PRESIDENTS, VICE-PRESIDENTS, SECRETARIES, AND TREASURERS—*continued.*

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

PRESIDENTS, VICE-PRESIDENTS, SECRETARIES, AND TREASURERS—*continued.*

President.	Vice-Presidents.	Hon. Secretaries.	Hon. Treasurers.
Hobart, 1892.			
His Excellency Sir Robert G. C. Hamilton, K.C.B., LL.D. (Tasmania).	Professor W. C. Kernot (Victoria).	Professor A. Liversidge, M.A., F.R.S., Permanent Hon. Sec. (N.S.W.).	H. C. Russell, C.M.G., B.A., F.R.S., F.R.A.S. (N.S.W.).
	Hon. A. Norton, M.L.C. (Queensland). Rev. Thomas Blackburn (South Australia). H. C. Russell, C.M.G., F.R.S. (N.S.W.).	A. Morton (Tasmania).	J. B. Walker, F.R.G.S. (Tasmania).
Adelaide, 1893.			
Professor Ralph Tate, F.G.S., F.L.S. (South Australia).	H. C. Russell, C.M.G., B.A., F.R.S., F.R.A.S. (N.S.W.).	Professor A. Liversidge, M.A., F.R.S., Permanent Hon. Sec. (N.S.W.).	H. C. Russell, B.A., F.R.S. (N.S.W.).
	Baron F. Von Müller, K.C.M.G., Ph.D., F.R.S. (Victoria).	Professor Rennie, M.A., D.Sc. (South Australia).	Fredk. Wright (South Australia).
	Sir James Hector, K.C.M.G., M.D., F.R.S. (New Zealand). Sir Robert Hamilton, K.C.B. (Tasmania). The Right Hon. the Earl of Kintore, P.C., G.C.M.G. (South Australia).	Professor Bragg, M.A. (South Australia).	

PRESIDENTS, VICE-PRESIDENTS, SECRETARIES, AND TREASURERS—*continued.*

President.	Vice-Presidents.	Hon. Secretaries.	Hon. Treasurers.
Brisbane, 1895.			
The Hon. A. C. Gregory, C.M.G., M.L.C. (Queensland).	His Excellency Sir Henry Wylie Norman, G.C.B., G.C.M.G., C.B. (Queensland). H. C. Russell, C.M.G., B.A., F.R.S. (N.S.W.). Baron F. Von Müller, K.C.M.G., Ph.D., F.R.S. (Victoria). Sir James Hector, K.C.M.G., M.D., F.R.S. (New Zealand). Professor Ralph Tate, F.G.S., F.L.S. (South Australia).	Professor A. Liversidge, M.A., LL.D., F.R.S., Permanent Hon. Sec. (N.S.W.). John Shirley, B.Sc. (Queensland).	H. C. Russell, C.M.G., F.R.S., F.R.A.S., B.A. (N.S.W.). Hon. A. Norton, M.L.C. (Queensland).
Sydney, 1898.			
Professor A. Liversidge, M.A., LL.D., F.R.S., &c. (N.S.W.).	H. C. Russell, C.M.G., B.A., F.R.S., F.R.A.S. (N.S.W.). Sir James Hector, K.C.M.G., M.D., F.R.S. (New Zealand). Professor Ralph Tate, F.G.S., F.L.S. (South Australia). The Hon. A. C. Gregory, C.M.G., M.L.C. (Queensland).	Professor A. Liversdige, M.A., LL.D., F.R.S., Permanent Hon. Sec. (N.S.W.).	H. C. Russell, C.M.G., F.R.S., F.R.A.S. (New South Wales).

PRESIDENTS, VICE-PRESIDENTS, SECRETARIES, AND TREASURERS—*continued.*

President.	Vice-Presidents.	Hon. Secretaries.	Hon. Treasurers.
	Melbourne, 1900.		
R. L. J. Ellery.	H. C. Russell, C.M.G., B.A., F.R.S., F.R.A.S. (N.S.W.). Sir James Hector, K.C.M.G., M.D., F.R.S. (New Zealand). Professor Ralph Tate, F.G.S., F.L.S. The Hon. A. C. Gregory, C.M.G., M.L.C. Professor A. Liversidge, M.A., LL.D., F.R.S.	Professor A. Liversidge, M.A., LL.D., F.R.S., Permanent Hon. Sec. (N.S.W.). Professor W. Baldwin Spencer, M.A. (Victoria). F. F. J. Love, M.A., F.R.A.S. (Melbourne).	H. C. Russell, C.M.G., F.R.S., F.R.A.S. (New South Wales). C. R. Blackell, F.C.S. (Melbourne).
	Hobart, 1902.		
Captain F. W. Hutton, F.R.S., F.G.S.		Professor A. Liversidge, M.A., LL.D., F.R.S. (N.S.W.). Alex. Morton.	H. C. Russell, C.M.G., B.A. F.R.S., F.R.A.S. R. M. Johnston, F.S.S.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION.

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
Section A.—Astronomy, Mathematics, and Physics			
1888—Sydney, N.S.W. ...	R. L. J. Ellery, F.R.S., Melbourne.	—	Professor R. Threlfall, M.A.
1890—Melbourne, Vic. ...	Professor R. Threlfall, M.A., Sydney.	Professor T. R. Lyle, M.A.	E. F. J. Love, M.A. W. Sutherland, M.A.
1891—Christchurch, N.Z. ..	Professor T. R. Lyle, M.A., Melbourne.	C. H. H. Cook, M.A.	A. C. Grifford, M.A.
1892—Hobart, Tasmania ...	Professor W. H. Bragg, M.A., Adelaide.	The Archbishop of Hobart. A. B. Briggs.	Captain Shortt, R.N. W. E. Shoobridge.
1893—Adelaide, S.A.	H. C. Russell, B.A., F.R.S., C.M.G., Sydney.	Sir Charles Todd, K.C.M.G., M.A., F.R.S., F.R.A.S. J. J. Stuckey, M.A.	R. W. Chapman, M.A.
1895—Brisbane, Q'nsland	Alexander McAulay, M.A., Tasmania.	Clement Wragge, F.R.M.S. C. H. Hodges, M.A. J. E. Davidson.	J. P. Thomson, F.R.S.G.S.
1898—Sydney, N.S.W. ..	P. Baracchi, F.R.A.S., Melbourne.	R. L. J. Ellery, C.M.G., F.R.S. Professor Alex. McAulay, M.A. Professor T. R. Lyle, M.A.	Professor R. Threlfall, M.A. J. Arthur Pollock, B.Sc. G. H. Knibbs, F.R.A.S., F.L.S.
1900—Melbourne, Vic. ..	G. H. Nibbs, F.R.A.S.	P. Baracchi, F.R.A.S.	R. J. A. Barnard, M.A. E. G. Hogg, M.A.
1902—Hobart, Tasmania ..	R. W. Chapman, M.A., B.C.E., Adelaide.	H. C. Kingsmill, M.A. F. M. Young, B.A. W. Aikenhead, M.H.A.	Professor A. Macaulay, M.A. W. F. D. Butler, B.Sc.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
		Section B.—Chemistry.	
1888—Sydney, N.S.W. ...	Professor J. G. Black, D.Sc., M.A., Dunedin.	A. Leibius, Ph.D., M.A., &c. Prof. A. Liversidge, M.A., F.R.S. Professor E. H. Rennie, M.A.	W. M. Hamlet, F.I.C., F.C.S.
1890—Melbourne, Vic. ...	Professor E. H. Rennie, M.A., D.Sc., Adelaide.	C. R. Blackett, F.C.S.	Professor Orme Masson, M.A., D.Sc.
1891—Christchurch, N.Z. ..	Professor Orme Masson, M.A., D.Sc., Melbourne.	Professor A. W. Bickerton, F.C.S. W. S. Key, F.C.S.	George Gray, F.C.S.
1892—Hobart, Tasmania ...	W. M. Hamlet, F.I.C., F.C.S., Sydney.	W. F. Ward, A.R.S.M. Samuel Clemes.	A. J. Taylor, F.L.S. H. T. Gould.
1893—Adelaide, S.A.	C. N. Hake, F.C.S., F.I.C., Melbourne.	T. C. Cloud, F.C.S. G. Goyder, Jun., F.C.S. A. Sutherland, M.A.	T. J. Greenway, F.C.S., F.I.C.
1895—Brisbane, Q'nsland ..	J. H. Maiden, F.L.S., Sydney.	J. B. Henderson. George Henry Irvine. A. S. Denham.	George Watkins.
1898—Sydney, N.S.W. ...	....	Professor E. H. Rennie, M.A., D.Sc. Richard T. Bellemey, M.P.S.	W. M. Hamlet, F.I.C., F.C.S.
1900—Melbourne, Vic. ...	F. B. Guthrie, F.C.S.	Prof. Mica Smith, B.Sc. W. M. Hamlet, F.I.C., F.C.S.	A. W. Craig, M.A., F.C.S. W. P. Wilkinson.
1902—Hobart, Tasmania ...	Professor Mica Smith, B.Sc., Ballarat.	W. F. Ward, A.R.S.M. S. Clemes.	Professor Neil Smith, M.A. G. C. Smith.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Section C.—Geology and Mineralogy.

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
1888—Sydney, N.S.W. ...	Robert L. Jack, F.R.G.S., F.G.S., Brisbane.	T. W. Edgemouth David, B.A., F.G.S.	Robert Etheridge, Jun.
1890—Melbourne, Vic. ...	Professor F. W. Hutton, M.A., F.G.S., C.M.Z.S., Christchurch.	Professor McCoy, C.M.G., M.A., D.Sc.	James Stirling.
1891—Christchurch, N.Z. ..	R. A. Murray, F.G.S., Melbourne.	Professor A. P. Thomas, M.A., F.L.S., F.G.S. H. Hill, B.A., F.G.S.	J. D. Enys, F.G.S.
1892—Hobart, Tasmania ...	Professor T. W. E. David, B.A., F.G.S., Sydney.	T. Stephens, M.A., F.G.S. A. Montgomery, M.A.	F. Belstead. B. Shaw.
1893—Adelaide, S.A.	Sir Jas. Hector, K.C.M.G., M.D., F.R.S., Wellington.	Sir Henry Ayres, K.C.M.G., F.G.S. H. Y. L. Burnne, F.G.S. J. V. Parkes.	W. Howchin, F.G.S.
1895—Brisbane, Q'nsland ..	Professor T. W. E. David, B.A., F.G.S., Sydney.	W. H. Rands. William Fryar Ernest.	W. A. Hargreaves, M.A., B.C.E.
1898—Sydney, N.S.W. ...	Professor F. W. Hutton, F.R.S., F.G.S., New Zealand.	W. Howchin, F.G.S. R. L. Keach, F.G.S.	T. W. E. David, B.A., F.G.S. E. F. Pittman, A.R.S.M.
1900—Melbourne, Vic. ...	Professor Ralph Tate, F.G.S., F.L.S., Adelaide.	A. G. Maitland, F.G.S. A. Montgomery, M.A.	F. S. Hall, M.A. G. B. Pritchard.
1902—Hobart, Tasmania ...	T. S. Hall, M.A., Melbourne.	Thomas Stephens, M.A., F.G.S. R. M. Johnston, F.S.S. W. H. Twelvetrees, F.G.S. G. A. Waller. W. F. Petterd, C.M.Z.S.	

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
	Section D.—Biology.		
1888—Sydney, N.S.W. ...	Professor Ralph Tate, F.L.S., F.G.S., Adelaide.	—	Professor W. A. Haswell, M.A., D.Sc.
1890—Melbourne, Vic. ...	Professor A. P. Thomas, M.A., F.L.S., Auckland.	P. H. MacGillivray, M.A., M.R.C.S.	A. Dendy, M.S.C., F.L.S.
1891—Christchurch, N.Z. ..	Professor W. A. Haswell, M.A., D.Sc., Sydney.	Professor T. J. Parker, B.Sc., F.R.S. Sir W. Buller, K.C.M.G., F.R.S. Thomas Kirk, F.L.S. T. F. Cheeseman, F.L.S.	C. Chilton, M.A., B.Sc. C. M. Thomson, F.L.S.
1892—Hobart, Tasmania ...	Professor W. Baldwin Spencer, M.A., Melbourne.	Colonel Legge, R.A. W. F. Petterd, C.M.I.S. Augustus Simpson.	P. S. Seager. L. Rodway, L.D.S.
1893—Adelaide, S.A.	C. W. De Vis, M.A., Brisbane.	Rev. T. Blackburn, M.A. M. Holtze, F.L.S. E. C. Stirling, C.M.G., M.D., F.R.S.	W. L. Cleland, M.B.
1895—Brisbane, Q'nsland ..	Professor Arthur Dendy, D.Sc., F.L.S., Christchurch.	F. Manson Bailey, F.L.S. W. MacIlwraith.	J. F. Bailey. J. H. Simmons.
1898—Sydney, N.S.W. ...	Professor C. J. Martin, M.B., D.Sc., Melbourne.	Professor J. T. Wilson, M.B., Ch.M. J. J. Fletcher, M.A., B.Sc.	Professor W. A. Haswell, M.A., D.Sc., F.R.S. J. J. Maiden, F.L.S. J. J. Fletcher, M.A., B.Sc.
1900—Melbourne, Vic. ...	J. J. Fletcher, M.A., B.Sc.	Professor W. B. Benham, D.Sc. A. H. S. Lucas, M.A., B.Sc. C. J. Martin, M.B., D.Sc.	W. Fielder, F.R.M.S. J. G. Luckman, F.L.S.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
	Section D.—Biology—*continued.*		
1902—Hobart, Tasmania ...	Professor W. B. Benham, D.Sc., Dunedin, N.Z.	Colonel W. V. Legge, R.A. A. M. Lea. W. F. Petterd, C.M.Z.S. Augustus Simson. W. L. May. Malcolm Harrison. Dr. L. Holden.	L. Rodway, L.D.S. P. S. Seager. W. A. Weymouth.
	Section E.—Geography.		
1888—Sydney, N.S.W. ...	Hon. John Forrest, C.M.G., F.R.G.S., Perth, W.A.	G. F. Griffiths, F.R.G.S., F.G.S.	J. H. Maiden, F.R.G.S., F.L.S., F.C.S.
1890—Melbourne, Vic. ...	W. H. Miskin, F.E.S., Sydney.	Commander Crawford Pasco, R.N. A. C. Macdonald, F.R.G.S.	G. S. Griffiths, F.R.G.S., F.G.S.
1891—Christchurch, N.Z. ...	G. S. Griffiths, F.R.G.S., F.G.S., Melbourne.	S. Percy Smith, F.R.G.S. F. R. Chapman.	R. M. Laing, M.A., B.Sc.
1892—Hobart, Tasmania ...	Commander Crawford Pasco, R.N., Melbourne.	E. A. Counsel, F.R.G.S. J. R. McClymont, M.A. Rev. J. B. Woollnough, M.A.	F. M. Young, B.A.
1893—Adelaide, S.A.	A. C. Macdonald, F.R.G.S., Melbourne.	Sir S. Davenport, K.C.M.G. Sir J. Elder, G.C.M.G. David Murray. A. W. Goyder, C.M.G.	J. W. Jones.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
	Section E.—Geography *continued.*		
1895—Brisbane, Q'nsland .	Baron F. Von Müller, K.C.M.G., Ph.D., F.R.S., Melbourne.	J. N. Waugh, M.D. D. S. Thistlewaite, C.E. Ernest Favenc.	Major A. J. Boyd.
1898—Sydney, N.S.W. ...	Sir James Hector, K.C.M.G., F.R.S., M.D., New Zealand.	Hon. P. G. King, M.L.C., F.R.G.S. A. C. Macdonald, F.R.G.S.	H. S. W. Crummer. John Mann.
1900—Melbourne, Vic. ...	W. H. Tietkens, F.R.G.S.	C. Winnecke, F.R.G.S. A. C. Macdonald, F.R.G.S. A. W. Howitt, F.R.S.	T. W. Fowler, M.C.E., F.R.G.S. A. J. Wright, F.R.G.S., F. R. Col. Inst.
1902—Hobart, Tasmania ..	Rev. Geo. Brown, D.D., Sydney.	F. J. Young, B.A. E. A. Counsel, F.R.G.S. J. R. McClymont, M.A. Rev. J. B. Woollnough, M.A. A. B. Watchorn. C. M. Tenison.	J. W. Beattie.
	Section F.—Ethnology and Anthropology.		
1888—Sydney, N.S.W. ...	A. Carroll, Sydney.	—	John Fraser, B.A., LL.D.
1890—Melbourne, Vic. ...	Hon. J. Forrest, C.M.G., M.L.C., Perth, W.A.	A. W. Howitt, F.G.S.	Rev. Lorimer Fison, M.A.
1891—Christchurch, N.Z. ..	A. W. Howitt, F.G.S., Melbourne.	Hon. W. B. D. Mantell, M.L.C., F.G.S. T. M. Hocker, M.R.C.S. Edward Tregear, F.R.G.S.	A. Hamilton.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Section F.—Ethnology and Anthropology—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
1892—Hobart, Tasmania ...	Rev. Lorimer Fison, M.A., Melbourne.	Rev. Geo. Clarke. James Barnard.	J. B. Walker, F.R.G.S.
1893—Adelaide, S.A.	Rev. Samuel Ella, Sydney.	Rev. W. R. Fletcher, M.A. A. T. Margarey. T. A. Parkhouse. T. Worsnop.	T. Gill.
1895—Brisbane, Q'nsland ..	Thomas Worsnop, Adelaide.	Thomas Petrie. Joseph Lauterer, M.D.	Archibald Meston.
1898—Sydney, N.S.W. ...	A. W. Howitt, F.G.S., Melbourne.	Professor W. Baldwin Spencer, M.A. Rev. L. Tison, M.A., LL.D.	John Fraser, B.A., LL.D.
1900—Melbourne, Vic. ...	F. J. Gillen, S.M.	Rev. Geo. Brown, D.D. W. E. Roth, B.A., M.R.C.S.	Rev. L. Fison.
1902—Hobart, Tasmania ...	Dr. W. E. Roth, B.A., M.R.C.S., Cooktown, Queensland.	Rev. Geo. Clarke. F. J. Young, B.A. Dr. Arthur Clarke.	W. H. Hudspeth, LL.D.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
Section G.—Social Science and Agriculture.			
1882—Sydney, N.S.W. ...	H. H. Hayter, C.M.G., Melbourne.	—	A. C. Wylie.
1890—Melbourne, Vic. ..	R. M. Johnston, F.L.S., Hobart.	Professor J. S. Elkington, M.A., LL.B.	H. K. Rusden, F.R.G.S. A. Sutherland, M.A.
1891—Christchurch, N.Z. .	Hon. G. W. Cotton, M.L.C., Adelaide.	W. T. L. Travers, F.L.S. W. R. E. Brown.	A. de Bath Brandon, B.A. A. T. Bothamley.
1892—Hobart, Tasmania ...	R. Teece, F.I.A., Sydney.	Hon. A. J. Clarke, M.C.C. Hon. N. J. Brown, M.H.A. A. J. Ogilvy.	R. M. Johnston, F.L.S.,
1893—Adelaide, S.A.	H. C. L. Anderson, M.A., Sydney.	Josiah Boothby, C.M.G. Professor Lounie, B.Sc. L. H. Shott. J. H. Symon, Q.C.	E. Pariss Nesbit.
1895—Brisbane, Q'nsland .	Professor Walter Scott, M.A., Sydney.	Sir John Madden, Knt., C.J., Victoria. Hon. A. J. Thynne, M.L.C. J. H. McConnell. Peter McLean. Alex. Paterson. John Cran.	Littleton E. Groom, M.A., LL.M. (Social Science). William Soutter (Agriculture).

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
Section G.—Social Science and Agriculture—*continued.*			
1898—Sydney, N.S.W. ...	R. M. Johnston, F.L.S. F.S.S., Hobart.	Hon. H. N. MacLaurin, M.D., M.L.C., LL.D. R. Teece, F.I.A., F.F.A. W. McMillan, M.L.A. E. M. Shelton, M.Sc. W. Farrer, M.A.	R. R. Garran, B.A. F. B. Guthrie, F.C.S.
1900—Melbourne, Vic. ..	Professor W. Lowrie, M.A., B.Sc. Prof. W. Jethro Brown, M.A., LL.D. (Chairman of Sub-Section of Economics).	R. M. Johnston, F.S.S. J. H. Maiden, F.L.S. D. Martin.	D. M'Alpine. J. J. Fenton.
1902—Hobart, Tasmania ...	T. A. Coghlan, F.S.S., Sydney, Sub-Sec. Agriculture. J. H. Maiden, F.L.S., Sydney.	Mr. Justice A. J. Clarke. Hon. G. T. Collins, M.E.C. Hon. J. N. Brown, M.E.C. Hon. G. R. Fitzgerald, M.E.C. Hon. John Henry, M.E.C. R. M. Johnston, F.S.S. A. J. Ogilvy. Thos. Tabart. H. J. Colbourn. A. Conlon.	F. W. Hudspeth. A. L. Evans.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
Section H.—Engineering and Architecture.			
1888—Sydney, N.S.W. ...	Professor W. C. Kernot, M.A., C.E., Melbourne.	—	John Sulman, F.R.I.B.A. H. Deane, M.A., M.I.C.E.
1890—Melbourne, Vic. ...	Professor W. H. Warren, M.Inst., C.E., Sydney.	H. C. Mais, M.Inst., C.E. A. Purchas, C.E.	A. C. Sachse, C.E.
1891—Christchurch, N.Z. ..	John Sulman, F.R.I.B.A., Sydney.	R. Wilson, F.R.S.E., M.I.C.E. E. Dobson, M.I.C.E. C. Napier Bell, M.I.C.E. W. N. Blair, M.I.C.E.	R. J. Scott, A.M.I.C.E.
1892—Hobart, Tasmania ...	C. Napier Bell, M.I.C.E., C.E., New Zealand.	C. H. Grant, C.E. James Fincham, C.E. F. Kayser. C. W. James, C.E., A.M.I.C.E.	W. W. Eldridge. A. North.
1893—Adelaide, S.A.	R. J. Scott, A.M.I.C.E., New Zealand.	Hon. J. Martin, M.L.C. A. B. Moncrieff, M.Inst. C.E. J. H. Reed.	J. T. Arrow, A.M.I.C.E.
1895—Brisbane, Q'nsland ..	James Fincham, M.Inst. C.E., Tasmania.	H. C. Stanley, M.Inst. C.E. A. B. Bradley, A.M.Inst. C.E. Richard Gailey. G. Phillips, C.E., M.L.A.	

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
Section H.—Engineering and Architecture—*continued.*			
1898—Sydney, N.S.W. ...	A. B. Moncrieff, M.Inst. C.E., M. Am. Soc. C.E., Adelaide.	H. Deane, M.A., M.Inst. C.E. G. A. Mansfield. Professor W. H. Warren, M.Inst. C.E., Wh. Sc.	J. W. Grimshaw, M.Inst. C.E., M.I. Mech. E. H. C. Kent, M.A.
1900—Melbourne, Vic. ...	H. Deane, M.A., M.Inst. C.E.	Lloyd Taylor, F.R.I.B.A., F.R.V.I.A. H. C. Mais, M.Inst. C.E., M.I. Mech. E.	A. W. Arnott, C.E. A. M. Henderson, M.C.E., F.R.V.I.A. W. H. Nimmo, C.E.
1902—Hobart, Tasmania ...	Percy Oakden, A.R.I.B.A., Melbourne.	J. J. McCormick, M.Inst. C.E. R. C. Patterson, M.H.A. C. Hudson. G. B. Edwards. R. F. Richards. G. Dudley Salier. Orlando Baker. C. C. Nairn. A. C. Parker. C. B. Target. P. E. Green F. Kayser. W. W. Eldridge.	James Fincham, C.E. Alan Walker, A.R.I.B.A.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
	Section I.—Sanitary Science and Hygiene.		
1888—Sydney, N.S.W. ...	J. Bancroft, M.D., Brisbane.	—	J. T. Wilson, M.B., C.M. F. B. Kyngdon.
1890—Melbourne, Vic. ...	J. Ashburton Thompson, M.D., D.P.H., Sydney.	A. P. Akehurst. G. Gordon, C.E.	G. A. Syme, M.B., F.R.C.S.
1891—Christchurch, N.Z. ..	Hon. Allan Campbell, M.D., M.L.C., Adelaide.	Professor J. A. Scott, M.D. I. de Zouche. C. Nedwill, M.D.	F. Ogston, M.D.
1892—Hobart, Tasmania ...	Professor W. H. Warren, M.Inst. C.E., Sydney.	Hon. P. O. Fysh, M.L.C. C. E. Barnard, M.D. E. O. Giblin, M.D.	A. Mault.
1893—Adelaide, S.A.	A. Mault, Hobart.	Hon. Allan Campbell, M.L.C. H. C. Whittell, M.D.	T. Borthwick, M.D.
1895—Brisbane, Q'nsland ..	J. W. Springthorpe, M.A., M.D., M.R.C.S., Melbourne.	F. H. Vivian Voss, F.R.C.S. A. E. Salter, M.B. J. H. Little, M.B.	David Hardie, M.D.
1888—Sydney, N.S.W. ...	Hon. Allan Campbell, M.L.C., L.R.C.P., L.F., P.S., Adelaide.	D. Hardie, M.B. J. W. Springthorpe, M.A., M.D. J. Ashburton Thompson, M.D.	Frank Tidswell, M.B., Ch.M., D.P.H.
1900—Melbourne, Vic. ...	J. Jamieson, M.D.	D. Astley Greswell, M.D.	B. A. Smith, M.C.E. J. W. Springthorpe, M.A., M.D.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
Section I.—Sanitary Science and Hygiene—*continued.*			
1902—Hobart, Tasmania ...	Sir Thomas Fitzgerald, K.C.M.G., M.R.C.S.E., Melbourne.	Hon. P. O. Fysh, M.E.C. Hon. G. Butler, M.D. Gregory Sprott, M.D. C. E. Barnard, M.D. Hon. W. W. Perkins. Thos. Bennison. E. J. Crouch, M.R.C.S. E. L. Crowther, M.D.	A. Mault.
Section J.—Mental Science and Education.			
1888—Sydney, N.S.W. ...	Professor E. V. Boulger, M.A., D.Lit., Adelaide.	—	E. L. Montefiore.
1890—Melbourne, Vic. ...	Hon. J. W. Agnew, M.D., M.L.C., Hobart.	Professor Tucker, M.A. J. Hamilton Clarke, Mus. Bac.	Louis Henry, M.D. Tennyson Smith.
1891—Christchurch, N.Z. ...	R. H. Roe, M.A., Brisbane.	Professor F. W. Haslam, M.A. G. F. Tendall, Mus.Bac., Oxon.	A. Wilson, M.A. A. J. Merton.
1892—Hobart, Tasmania ...	Professor E. E. Morris, M.A., Melbourne.	Hon. J. W. Agnew, M.D. Rev. Thomas Kelsh. Russell Young.	F. J. Young, B.A.
1893—Adelaide, S.A.	Professor Henry Laurie, LL.D., Melbourne.	His Honour Chief Justice Way, D.C.L. Professor E. V. Boulger, M.A., D.Lit. H. P. Gill. J. A. Hartley, B.A., B.Sc.	J. A. Sunter, B.A.

PRESIDENTS, VICE-PRESIDENTS, AND SECRETARIES OF THE SECTIONS OF THE ASSOCIATION—*continued.*

Date and Place.	Presidents.	Vice-Presidents.	Secretaries.
Section J.—Mental Science and Education—*continued.*			
1895—Brisbane, Q'nsland ...	Professor Francis Anderson, M.A., Sydney.	Hon. T. J. Byrnes, B.A., LL.D., M.L.A. Reginald H. Roe, M.A. J. Brunton Stephens. Thomas Bradbury.	J. L. Woolcock, B.A. (Mental Science). J. J. Dempsey (Education).
1898—Sydney, N.S.W. ...	John Shirley, B.Sc., Brisbane.	Hon. A. Garran, LL.D., M.A. R. H. Roe, M.A.	Professor Francis Anderson, M.A. J. B. Peden, B.A. J. R. Bavin, B.A., LL.B.
1900—Melbourne, Vic. ...	W. L. Cleland, M.D.	Rev. A. Gosman, D.D. F. C. Eddy, M.A. H. Jackson, M.A.	Rev. E. H. Sugden, M.A., B.Sc. J. T. Collins, M.A., LL.M.
1902—Hobart, Tasmania ...	Professor Arnold-Wall, M.A., Christchurch.	Rev. Geo. Clarke. Right Rev. Dr. Delany. C. M. Tenison. Rev. Thomas Kelsh. Geo. Masters, M.A. Russell Young. Thos. Stephens, M.A. Rev. Dr. Scott. Professor McDougall, M.A. Professor W. H. Williams, M.A. W. H. Dawson. C. J. Barclay. F. J. Young, B.A.	C. B. Petersen. M. M. Ansell, LL.B.

LIST OF EVENING LECTURES.

Date and Place.	Lecturer.	Subject of discourse.
Sydney ... ... (1888)	Sir James Hector, K.C.M.G., M.D., F.R.S.	The Volcanic Eruptions of the Hot Lake District of New Zealand.
	Professor Baldwin Spencer, M.A.	On his Recent Discoveries on the Pineal Eye.
Christchurch, N.Z. (1891)	G. E. Mannering	The Glaciers of the Tasman Valley.
	W. Saville Kent, F.L.S., F.Z.S.	Oysters and Oyster Culture in Australia.
	G. F. Tendall, Mus. Bac. (Oxon.).	The History of Vocal Music.
Hobart ... ... (1892)	C. W. Adams	The Great Sutherland Water Falls.
	J. B. Walker	Early Hobart.
Adelaide... ... 1893)	C. W. De Vis, M.A. ...	The Diprotodon and its Times.
	E. C. Stirling, C.M.G., M.D., F.R.S.	Prehistoric Man.
Brisbane... ... (1895)	H. C. Russell, C.M.G., F.R.S., F.R.A.S.	Star Depths.
	N. Cobb, Ph. D.	Looking Forward.
Sydney ... ... (1898)	Professor Baldwin Spencer, M.A.	The Centre of Australia.
	Sir James Hector, K.C.M.G., M.D., F.R.S.	Antarctica and the Island of the Far South.
	J. A. Pollock, B.Sc. ...	Electric Signalling without Wires.

List of Evening Lectures—*continued.*

Date and Place.	Lecturer.	Subject of discourse.
Melbourne ... (1900)	E. E. Morris, M.A., Litt.D.	The Early Men of Science in Australia.
	Rev. G. Brown, D.D....	An Anthropologist in the Bismarck Archipelago.
Hobart ... ... (1902)	Dr. W. E. Roth	On the Games, Sports, and Amusements of the North Queensland Aboriginals.
	Rev. G. Brown, D.D....	The Pacific, East and West.
	Professor T. W. E. David, M.A.	The Island of Funafuti.
	Professor Pollock	Flight of the Boomerang : An account of the Construction and Method of Throwing a Boomerang, with an Explanation of the Returning Flight.
	Mr. J. W. Beattie ...	A Trip through Tasmania.

BALANCE-SHEETS, HOBART SESSION, 30th September, 1900, to 31st December, 1902.

VICTORIA.

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				,, Cash in hand	0	19	7
				,, Balance in Bank of Victoria	1	12	6
£	121	3	0	£	121	3	0

Audited and found correct.

(Signed) E. H. SUGDEN.

SOUTH AUSTRALIA.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance in hand from Melbourne Meeting	0	4	10	By Advertising	3	14	2
,, Subscriptions—				,, Postage and Telegrams	0	14	9
47 Members	47	0	0	,, Exchange on Draft	0	5	3
21 Ladies' Tickets	10	10	0	,, Draft to Sydney	52	10	8
				,, Balance in Savings Bank	0	10	0
	£57	14	10		£57	14	10

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

New Zealand.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Balance	5	13	5	By Stationery	1	14	6
,, Subscriptions	22	1	0	,, Postages	0	19	5
				,, Exchanges	0	2	7
				,, Draft to Sydney	20	5	0
				,, Balance in Savings Bank	4	10	0
				,, Cash in hand	0	2	11
	£27	14	5		£27	14	5

(Signed) W. B. BENHAM.

Queensland.

	£	s.	d.		£	s.	d.
To Subscriptions—				Forwarded—			
18 Members	18	0	0	To Hobart	1	0	0
4 Ladies' Tickets	2	0	0	,, Sydney	18	18	0
				Exchanges	0	2	0
	£20	0	0		£20	0	0

(Signed) JOHN SHIRLEY, Local Secretary.

Dr. BALANCE SHEET FOR VICTORIA—MELBOURNE SESSION, 1900. Cr.

Dr.

1899.		£ s. d.	£ s. d.
30 Jan.	To Balance in E.S. and A. Bank...	...	14 9 1
	Local Subscriptions—		
	(*a*) To 31st March, 1900......	300 14 6	
	(*b*) Paid since 31st Mar., 1900	4 8 0	
			305 2 6
	Cheques from Adelaide (less exchange)......	...	52 8 10
	Cheques from Hobart (less exchange)	...	11 19 0
	Cheques from Sydney (less exchange)......	...	177 12 2
	Donations to Publication Fund—		
	(*a*) Paid during 1900	37 1 6	
	(*b*) " " 1901	8 3 0	
	(*c*) " " 1902	20 0 0	
			65 4 6
			626 16 1
	Debit Balance	...	41 15 6
			£668 11 7

Cr.

1899.		£ s. d.
30 Jan	By Printing (general) and Stationery	8 11 2
	Printing, Ford and Son	139 3 4
	" of Report, McCarron, Bird, and Co.	229 15 7
	Advertising	29 14 0
	Clerical Assistance	76 0 0
	Expenses of Meeting	67 10 9
	Caterer	66 2 0
	Paterson, Shugg, and Co.	13 16 4
	Tate and Co.	0 10 0
	Bank Charges	0 15 0
	Postage, Exchanges, and Petty Cash	36 13 5
		£668 11 7

20th Jan., 1903.

E. F. LOVE, Local Secretary,
pro C. R. BLACKETT, Local Treasurer (deceased).

Audited and found correct—E. H. SUGDEN.
21st Jan., 1903.

GENERAL BALANCE SHEET (SYDNEY OFFICE).

The Hon. Treasurer in account with the Australasian Association.—Hobart Session.

DR. *Cash Statement, 30th September*, 1900, *to 31st December*, 1902. CR.

Dr.	£ s. d.	£ s. d.	Cr.	£ s. d.	£ s. d.
To Subscriptions received N.S. Wales	168 3 0		By Clerical Assistance, 30th Sep., 1901–31st Dec., 1902	...	79 0 0
" " Life Member (N.Z.)	10 0 0		Printing and Stationery	6 13 6	
" " Victoria	69 16 3		Advertising	3 12 0	
" " South Australia	52 10 8		Petty Expenses	7 12 0	
" " New Zealand	20 5 0		Exchanges	1 11 0	
" " Queensland	19 18 0		Office Furniture, &c.	4 10 0	
		340 12 11			23 18 6
Sale of Volumes of Reports	...	0 12 6	Transferred to Perpetual Fund (see below)	...	225 1 7
			Balance in Bank, 31st Dec., 1902	...	13 5 4
	£	341 5 5			£341 5 5

Research Fund.

Dr.	£ s. d.	£ s. d.	Cr.	£ s. d.	£ s. d.
To Amount of Research Fund, 29th Sep., 1900	1566 14 10		By Investments, Bank Deposits, with Interest added		374 8 7
Less invested at that date	1524 7 1		Balance in Bank, 31st Dec., 1902		45 9 1
Balance in Bank 29th Sep., 1900	...	42 7 9			
Interest on Mortgage	140 0 0		[Total Investments—31st Dec., 1902.		
" Bank Deposit	12 8 4			£ s. d.	
		152 8 4	Mortgage	1400 0 0	
Transferred from General Account	214 9 1		Bank Deposits	498 15 8	
Life Subscription	10 0 0			£1898 15 8]	
Sale of Volumes of Reports	0 12 6				
		225 1 7			
	£	419 17 8			£419 17 8

Audited and found correct. { RICHARD TEECE.
ROBERT A. DALLEN.

TABLE SHOWING ATTENDANCES AND RECEIPTS, AND SUMS PAID OR VOTED FOR SCIENTIFIC PURPOSES.

Date of Meeting.	Place of Meeting.	President.	Secretary.	Attended by: Members.	Attended by: Ladies.	Total.	Amount received up to and during the Meeting. £ s. d.	Sums granted for Scientific purposes. £ s. d.
1888 { Aug. Sept. }	Sydney, New South Wales	H. C. Russell, C.M.G., B.A., F.R.S.	A. Liversidge, M.A., LL.D., F.R.S.	805	45[a]	850	858 8 0	...
1890—Jan. ...	Melbourne, Victoria	Baron von Mueller, K.C.M.G., Ph D., F.R.S.	W. Baldwin Spencer, M.A.	1081	81[a]	1162	2081 0 0	...
1891—Jan. ...	Christchurch, New Zealand	Sir James Hector, K.C.M.G., M.D., F.R.S.	Captain F. W. Hutton, F.R.S., F.G.S. C.M.Z.S.	...	...	550	785 13 7	25 0 0
1892—Jan. ...	Hobart, Tasmania	His Excellency Sir Robert G. C. Hamilton, K.C.B., LL.D.	A. Morton, F.L.S.	...	...	600	933 16 3	...
1893—Sept ...	Adelaide, South Australia	Ralph Tate, F.G.S., F.L.S.	E. H. Rennie, D.Sc. W. H. Bragg, M.A.	367	121[b]	488	*426 2 0	30 0 0
1895—Jan. ...	Brisbane, Queensland	Hon. A. C. Gregory, C.M.G., F.R.G.S., M.L.C.	John Shirley, B.Sc. C. W. de Vis, M.A.	{ 392 †10[b]	122[b]	524	‡858 7 2	10 0 0
1898—Jan. ...	Sydney, New South Wales	A. Liversidge LL.D., F.R.S.	A. Liversidge, LL.D., F.R.S.	{ 573 †8[c]	104[a]	685‖	815 12 6	25 0 0
1900—Jan. ...	Melbourne, Victoria	R. L. J. Ellery, C.M.G., F.R.S., F.R.A.S.	W. Baldwin Spencer, M.A., F.R.S.	571	122[c]	693‖	635 15 6	10 0 0
1902—Jan. ...	Hobart, Tasmania	Captain F. W. Hutton, F.R.S., F.G.S., C.M.Z.S.	E. T. J. Love, M.A. Alex. Morton	300	250	550	[d]1160 0 0	50 0 0

* From South Australian sources only. ‖ Including Life Members. † Students, youths under 21. ‡ From all sources in Queensland only.
a Paid 20s. subscription. b Paid 5s. subscription. c Paid 10s. subscription. d Including £350 for printing volume.

	N. S. Wales.	Victoria.	South Australia.	New Zealand.	Queensland.	Tasmania.
Full members £1	184	93	47	—	18	225
Ladies......... 10*s*.	31	54	21	—	14	170
Total	215	147	68	22	32	395

BALANCE SHEET FOR TASMANIA—HOBART SESSION, 1902.

Receipts.	£	*s.*	*d.*	£	*s.*	*d.*
Grant-in-aid from the Tasmanian Government...		...		500	0	0
Subscriptions received at Hobart—Full Members	225	0	0			
Lady Members, 10*s*.	85	0	0			
				310	0	0
Sale of Luncheon and Excursion Tickets		...		110	3	0
				£920	3	0

Expenditure.	£	*s.*	*d.*	£	*s.*	*d.*
Printing, Advertising, and Stationery	197	6	9			
Clerical Assistance..	48	9	0			
Excursions	200	10	6			
Caterer	148	9	0			
Sundries	191	12	9			
Grant-in-aid to Section D retained..................	50	0	0			
				836	8	0
Balance transmitted to the Permanent Honorary Secretary, Sydney		...		83	15	0
				£920	3	0

R. M. JOHNSTON, Hon. Treasurer.

Audited and found correct.

H. W. W. Echlin, Auditor.

ALEX. MORTON, Hon. Secretary.

September 15, 1903.

EXTRACTS FROM THE MINUTES.

GENERAL COUNCIL MEETING.

NINTH SESSION.

WEDNESDAY, 8TH JANUARY, 1902.

The ninth meeting of the Australasian Association for the Advancement of Science was opened in the new Museum Room of the Royal Society and Museum Buildings, yesterday morning, at 11 o'clock, when representatives from all the Australian States assembled for the general meeting of the Council. The arrangements made by Mr. Alex. Morton, the General Secretary for Tasmania, and Mr. R. M. Johnston, the Local Treasurer, and members of the Royal Society of Tasmania, seemed to be very complete. Rooms are set apart in the new portions of the building, and at the Town Hall, for the sectional meetings, an official journal arranged for, a reception room provided at the Town Hall, and luncheons in the new Tourist Court of the Museum buildings, Mr. C. D. Haywood being the caterer.

In the absence of Mr. R. L. Ellery, C.M.G., F.R.S., who was President of the Melbourne meeting, Professor A. LIVERSIDGE, M.A., LL.D., F.R.S. (Sydney), the Permanent Hon. Secretary, and who was President of the Sydney meeting in 1898, took the Chair.

PATRON OF THE ASSOCIATION.

Mr. A. Morton said he was able to announce that Sir Arthur Havelock, Governor of Tasmania, had consented to become patron of the Association, and would do all that was possible to further the interests of science. (Applause.)

MISCELLANEOUS BUSINESS.

The minutes of the meeting held two years ago were taken as read. The election of sectional officers, and arrangements made for the Tasmanian meeting, were confirmed, and members provisionally elected were admitted.

The following delegates, representing the several Scientific Societies of Australasia (Tasmania excepted), were present:—Royal Society of New South Wales: His Honour Judge Docker, M.A., Messrs. D. Carment, F.I.A., F.F.A., R. T. Baker, F.L.S., G. H. Halligan, F.G.S., J. W. Grimshaw, M.I.C.E. Linnean Society of New South Wales: Messrs. R. T. Baker, F.L.S., C. Hedley, F.L.S. Queensland Royal Society: Messrs. J. Shirley, B.Sc., J. F. Bailey, F.L.S. Victorian Royal Society: Professor W. C. Kernot, M.A., M.C.E., Mr. G. Sweet, F.G.S. Zoological Society of Victoria (Aboriginal Board): Mr. J. R. Godfrey. Field Naturalist Club of New South Wales: Mr. A. H. Lucas. Royal Society of South Australia: Messrs. S. Dixon, S. Smeaton.

Alterations to by-laws agreed to at the Melbourne meeting were confirmed. A letter was read from Sir H. W. Norman, G.C.B., expressing his regret at being unable to attend the ninth Jubilee of the University of Glasgow, to represent this Association. Some apologies for absence were read.

Correspondence with the various Governments, respecting recommendations from the Melbourne meeting, on the subject of a uniform system of spelling native names and places, was read. Some of the Governments acknowledged the correspondence, and others intimated that the subject was receiving consideration. Further consideration of the subject was referred to the joint Sections for Geography and Ethnology, acting in conjunction.

Reply read from the Government of Queensland, on the Association's recommendation, on the subject of forest areas. Referred to the Biological Section.

As to the prevention of tuberculosis, replies were received from the Governments of South Australia, New South Wales, New Zealand, Tasmania, Queensland, and Victoria. Also, from Boards of Health of Sydney and Melbourne. Consideration of the replies referred to the Sanitary Science Section.

Balance-sheets, excepting that for the Melbourne meeting (which will be considered later), were adopted.

Reports from the following Research Committees were referred to the sectional committees concerned :—Seismological, Magnetic Survey of New Zealand, Glacial, and Mental Science Committees. A complaint was made that there was no report from the Biological Committee.

Mueller Memorial.

Mr. S. Hall, Melbourne University, wrote, stating that the Committee of the Baron von Mueller National Memorial Fund had decided to place the money collected by it in the hands of the Australasian Association for the Advancement of Science, for the purpose of founding a medal. He enclosed a copy of the regulations which it was desired should govern the administration of the fund. The Memorial Committee would place a suitable die, and the balance of the fund would be at the disposal of the Association, if the offer were accepted.

The regulations provided that the fund was to be administered by a committee to be appointed by the Council of the Association at each meeting; the capital of the fund to remain entire, interest only to be at the disposal of the committee. The interest of the fund to be devoted to the purchase of a bronze medal, to be awarded not more frequently than every second year to the author of the most important contribution, or series of contributions, to natural knowledge, published originally within His Majesty's dominions within a period of not more than five, nor less than one year, of the date of the award, preference being always given to work having special reference to Australasia. The portion of the interest remaining, after the purchase of the medal, to be awarded as a prize to accompany the latter. The first committee to be elected at the Hobart meeting.

Captain Hutton, seconded by Mr. R. M. Johnston, moved that the offer be accepted, and that details be referred to the Mueller Committee already in existence. Agreed to, with the name of Mr. T. S. Hall, Melbourne University, being added.

Recommendation Committee.

Mr. J. H. Maiden (Sydney) moved that the Recommendation Committee consist of the present and past Presidents, the Treasurer, and past and present General Secretaries. Agreed to.

President for 1904.

Captain Hutton, F.R.S., New Zealand, seconded by Mr. R. M. Johnston, F.S.S., Tasmania, moved that Professor David, of the Sydney University, be nominated President of the Association for the meeting of 1904 in Dunedin.

Carried unanimously, amid hearty applause.

Professor David, N.S.W., thanked them. The proposal had only been mentioned to him after his arrival in Hobart, and it was only upon receiving assurances that it was the wish of members that he should be nominated that he had consented. He esteemed it as a high honour, the position being the most honourable that Australia had to confer on scientific men. (Applause.) He would do his best to follow in the footsteps of many worthy and distinguished Professors who had occupied the Chair. (Applause.)

Other officers elected for the 1904 meeting:—Mr. G. M. Thomson, Secretary; Mr. J. Sinclair Thomson, Local Treasurer.

The 1906 Session.

Mr. W. Howchin (S.A.) suggested that the period of the year at which the Congress should meet in South Australia in 1906 should be left for future arrangement.

Mr. R. W. Chapman (S.A.) supported the suggestion.

Mr. R. M. Johnston (Tas.) moved, "That the matter be postponed until the next meeting of the Council."

Mr. J. W. Grimshaw (N.S.W.) seconded the motion, which was agreed to.

A Permanent Secretary.

Mr. E. F. J. Love (Vic.) moved, "That each Section shall have a Permanent Secretary, in addition to the Local Sectional Secretaries, the Permanent Secretary to be nominated by the Committee of Recommendations, and elected by the Council." He said that the motion was not a revolutionary one, as the same thing was done in the British Association for the Advancement of Science.

Professor MacAulay (Tas.) seconded the motion.

Professor Pollock (N.S.W.) asked what the motion really meant.

Mr. Love said it was intended that the Secretary should be re-elected, say, every few years. He would withdraw the words "Permanent Secretary," and substitute the word "Recorder," and also add the words "nominated at each Session."

Mr. A. Morton (Tas.) said he would support the motion, provided the question of recommendation were left with the several Sections. He moved as an amendment, "That the matter be deferred until the next general meeting of the Council."

Mr. E. A. Counsel (Tas.) seconded the amendment, which was agreed to.

Recommendations of Sections.

Section A (Astronomy, Mathematics, Physics, &c.) recommended:—(1.) That the Seismological Committee be re-appointed as previously constituted, with Mr. Hogben and Mr. Baracchi as joint Secretaries, with renewal of the unexpended balance of £10. (2.) That the General Committee of the Association be asked to approach the Governments of South Australia and Tasmania with a view of securing the early installation and maintenance of Milne horizontal pendulums. (3.) That a committee, consisting of Mr. H. C. Russell, Mr. Baracchi, Mr. C. C. Farr, Mr. Hogg, and Mr. Love, be appointed to consider and report upon the progress of investigations in Terrestrial Magnetism in Australasia, with Mr. Baracchi as Secretary. Agreed to.

Section B recommended the change of the name to Chemistry, Metallurgy, and Mineralogy. Agreed to.

Recommended by Section 6 (Geology and Palæontology), the following to be members of the Glacial Committee :—Captain F. W. Hutton, F.R.S., E. G. Hogg, A. Gibb Maitland, W. H. Rands, R. M. Johnston, G. Sweet, W. H. Twelvetrees, W. Howchin, Professor Gregory, and Professor T. W. E. David, F.R.S. (Secretary).

Committee for recording structural features, such as important folds and faults in Australia, with a view to studying the evolution of the Australasian land surface :—Professor J. W. Gregory, W. H. Twelvetrees, G. A. Waller, T. S. Hall, M.A., Hy. L. Brown, A.R.S.M., Walter Howchin, A. Gibb Maitland, E. F. Pittman, A.R.S.M., W. H. Rands, W. H. Clunes Ross, B.Sc., and Professor David, F.R.S. (Secretary).

That the Committee of Geological Survey to be re-appointed, with the additions of the names of G. Halligan and Mr. Ferbur.

A committee to recommend a uniform system for the nomenclature of the igneous rocks of Australasia :—Mr. R. M. Johnston, F.S.S., W. H. Twelvetrees, Professor Gregory, Professor David, W. G. Woollnough, B.Sc., A. Gibb Maitland, G. A. Waller, E. G. Hogg, M.A., W. F. Petterd, Captain Hutton, H. J. Jenkins, A.R.S.M., A. W. Howitt, W. H. Rands, W. A. MacLeod, B.Sc., A. J. Dunstan, R. M. Johnston, and G. W. Card (Secretaries), Mr. W. H. Twelvetrees.

Recommended by Section D (Biology)—That the General Council of this Association be asked to communicate with the Government of New Zealand, and to urge respectfully that the construction of the proposed Biological Station, near Dunedin, be proceeded with as a matter of Colonial importance.

That a committee, consisting of Messrs. A. Morton, W. L. May, C. J. Atkins, R. M. Johnston, and Colonel W. V. Legge, be appointed to carry on Marine Biological research in the neighbourhood of Hobart; that Mr. Morton be Secretary and Convener; and that a grant of £50 be placed at their disposal.

This Committee recommends the General Council that the Committee on the Catalogue of the Marine Mollusca of Australia be discharged.

That, in view of the enormous waste of timber, and of the other valuable products derivable from it, which is now going on, it is urgently necessary, in the opinion of this Association, both from commercial and scientific points of view, that more effective measures should be adopted for the conservation of forests throughout Australia.

That it is advisable that suitable forest areas, especially at the sources of rivers and streams, should be rendered inalienable, and vested in permanent boards, which should control the use of the timber thereon; and that other forest lands, wholly or in part, denuded of timber, should also be vested in such boards for the improvement of existing timber areas or natural regeneration of forests.

That the adoption of these measures would have the immediate effect of rendering the forestry departments self-supporting, and would, in the near future, result in large additions being made to the revenues of the States.

The forestry recommendations, brought up in another form, were discussed at some length, and agreed to in the amended form above given. It was also agreed that the attention of the Governments of the Australasian States should be drawn to them.

Recommended by Section E (Geography). Spelling of native names of places. Committee to collect lists of names and recommendations as to spelling. To report to the Council at Dunedin :—For Victoria : Dr. Fison and Professor B. Spencer. New South Wales : Dr. Brown and Rev. J. J. Prescott. South Australia : Mr. Maurice and Mr. Gillen. Tasmania : Mr. Alex. Morton and Mr. R. M. Johnston. Queensland : Dr. Roth and Mr. J. F. Bailey. New Zealand : Captain Hutton, Mr. Percy Smith, Mr. E. Tregear, and Mr. A. Hamilton. West Australia : Mr. Alex. Morton and Mr. Prinseps, with power to add to their number. Agreed to.

Recommended by Sections G and I (Ethnology and Mental Science) that Section G be dropped out, and that Anthropology and Philology be the name of the Section. Agreed to.

Reasons for establishment of a Philological Section from the Committee of Section I. (1.) To encourage and develop study of Polynesian and Australian languages from the linguistic and phonetic standpoints. (2.) Collation of the results of the work of Polynesian scholars, with the latest linguistic and philological movements in Europe. (3.) Much purely philological work, now crowded into the Education and Ethnological Sections, should have its own separate recognition. (4.) Students of classical, romance, and Teutonic philology can at present find no field at all. The "Education" Section is very remotely allied to these studies. (5.) With Philology should be included Phonetics, without which the study of Aboriginal languages cannot be complete.

Recommended by Section H (Sanitary Science, &c.) that the sanitary legislation of every State should contain provisions for the notification of phthisis as an infectious disease, and for the prevention of its spread by the taking of proper precautions against its dissemination, and especially through the sputum of consumptives. That there should be provided in every State at least one sanatorium where tuberculosis patients could be treated on terms within the means of all. Agreed to.

Recommended by Section I. (1) The following committee to report on the education of defective children :—Mr. R. M. Johnston, Mr. S. Clemes, Mr. C. Bjelke-Petersen, Dr. Scott, Mr. T. Stephens, Dr. Delany, Mr. Richard Smith, Miss S. Clarke, Miss Poulett-Harris, Miss Jay, Mr. E. I. Gower (Secretary), with power to add to their number. 2. (*a*) That it be a rule that all papers be sent to the General or Sectional Secretaries at least a fortnight before the Congress, and that each paper be accompanied by an abstract for the Press and a brief synopsis of its contents. (*b*) That these papers be submitted to the Vice-Presidents and Secretary of the respective Sections for examination. (*c*) That they shall determine which papers shall be read, and in what order. (*d*) That all writers of papers who do not conform to these rules must take the chance of having their papers rejected. Agreed to.

Reasons for Establishment of a Philological Section from the Committee of Section I.

1. To encourage and develop study of Polynesian and Australian languages from the linguistic and phonetic standpoints.
2. Collation of the results of the work of Polynesian scholars, with the latest linguistic and philological movements in Europe.
3. Much purely philological work, now crowded into the Education and Ethnological Sections, should have its own separate recognition.
4. Students of Classical, Romance, and Teutonic Philology can at present find no field at all. The "Education" Section is very remotely allied to these studies.
5. With Philology should be included Phonetics, without which the study of Aboriginal languages cannot be complete.

1. The following Committee to report on the Education of Defective Children :—
   Mr. R. M. Johnston, Mr. S. Clemes, Mr. C. Bjelke-Petersen, Dr. Scott, Mr. T. Stephens, Dr. Delaney, Mr. Richard Smith, Miss S. Clarke, Miss Poulett-Harris, Miss Jay, Mr. E. I. Gower (Secretary), with power to add to their number.
2. (*a*) That it be a rule that all papers be sent to the General or Sectional Secretaries at least a fortnight before the Congress, and that each paper be accompanied by an abstract for the press and a brief synopsis of its contents.
   (*b*) That these papers be submitted to the Vice-Presidents and Secretary of the respective Sections for examination.
   (*c*) That they shall determine which papers shall be read and in what order.
   (*d*) That all writers of papers who do not conform to these rules must take the chance of having their papers accepted.

Section H.

The Committee of Section H recommend that a suggestion be sent to the Prime Minister, asking that before the site of the Federal capital is determined the advice be obtained of a Board to consist of Architects, Engineers, and Surveyors, with the addition of one or more medical men, and one or more business men.

General Programme for the Week.

Wednesday, 8th January.

- 11 a.m.—General Council meets in the room of the Royal Society.
- 2 p.m.—Sectional Committees meet in their rooms.
- 3 p.m.—Garden Party at Stoke, Sir John and Lady Dodds.
- 8 p.m.—Presidential Address in the Reception Room, Town Hall.

THURSDAY, 9TH JANUARY.

10 a.m.—Sectional Committees meet in their Section Rooms. The following Presidential Addresses will be delivered :—

10·30 a.m.—Section A : Mr. W. R. Chapman, M.A., B.C., E.
Section B : Professor Mica-Smith, B.Sc.
Section C : Mr. T. S. Hall, M.A.
11·30 a.m.—Section D : Professor W. D. Benham, D.Sc.
Noon—Section F : Mr. T. A. Coghlan, F.S.S.
Noon—Section H : Sir Thos. Fitzgerald, K.C.M.G.
3 p.m.—Section I : Professor Arnold Wall, M.A.
3·30 p.m.—Section J : Mr. Percy Oakden, F.R.I.B.A.
8 p.m.—Section G : Dr. W. E. Roth, M.R.C.S.E.

FRIDAY, 10TH JANUARY.

10 a.m.—Sectional Committees meet.
10·30 a.m.—Sections meet for reading and discussing Papers.
3 p.m.—Garden Party at Mr. and Mrs. R. C. Patterson's. Trams will leave the Town Hall at 3 p.m. sharp.
8 p.m.—Section E : Lecture in Reception Hall by Rev. Dr. Geo. Brown.

SATURDAY, 11TH JANUARY.

10 a.m.—Sectional Committees meet.
10·30 a.m.—Sections meet for reading and discussing Papers.
3 p.m.—Garden Party at Mrs. C. H. Grant's, High Peak, Huon Road. Conveyances will leave the Town Hall at 2 p.m.

MONDAY, 13TH JANUARY.

10 a.m.—Sectional Committees meet.
11·30 a.m.—Sections meet for reading and discussing Papers.
2 p.m.—Recommendation Committee meets in Secretary's Office.
3 p.m.—Garden Party at the Springs, Mount Wellington, Hon. Henry and Mrs. Dobson. Conveyances will leave the Town Hall at 2 p.m.
8 p.m.—Lecture by Professor David, M.A., F.G.S.

TUESDAY, 14TH JANUARY.

10 a.m.—Sectional Committees meet.
10·30 a.m.—Sections meet for reading and discussing Papers.
8 p.m.—Musical Evening in the Reception Room, under the Conductorship of Mr. Bradshaw Major.

WEDNESDAY, 15TH JANUARY.

10 a.m.—Sectional Committees meet.
10·30 a.m.—Sections meet for reading and discussing Papers.
2 p.m.—Recommendation Committee meets.
3 p.m.—Garden Party at the Botanical Gardens, given by His Worship the Mayor (Alderman Geo. Kerr) and the Mayoress.
8 p.m.—Lecture for workingmen only, by Professor Pollock.

THURSDAY, 16TH JANUARY.

10 a.m.—General Council meets.
8 p.m.—Lecture in the Reception Room, "A Trip through Tasmania," by Mr. J. W. Beattie.

FRIDAY, 17TH JANUARY.

Marine Excursion, given by the Directors of the Union S.S. Co., of New Zealand.

Garden Parties.

WEDNESDAY, 8TH JANUARY.

His Honour Sir John and Lady Dodds invite the members to a Garden Party at Stoke, New Town. Trams will leave the Town Hall at 3 p.m.

FRIDAY, 10TH JANUARY.

Mr. and Mrs. R. C. Patterson invite the members to a Garden Party at Varuna, Davey-street. Trams will leave the Town Hall at 3 p.m.

SATURDAY, 11TH JANUARY.

Mrs. C. H. and Miss Grant invite the members to a Garden Party at High Peak, Huon Road. Coaches will leave the Town Hall at 2 p.m. sharp.

MONDAY, 13TH JANUARY.

The Hon. Henry and Mrs. Dobson invite the members to a Garden Party to the Springs, Mount Wellington. Coaches will leave the Town Hall at 2 p.m. sharp.

WEDNESDAY, 15TH JANUARY.

His Worship the Mayor of Hobart (Alderman Geo. Kerr) and the Mayoress invite the Members to a Garden Party at the Botanical Gardens. A special train will leave for the gardens at 4 p.m.

FRIDAY, 17TH JANUARY.

The Directors of the Union S.S. Co. of New Zealand invite the members of the Association to a Marine Excursion. The trip will be to the D'Entrecasteaux Channel. The steamer will leave the wharf at 2·30 sharp.

OFFICIAL JOURNAL.

The Journal, containing lists of the Papers to be read in the Sections, and other arrangements for the day, will be issued each morning. Copies may be obtained in the Reception Room, where they will be placed on a special table.

An epitome of the arrangements for the day will also be supplied to the papers for publication each morning.

This concluded the business at the morning sitting, and the Council adjourned.

THURSDAY, 16TH JANUARY, 1902.

GENERAL COUNCIL MEETING.

A meeting of the General Council was held in the new Museum Room at 10 a.m., Captain F. W. Hutton, F.R.S., &c., the President, in the Chair. Also present—Professor A. Liversidge, F.R.S. (Permanent Secretary), Hon. N. E. Lewis, C.M.G. (Premier), E. F. J. Love, M.A., Professor Laurie, Rev. Dr. Fison, P. Oakden, Professor Kernot, R. J. Blackett, T. S. Hall, Professor Mica-Smith (Victoria), Mr. Craig (Victoria), Professor Pollock, H. Deane, C.E., T. A. Coghlan, Professor David J. Grimshaw, Rev. Dr. Geo. Brown, J. Halligan, W. Carment, R. T. Baker (New South Wales), Professors Benham and Arnold-Wall (New Zealand), Dr. Roth (Queensland), Messrs. R. M. Johnston, S. Clemes, P. S. Seager, W. A. Weymouth, F. M. Young, F. J. Young, Chas. Hudson, L. A. Evans, Rev. Dr. Scott, F. Abbott, H. C. Kingsmill, A. C. Parker, W. F. Ward, G. A. Waller, A. Conlon, C. B. Target, C. B. Petersen, W. H. Hudspeth (Tasmania).

The Minutes of the meeting held on the 8th inst. were read and confirmed.

CORRESPONDENCE.

A letter from Professor Baldwin Spencer, resigning his position of Secretary for Victoria, in consequence of absence from the State, was read.

The President spoke appreciatingly of Professor Spencer's services, and it was resolved to accept it with regret.

SECTIONAL SECRETARIES.

Professor Love moved, "That in each Section there should be if possible one Sectional Secretary who has had previous experience of the work." He withdrew his previous motion on the subject.

Mr. Alex. Morton seconded, and the motion was agreed to.

ADELAIDE MEETING.

The question of fixing the date of the meeting after the Dunedin one, at Adelaide, was postponed till the meeting at Dunedin.

RECOMMENDATION.

Recommended by Section H (Architecture and Engineering)—That a suggestion be sent to the Prime Minister, asking that, before the site of the Federal capital is determined, the advice be obtained of a board, to consist of architects, engineers, and surveyors, with the addition of one or more medical men, and one or more business men. Agreed to.

NEW RULES.

Professor Liversidge moved that Rule 9 be amended as follows:—"That the President, eight Vice-Presidents, a General Treasurer, one or more General Secretaries, and the Local Secretaries, shall be elected by the Council at each Session. Five of the above Vice-Presidents shall be elected from former Presidents, and three (who must be residents of the State or Colony in which the Session is to be held) shall be nominated by the Local Committee." Agreed to.

National Museum.

Professor Liversidge moved, "That the Federal Government be requested to reserve a site for a National Museum, and for the housing of scientific societies and institutions in the proposed Federal capital."

Professor Kernot seconded, and the motion was agreed to.

Mueller Memorial.

Kasouka Road, Camberwell,
Victoria, 30th December, 1901.

Dear Sir,

The Committee of the Mueller National Memorial Fund has decided to place the money collected by it in the hands of the Australasian Association for the Advancement of Science, for the purpose of founding a Medal in memory of the late Baron Sir Ferdinand Von Müeller. I have the honour to enclose a copy of the regulations which it desires will govern the administration of the fund. It is hoped that the Committee for the purpose of awarding the Medal will be appointed at the Hobart meeting.

The Memorial Committee will place a suitable die and the balance of the fund at the disposal of the Association, if this present offer is accepted.

The amount collected is about £450.

I have the honour to remain,
Yours obediently,

T. S. HALL, *Acting Secretary.*

Professor A. Liversidge, M.A., LL.D., F.R.S.,
Permanent Hon. Sec. Aust. Ass.

Regulations for the Mueller Medal Fund.

1. That there shall be a fund called the Müeller Medal Fund.

2. All contributions shall be invested in the name of the Müeller Medal Fund, in such funds as are authorised for investment by Trustees, and in such manner as to form a separate account from that of the Association's other funded property.

3. The fund shall be administered by a Committee called the Müeller Medal Committee, which shall consist of six members, who shall be appointed by the Council of the Association at each Session, and shall hold office until the first Council meeting of the next ensuing Session.

4. The President and Treasurer of the Association for the time being shall be *ex-officio* members of the Committee, and the former shall act as Chairman; the other four members shall not of necessity be members of the Association. Should a vacancy occur, by reason of death or otherwise, at any intermediate time, the remaining members of the Committee shall appoint a person to fill the vacancy, and such person shall act until his election be ratified or otherwise by the Council at its next ensuing meeting.

5. No award shall be made except on the recommendation of an absolute majority of the Committee, whose award shall be final, and shall be communicated to the Council by the President at the first meeting held after the award has been made.

6. The capital of the fund shall remain entire, and the interest only shall be at the disposal of the Committee.

7. The interest of the fund shall be devoted to the purchase of a bronze medal, to be awarded not more frequently than every

second year to the author of the most important contribution, or series of contributions, to Natural Knowledge, published originally within His Majesty's dominions, within a period of not more than five nor less than one year of the date of the award, preference being always given to work having special reference to Australasia. The portion of the interest remaining after the purchase of the medal shall be awarded as a prize to accompany the latter.

8. If, in the opinion of the Committee, no contribution of sufficient importance shall have been thus made, the medal may not be given; but the value of it may be reserved, and an additional medal may be awarded on some future occasion, when, in the opinion of the Committee, it is advisable to make such an award.

9. The first Committee shall be elected at the Hobart meeting, 1902.

Mueller Medal Committee.

A report was received from the Müeller Medal Committee, stating that a meeting of the Müeller Memorial Fund was held in the General Secretaries' office on Monday, the 13th January, at noon, when there were present—Captain F. W. Hutton, F.R.S. (President of the Association), Professor A. Liversidge, M.A., F.R.S., Messrs. J. H. Maiden, F.L.S., T. S. Hall, M.A., R. M. Johnston, F.S.S., and A. Morton. On the motion of Mr. T.S. Hall, seconded by R. M. Johnston, the following resolution was unanimously agreed to :—"That the Müeller National Committee be requested to substitute General Secretary for General Treasurer as *ex-officio* member of the Müeller Medal Committee; that the following be the four elected members of the Müeller Medal Committee :—Professors W. Baldwin Spencer, F.R.S., J. W. Gregory (M.A.), Messrs. E. F. J. Love (M.A.), and J. H. Maiden (F.L.S.)."

Messrs. R. Teece and R. Dallen were re-appointed Auditors for the General Council of the Session, and a Publication Committee was also appointed, the publication to consist of the Hon. Treasurer and Hon. Secretary for Tasmania, Secretaries of Sections, together with Messrs. F. M. and F. J. Young.

The report was adopted.

Research Committees.

Hobart, 15th January, 1902.

Dear Sir,

We have the honour to inform you that the following Research Committees have been appointed to report to the Council at its next Session, to be held in Dunedin in January, 1904.

We are,
Yours truly,

A. LIVERSIDGE, } *Hon. Secretaries.*
ALEX. MORTON, }

Section A.

1. *Seismological Committee.*—Mr. E. G. Hogg, Mr. Davidson, Mr. W. E. Cooke, Mr. R. L. J. Ellery, Sir Jas. Hector, Mr. H. C. Russell, Sir Chas. Todd, Mr. Geo. Hogben (Timaru, New Zealand), and Mr. P. Baracchi (Secretary), with authority to expend the balance of the last £10 grant.

2. That a committee, consisting of Mr. H. C. Russell, M. C. C. Farr, Mr. Hogg, and Mr. Love, be appointed to consider and report upon the progress of investigations in Terrestrial Magnetism in Australasia, with Mr. Baracchi as Secretary.

Section C.

1. *Glacial Committee.*—Captain F. W. Hutton, F.R.S., E. G. Hogg, A. Gibb Maitland, W. H. Rands, R. M. Johnston, G. Sweet, W. H. Twelvetrees, W. Howchin, Professor Gregory, and Professor T. W. E. David, F.R.S. (Secretary).

2. Committee for recording structural features, such as important folds and faults in Australia, with a view to studying the evolution of the Australasian land surface :—Professor J. W. Gregory, Messrs. W. H. Twelvetrees, G. A. Waller, T. S. Hall, M.A., Hy. L. Brown, A.R.S.M., Walter Howchin, A. Gibb Maitland, E. F. Pittman, A.R.S.M., W. H. Rands, W. J. Clunes Ross, B.Sc., and Professor David, F.R.S. (Secretary).

3. Committee to recommend a uniform system for the nomenclature of the igneous rocks of Australasia :—Professor Gregory, Professor David, Messrs. W. G. Woollnough, B.Sc., A. Gibb Maitland, G. A. Waller, E. G. Hogg, M.A., W. F. Petterd, Captain Hutton, R. M. Johnston, F.S.S., H. J. Jenkins, A.R.S.M., A. W. Howitt, W. H. Rands, W. A. MacLeod, B.Sc., and A. J. Dunstan. Professor Neil Smith, Messrs. G. W. Card and W. H. Twelvetrees, F.G.S., to be Secretaries.

4. *Photography in Geological Surveys Committee.*—Sir James Hector, Professor David, Messrs. T. F. Furber, Halligan, J. H. Harvey (Secretary).

Section D.

(2.) "That a committee, consisting of Messrs. A. Morton, W. L. May, C. J. Atkins, R. M. Johnston, and Colonel W. V. Legge, be appointed to carry on Marine Biological research in the neighbourhood of Hobart; that Mr. Morton be Secretary and Convener; and that a grant of £50 be placed at their disposal."

Section E.

Committee to collect lists of names and recommendations as to the spelling of native names of places :—For Victoria : Dr. Fison and Professor B. Spencer. New South Wales : Dr. Brown and Rev. C. J. Prescott. South Australia : Mr. Maurice and Mr. Gillen. Tasmania : Mr. Alex. Morton and Mr. R. M. Johnston. Queensland : Dr. Roth and Mr. J. F. Bailey. New Zealand : Captain Hutton, Mr. Percy Smith, Mr. E. Tregear, and Mr. A. Hamilton (Secretary). West Australia : Mr. Alex. Morton and Mr. Prinseps, with power to add to their number, "To report to the Dunedin Council."

Section J.

Committee to report on the Education of Defective Children :—Mr. R. M. Johnston, Mr. S. Clemes, Mr. C. Bjelke-Petersen, Dr. Scott, Mr. T. Stephens, Dr. Delaney, Mr. Richard Smith, Miss S. Clarke, Miss Poulett-Harris, Miss Jay, Mr. E. I. Gower (Secretary), with power to add to their number.

[Copy.]

From Gen. Sir H. Wylie Norman, G.C.B., &c.

85, Onslow Gardens, London, S.W.,
31st May, 1901.

Dear Professor Liversidge,

I have the pleasure to acknowledge your letter of the 3rd April, doing me the honour to inform me that the Australasian Association for the Advancement of Science would be pleased if I would attend as their representative at the celebration of the Ninth Jubilee of the University of Glasgow on the 12th, 13th, and 14th June.

Unfortunately, when your letter came I already had several engagements for the month of June, and the day on which I have been invited to attend the celebration, namely, the 14th, is one of these days.

I have therefore very reluctantly been obliged to say that I cannot accept the invitation.

Will you kindly inform your Association how much indebted I am to them for doing me the honour of selecting me as their representative on such an important occasion, and how much I regret to have been unable to accept the position.

Believe me,

Yours sincerely,

H. W. NORMAN.

Professor Liversidge.

Valedictory.

Rev. Dr. Fison (Victoria) moved, "That a special vote of thanks be accorded to His Excellency, Sir Arthur Elibank Havelock, G.C.S.I., G.C.M.G., G.C.S.I.E., and Lady Havelock, to His Honour Sir John and Lady Dodds, His Worship the Mayor of Hobart (Alderman Kerr) and Mayoress, to Mr. and Mrs. R. C. Patterson, to Mrs. C. H. and Miss Grant, to Senator Dobson and Mrs. Dobson, to the Directors of the Union S.S. Co. of New Zealand, and the General Manager for Tasmania (Mr. Thos. Henderson), for hospitality." He said it was only possible for him to say that His Excellency Sir Arthur Havelock had acted like his usual self, and no higher praise could be given, because right heartily had Sir Arthur Havelock helped the Association. (Applause.) It was ten years ago since the Association had met at Hobart. On that occasion a magnificent display of hospitality had been extended to them, but this year it appeared to be heartier than ever. (Applause.) He could not find words to give adequate expression to his feelings, and would take refuge in the saying employed by a Fijian Chief, who made the following reply to a vote of thanks :—"It is we who have been honoured, and we cannot express our thankfulness, because our words are too short. Oh! that we were dogs; then would our thankfulness be seen in the wagging of our tails." (Laughter and applause.) Like the Fijian, he regretted that he could not give better expression to his feelings.

Professor Pollock (N.S.W.) seconded the motion.

Professor David (N.S.W.) moved a vote of thanks to the Government of Tasmania for the generous vote of £500, and the printing of the Journal up to a sum of £350; also for the privilege of franking the correspondence of the Association; to His Worship the Mayor and Aldermen of the City of Hobart, for the use of the

Town Hall and the several rooms; to the President, Committee, and members of the Hobart Chamber of Commerce, for the use of the Chamber of Commerce room; to the Council of the Royal Society of Tasmania, for the use of their Board-room; to the Trustees of the Tasmanian Museum and Art Gallery, for the use of several rooms; to the Tasmanian Minister of Railways and the General Manager of Railways (Mr. Chas. Hudson), for the very liberal concessions granted to members; to the Railway Commissioners of New South Wales, Victoria, South Australia, Queensland, and New Zealand; and to the Union S.S. Company of New Zealand, and Messrs. Huddart, Parker, and Co., for reduction in fares; to the Directors of the Mount Lyell Railway and Mining Company and Mr. Robert Sticht, for their very liberal concessions granted by them to the members, and the Directors of the Emu Bay Railway Company; to Mr. T. Julian Haywood, the City Organist, for presiding at the organ during the evening lectures; to Mr. Bradshaw Major and the members of the Philharmonic Society of Hobart. He said their thanks were certainly due to the Government, and especially the Premier (Hon. N. E. Lewis), who was present that day. A great many acts of kindness had been received, not only from the Government, but also from many private individuals. (Applause.)

Professor Kernot (Victoria) seconded the motion, and said that, taking into consideration the revenue and population of Tasmania, the treatment given the members of the Association was really magnificent. (Applause.) Hobart was certainly an attractive place for the Association to meet. The climate was delightful, and for hospitality and generosity Tasmania was unrivalled. (Applause.)

The motion was agreed to.

The Premier (Hon. Sir N. E. Lewis, K.C.M.G.), who was received with applause, expressed pleasure that the Association was satisfied with the little that the Tasmanian Government had been able to do for it. The people of Tasmania had had an intellectual treat, and it was a great privilege for them to receive the members of the Association; and if they had not been able to do as much in the way of hospitality as had been done by the larger and wealthier States, there was one point in which Tasmania would not yield, and that was in the heartiness and cordiality with which the members of the Association were welcomed to these shores. (Applause.) It was ten years since the Association had last been here, but he hoped that another Session would be held in Tasmania before another ten years elapsed.

Dr. Roth (Queensland) moved a vote of thanks to the Commissioner of Police (Major Richardson), the Superintendent of Police (Mr. F. Pedder), for the very great assistance they have, with their efficient staff, rendered in regulating the traffic in connection with the visit of the members to High Peak and the Springs, Mount Wellington.

Mr. R. M. Johnston (Tas.) seconded the motion, which was agreed to.

Professor Mica-Smith (Ballarat) moved, "That Professor Liversidge be elected the first life member of the Association, in recognition of his labours in having been the originator of the Association, and of his services throughout its past history."

Hon. Sir N. E. Lewis seconded the motion, and referred to the interest that Professor Liversidge had taken in the work of the Association.

The motion was carried by acclamation, after which Professor Liversidge returned thanks, and explained that the Association now had a research fund amounting to about £1700. (Applause.)

Professor David moved, "That a vote of thanks be accorded the Minister of Lands (Hon. E. Mulcahy) for having allowed Messrs. Twelvetrees and Waller to attend all meetings of the Geological Sections."

Mr. T. S. Hall, M.A. (Melbourne), seconded the motion, which was agreed to.

Professor Benham (New Zealand) moved a vote of thanks to the Secretaries of the Sections, and to Mr. E. F. J. Love, as editor of the "Official Journal."

Professor Laurie (Victoria) seconded the motion, which was carried.

Professor Laurie then moved a special vote of thanks to Mr. A. Morton for the very valuable services he had rendered to the Association. He did not believe any other member would have been able to carry out the duties with the same smoothness and success as Mr. Morton had done. Mr. Morton was undoubtedly well suited for the onerous duties, and was possessed of suitable humour and great sagacity.

Professor David seconded the motion, which was carried with acclamation.

Mr. Morton briefly responded, and, after thanking the members for their kind expression of opinion, he paid a tribute to the Railway authorities for the attention that had been extended to the members of the Association.

On the motion of Professor Liversidge (New South Wales), seconded by Mr. E. F. J. Love (Victoria), a vote of thanks was accorded to the Press, both speakers stating that the gratitude expressed was no empty form of speech.

Rev. Dr. Brown moved a vote of thanks to the President for presiding, and the very able address he had delivered.

Voices: Everyone will second.

The motion was passed amid enthusiastic applause.

Appointment of Officers.

The following officers were appointed for 1904:—President, already elected (Professor David); General Treasurer, Mr. H. C. Russell; General Secretary, Professor Liversidge; Secretary for Victoria, Professor Love; Tasmania, Mr. Alex. Morton; South Australia, Professors Rennie and Bragg; New Zealand, Mr. Thomson; Queensland, Mr. Shirley; West Australia, yet to be chosen.

Professor Liversidge spoke regretfully of losing Professor Baldwin Spencer's services, through his being away on scientific work, and reminded members of how much time and attention Professor Spencer had given to the work of the Association, especially at the Melbourne meetings.

The motion was agreed to.

The President said they now brought the Ninth Session to a close. A lot of really good work had been done. The volume that would be issued of the Papers and Proceedings would, he thought, be one of the most interesting of the volumes connected with previous Sessions. (Applause.) He hoped to meet them all at Dunedin. (Warm applause.)

The meeting then terminated.

RECOMMENDATIONS.

SECTION A.

1. That the Seismological Committee be re-appointed as previously constituted, with Mr. Hogben and Mr. Baracchi as Joint Secretaries, with renewal of the unexpended balance of £10.

2. That the General Committee of the Association be asked to approach the Governments of South Australia and Tasmania with a view of securing the early installation and maintenance of Milne horizontal pendulums.

3. That a Committee, consisting of Mr. H. C. Russell, Mr. Baracchi, Mr. C. C. Farr, Mr. Hogg, and Mr. Love, be appointed to consider and report upon the progress of investigations in Terrestrial Magnetism in Australasia, with Mr. Baracchi as Secretary.

SECTION B.

That the name of Section B be changed to "Chemistry, Metallurgy, and Mineralogy."

SECTION C.

The following are recommended as members of the Glacial Committee :—Captain F. W. Hutton, F.R.S., E. G. Hogg, A. Gibb Maitland, W. H. Rands, R. M. Johnston, G. Sweet, W. H. Twelvetrees, W. Howchin, and Professor T. W. E. David, F.R.S. (Secretary).

Committee for recording structural features, such as important folds and faults in Australia, with a view to studying the evolution of the Australasian land surface :—Professor J. W. Gregory, W. H. Twelvetrees, G. A. Waller, T. S. Hall, M.A., Hy. L. Brown, A.R.S.M., Walter Howchin, A. Gibb Maitland, E. F. Pittman, A.R.S.M., W. H. Rands, W. J. Clunes Ross, B.Sc., and Professor David, F.R.S. (Secretary).

A committee to recommend a uniform system for the nomenclature of the igneous rocks of Australasia :—W. H. Twelvetrees, Professor Gregory, Professor David, W. G. Woollnough, B.Sc., A. Gibb Maitland, G. A. Waller, E. G. Hogg, M.A., W. F. Petterd, Captain Hutton, H. J. Jenkins, A.R.S.M., A. W. Howitt, W. H. Rands, W. A. MacLeod, B.Sc., A. J. Dunstan, and G. W. Card (Secretary).

SECTION D.

(1.) "Recommend that the General Council of this Association be asked to communicate with the Government of New Zealand, and to urge respectfully that the construction of the proposed Biological Station, near Dunedin, be proceeded with as a matter of colonial importance."

(2.) "That a committee, consisting of Messrs. A. Morton, W. L. May, C. J. Atkins, R. M. Johnston, and Colonel W. V. Legge, be appointed to carry on Marine Biological research in the neighbourhood of Hobart; that Mr.

Morton be Secretary and Convener; and that a grant of £50 be placed at their disposal."

(3.) This Committee recommends the General Council that the Committee on the Catalogue of the Marine Mollusca of Australia be discharged."

(4.) "That, in the opinion of this Association, the results of past experience demonstrate the urgent necessity for the observance throughout Australasia of certain principles for the effective conservation of forests.

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

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

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

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

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

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

The Recommendation Committee cannot recommend the above in its present form.

Section E.

Spelling of native names of places.

Committee to collect lists of names and recommendations as to spelling:—For Victoria: Dr. Fison and Professor B. Spencer. New South Wales: Dr. Brown and Rev. J. J. Prescott. South Australia: Mr. Maurice and Mr. Gillen. Tasmania: Mr. Alex. Morton and Mr. R. M. Johnston. Queensland: Dr. Roth and Mr. J. F. Bailey. New Zealand: Captain Hutton, Mr. Percy Smith, Mr. E. Tregear, and Mr. A. Hamilton. West Australia: Mr. Alex. Morton and Mr. Prinseps, with power to add to their number.

Section G.

"That the proposed formation of a separate Philological Section for the present does not meet with the approval of this meeting."

"That the subject of Philology remain attached to Section G (Ethnology and Anthropology)."

Section H.

"That the sanitary legislation of every State should contain provisions for the notification of phthisis as an infectious disease, and for the prevention of its spread by the taking of proper precautions against its dissemination, and especially through the sputum of consumptives."

"That there should be provided in every State at least one sanatorium where tuberculosis patients could be treated on terms within the means of all."

Section I.

"That a new Section of Philology be formed, or that, in the alternative, Philology be added to Section I., and to request that the matter be laid before the Council of the Association."

PRESIDENTIAL ADDRESS

BY

CAPTAIN F. W. HUTTON, F.R.S.,

PRESIDENT,

HOBART, WEDNESDAY, JANUARY 8, 1902.

EVOLUTION AND ITS TEACHING.

I WISH, very sincerely, to thank the Members of the Council of the Association for choosing me to preside over this meeting. The position of your President, elected by his brother workers, is the greatest honour to which a scientific man in Australasia can aspire, and the offer of it to me gave me very great pleasure. The feeling of responsibility for having undertaken to prepare an address to be read before such a distinguished and learned audience came later. It is a task from which the boldest might well shrink.

OBITUARY NOTICE OF PROFESSOR TATE.

But before commencing my address, I regret to say that I have to record the death of a former President—Professor Ralph Tate. Born at Alnwick, in Northumberland, in 1840, he early showed a strong taste for natural science, and in 1858 won an exhibition at the School of Mines in London. Subsequently, he became a teacher of science, and in 1864 was appointed Library and Museum Assistant to the Geological Society.

In 1867 he went to Nicaragua, and afterwards to Venezuela, to examine some mining properties in those countries, and on his return to England he was, in 1871, engaged to organise mining schools in Durham and North Yorkshire. In 1875 he was appointed Professor of Natural Science in the Adelaide University, which appointment he held until his death, last September.

At first he turned his attention to geology and conchology, publishing, in 1866, an appendix to S. P. Woodward's "Manual of Mollusca," and, in 1871, a "Rudimentary Treatise on Geology." In 1876 he published, in conjunction with Mr. J. F. Blake, a book on the "Lias of Yorkshire." On his appointment to the Chair in the Adelaide University, he at once, with great zeal, threw himself into the study of the geology and palæontology of South Australia, making extensive travels over the country. He now added botany to his other accomplishments, and published a "Handbook to the Flora of South Australia."

He was President of Section D of this Association at its first meeting in Sydney in 1887, taking for the subject of his address the geographical distribution of the plants of Australia and its relation to the geological history of the continent. When we met at Adelaide, in 1893, he was chosen President, and gave us a very complete account of the progress of geological discovery in Australia. And, at the Melbourne meeting, in 1900, as President of Section C. he made a vigorous attack on the doctrine of homotaxy.

The Association.

During the ten years which have passed since our previous meeting in Hobart, the Association has grown greatly in strength and influence through the good work it has done for the advancement of science in the Southern Hemisphere, and I think that our Permanent Secretary, who was the founder of the Association, ought to be proud of his work, and very hopeful for the future.

The ten Sections into which the Association is divided include all branches of Science—physical, physiological, and mental—and we try to advance both pure and applied science. For scientific men may be divided into two groups—the investigators of theory, and the reducers of theory to practice. The workers in applied science have for their aim the material advancement of the human race. Not only do they bring health to the sick, and an increase of comfort to us all, but they help to make every-day work more interesting to the intelligent, and thus lift the toiler on to a higher level. Also, by increasing the wealth of the world, they give to some men sufficient leisure to pursue pure science or philosophy undisturbed.

On the other hand, the student of pure science—whether he be an astronomer engaged in studying the movements and composition of the starry host, or whether he be a humble entomologist—he, also, has a high object to attain beyond the facts he so industriously gathers together. Consciously, or unconsciously, he is helping to solve the riddle of the Universe by collecting evidence which may, perhaps, enable us to ascertain the laws which the Creator has imposed upon His work. He is seeking the truth, partly, no doubt, out of curiosity, but partly because he feels that a knowledge of the truth is of the greatest importance to the human race. We can never know the whole truth about the Universe, but we can make an approximation to it; and we may even hope to get some dim idea of why it has been called into existence, and what is the purpose of its Creator.

Thus, pure science culminates in a Natural Philosophy. That is, a philosophy built up on an observational basis, which tries to harmonise and explain all observed facts. And this Natural Philosophy must, of course, vary with our knowledge, and get more and more precise as that knowledge increases.*

We have lately heard a good deal about the strides made in applied science during the nineteenth century, and we are all agreed as to their importance. In pure science, also, we have heard much of another great feat of the last century, namely, the establishment of the theory of evolution. In this case, all acknowledge its importance, but all are not agreed as to its meaning, and some still think its teaching to be decidedly hurtful. This is a subject to which I have given much thought for the last thirty years; during which time a great change has taken place in scientific opinion, and it is to this change that I wish to direct your attention this evening. It is quite possible that I may have over-estimated the growth of the change; for we, who live in the Southern Hemisphere, are not so advantageously placed for recognising contemporary scientific opinion as those who live nearer the centres of scientific activity. But, whether the change be slow or rapid, it is unquestionably going on, and there can be no doubt about its importance.

I am quite aware that the theme I have selected is an ambitious one. But if our ideas are ever to crystallise into some definite shape, it is necessary that a general survey of the position should occasionally be made, and I do not know a better opportunity than the presidential address to an Association like this, where all branches of science are represented. I do not claim to speak with authority, nor do I wish to pose as a philosopher; but I will give you a simple

* The term "Natural Philosophy," was formerly limited to the study we now call Physics; but as this use has been altogether abandoned, I hope that I may be allowed to revert to the still earlier and truer meaning of the term.

statement of the conclusions to which I have been led, and so, I hope, enable each of you to form his own opinion of their value.

The Growth of Natural Philosophy.

Ever since the dawn of the human intellect, man has tried to increase his knowledge in two ways, by observation and by speculation. Observation came first, for that is common to man and animals. Speculation is a distinctly human attribute, and we find that it soon out-distanced observation, and formed the basis of the earlier philosophies. But, during the last few centuries, the observational method has once more come to the front, under the name of science, and its conclusions have not always been in accord with those of the speculative philosophies which preceded it.

The difference between the two methods is that, whereas speculation starts a chain of reasoning from one or two propositions which are taken as absolutely true, science reasons from the basis of as large a number of observations as possible, and tries to find a hypothesis which connects them all together, or explains them, as it is usually called.

Evidently, this scientific process is a very laborious one, but it is to be more trusted than speculation. For we can never be certain that any single proposition is quite true, or that it contains the whole truth; and, as it is impossible to allow for modifying circumstances, reasoning alone may lead us far astray. While, with the scientific method, attention is directed to errors of observation, which can be corrected, and new facts are constantly confronting us which tend to prove, or to disprove, or to modify, our theories. These theories, in time, get established as what we call "laws of Nature"; that is, accurate records of observed cause and effect, and they thus form a touchstone of exact knowledge by which the speculative philosophies must be tried.

No doubt, these two processes of observation and speculation went on in a desultory, impulsive manner for several thousands of years, during which man not only learnt a great deal about the material world, but was led to speculate about the immaterial, or spiritual, world, which he believed to encompass him on all sides. We can never know with certainty how the conception of an invisible, spiritual world arose in the human mind; but we know, as a matter of fact, that it did do so at an early stage of the human intellect. Judging from the beliefs now held by the lowest races of mankind, it seems probable that when man first began, in an incoherent manner, to speculate on himself and his surroundings, the remarkable facts connected with sleep and dreams made him conclude that his intelligence was due to an unsubstantial body, or spirit, living inside him, which could leave him, travel about. and return. Dreaming of dead friends led him to believe that this spirt lived on as a ghost after the death of the body, and this belief, in time, gave rise to ancestor worship, which passed, first, into the deification of ancestors, and, afterwards, into that of mythical personages who were not considered as ancestors. Thus arose that belief in beneficent tribal gods which still has great influence even among civilised nations.

Primitive man passed from the idea of human spirits to the belief that inanimate bodies also contained spirits. But, as these inanimate things were often thwarting his wishes, and frightening him by noises which he could not understand, he assumed that their spirits were hostile to him, and he tried to appease them by sacrifices, or to disarm them by spells.

The belief that spirits inhabit all kinds of bodies is called Animism. Both it and deification are different forms of Polytheism, which have become so mingled together that it is now often impossible to disentangle them.

This was the natural philosophy of the earlier races of man, and it came to a standstill for want of further knowledge. A very imperfect acquaintance with nature had led to erroneous ideas of religion, and a more accurate acquaintance with nature was not then possible. However, a foundation had been laid which was subsequently built upon by metaphysicians, and, in the course of time, Polytheism passed into what Professor Max Müller has called Henotheism. That is, the gods are no longer regarded as of equal power, but a supreme spirit rules over the others.

Henotheism appears to have originated independently among the negroes of Africa and the Red Indians of America, as well as among the semi-civilised nations near the eastern shores of the Mediterranean. In Persia and N.W. India, the philosophers developed Animism into Pantheism, a philosophy which teaches that mind pervades all matter, and that nature and God are one. On the other hand, among the Semitic nations, the prophets of Israel gradually passed from a belief in tribal gods to Theism, in which God is recognised as existing outside of, and unconnected with, the material universe, which He has created.

The originators of these philosophies were, however, poets or mystics, who arrived at their conclusions intuitively, and could offer no proofs, thinking, indeed, that their beliefs must be self-evident to all. So, at a later date, we find an Atheistic philosophy, or Materialism, also, in existence, due, probably, to a reaction against the excesses of the Greek Mythologists. That the truth of none of these philosophies was self-evident is shown by the fact that, in the classical world, all of them flourished together, and highly cultivated men could be found among the Polytheists, the Pantheists, the Theists, and the Atheists.

At last science awoke from its long sleep, and began to study with care the material phenomena of the Universe.

Scientific observations commenced with the Chaldeans and early Greeks; but it was a dreamy kind of science, confined to a few. The spirit of inquiry was not thoroughly aroused until the bold navigators of the fifteenth and sixteenth centuries sailed round the world, and demolished the old dogma that the earth was a flat disc, with Jerusalem in its centre. Then the invention of the printing press spread the news far and wide, and from that time forwards science took an important position in the world.

Long before this, however, the idea of law and order in Nature had been gradually growing. The wonders of the thunderstorm, of eclipses, even of the rainbow, had been explained as the result of physical laws, and the consequence was that the belief in the crude Polytheism of the ancients had been destroyed.

The advance of scientific knowledge was at first very slow, until, in the seventeenth century, the great improvements which were made in mathematical analysis, as well as the invention of the telescope, enlarged men's ideas enormously, and added vastly to their powers of observation and reasoning. Before the century was over, the size of the earth had been ascertained with tolerable accuracy, and the law of universal gravitation had been discovered. In the eighteenth century, great progress was made in the experimental sciences of physics and chemistry. Electricity was detected, as, also, was oxygen, and this laid the foundation of modern chemistry. Instruments of precision for weighing and measuring were invented, and, at the end of the century, not only was the distance of the sun approximately ascertained, but it was proved that matter was not destroyed when it was burnt, but only rendered invisible. The discovery that matter was indestructible led, in the nineteenth century, to the further discovery that the physical forces are so correlated that one can be changed into another. And, at last, it was definitely proved that energy was as indestructible as matter; that it was not lost when it was no longer exhibited, but had merely passed into the potential or invisible state.

Another important result of these investigations was to prove experimentally that matter is inert, and that it exercises no initiative of its own; that it is moved only by external agencies; and that, in physics, action and reaction are always exactly equal and opposite, from which it follows that all material things are under the reign of law. This cannot be taken as a proof that mind is absent from dead matter, for it is possible to conceive mind as present, but unable to manifest itself to us. But the experiments destroyed the supposed basis of fact on which Pantheism had formerly been built, and reduced it to a purely metaphysical speculation.

If, however, science showed that the original basis of Pantheism was erroneous, it now furnished new evidence, which seemed to place that philosophy on a firmer foundation than ever.

Up to the middle of last century, it seemed probable that the Universe might be eternal. Matter and energy were known to be indestructible, and it followed that the amount of each in the universe must be fixed and unalterable. Also, the mathematicians, Lagrange, Poisson, and Laplace, were supposed to have demonstrated that the Solar System was truly a perpetual motion. Even in the earth itself, the celebrated geologist, Dr. James Hutton, sought, as he said, in vain, for any "vestige of a beginning or prospect of an end." So far as could then be seen, the world might go on for ever as it is now, an endless succession of similar years and of nearly similar plants and animals. It was not even necessary to suppose, with Democritus, that the Universe was the result of a fortuitous concourse of atoms, for there was no beginning. The Universe had always been here, and here it would remain. Life, they thought, had always been on the earth, and where life was there also was mind. And just as one form of matter, or one form of energy, passed into another, so life kept renewing itself—constant decay and death with constant rejuvenescence. If matter was indestructible, so, also, was mind. All was eternal. All was made to go on for ever. No controller was necessary. The Universe and its Maker were one.

Thus, the conclusions of science seemed to prove that mind pervades all matter; and this belief was more acceptable to our reason than the opposite one, that mind can exist outside of matter, for of the latter we have no experience. Thus, a pantheistic, or monistic, view of the Universe became prevalent, especially in Germany. As the study of palæontology advanced, the succession of life on the earth became a difficulty, and Darwin's theory of organic development, by means of natural selection, was hailed with delight as the explanation so long hoped for. But, in truth, the pantheistic argument was completely destroyed by the establishment of the theory of evolution, which showed that the Universe was not eternal, and that progress, not repetition. was the law under which it existed.

The change thus brought about was sudden and perplexing, and some very able men could not see their way clearly. So they called themselves Agnostics, thinking that no well-established beliefs on theological questions were possible to the impartial investigator. If this had been correct, it would have been a fatal objection to the claim, which was at the same time being made, that science should be included in general education. Fortunately, broader and more sensible views have prevailed, and it is no longer considered that a scientific man must necessarily be an Agnostic.

An Outline of Evolution.

Let me now give you an outline of this theory, which wrought such a momentous change.

The idea of evolution originated with the Greeks. but only as a speculation, which led to nothing; and its scientific history may be said to commence in the early part of the last century, when the practically new theory of the origin of species by gradual development was proposed by Lamarck. This theory was at first discredited for lack of evidence, but it was developed and demonstrated by C. Darwin in the middle of the century. About the same time, it was pointed out by Lord Kelvin that not only was the sun cooling, but that all kinds of energy, when converted into heat, lost a portion by radiation into space, and that this process must go on until the whole universe was of a uniform temperature. So that, although the amount of energy in the Universe remains unalterable, it will, by re-distribution, be brought into the potential state, and thus, when every possible action is counterbalanced by other actions, energy will practically disappear.

From this theory of "dissipation of energy," it follows that, as the earth is cooling, life cannot go on for ever; and also that at some former time the earth must have been too hot for the existence of protoplasm. Consequently, life can only have a limited existence on the earth. It must have had a beginning, and must come to an end.

But the inference extended further. Not only living beings, but even the whole Solar System, must have had a beginning. not indefinitely remote; because most of its mem bers still contain a large amount of their original heat. And if the Solar System had a beginning, so, also, must each star in the heavens have had a beginning; for the very fact that we can see them is a proof that they are radiating out energy. And, it was asked, why should not the whole Universe, visible and invisible, have had a common origin and a common beginning in time? This had been the opinion of Immanuel Kant in the middle of the eighteenth century, and, although modern astronomy has not altogether confirmed his speculations, it has proposed a hypothesis which is not very dissimilar. This is the "Meteoritic Hypothesis," and is chiefly the work of Sir Norman Lockyer and Professor G. H. Darwin. I will give you a short sketch of the views held by the former.*

Inorganic Evolution.

The close connection between the orbits of comets and those of meteoritic streams has led to the universally-admitted conclusion that comets are neither more nor less than swarms of meteorites. Again, the resemblance between the spectra of comets and those of nebulæ suggests that these, also, are swarms, or aggregations, of meteorites. And we naturally infer that the stars with similar bright-line spectra must be collections of meteorites. From bright-line stars we pass to those whose meteoritic origin is no longer to be recognised, all having blended together. Further, it is claimed that, by supposing variable and temporary stars to be due to the meeting and entanglement of two meteoritic swarms, we get a better explanation of the observed phenomena than any other hypothesis can give.

This meteoritic hypothesis supposes that the present material Universe was at one time in a state of "cosmic dust," spread irregularly through space, and moving slowly in many directions. It is the original irregular distribution of the cosmic dust and its irregular movements which are the source of all the energy in the Universe. We have specimens of this cosmic dust in the chondroi, or spherules, of which many of the stony meteorites are built up. They are small round bodies of crystallised minerals, varying from microscopic dimensions to the size of a marble. Of course, these chondroi are not the first form in which matter existed. They are evidently due to chemical reactions, and we could frame several different hypotheses as to their origin and his-

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* See "The Meteoritic Hypothesis," Macmillan, 1890; and "Inorganic Evolution," Macmillan, 1900.

tory. But these would be speculations which could not, at present, be verified, and so we must content ourselves with the chondroi as the earliest form of matter known to us.

Through the action of gravitation much of the cosmic dust is supposed to have aggregated into meteorites, whose irregular movements were, in certain places, reduced to order; and so arose a number of meteoritic streams, or swarms, moving through space. Still, under the force of gravitation, each of these swarms got more and more dense, until, at last, collisions took place between the meteorites; light and heat were given out, and the swarm became a nebula. The heat produced by the collisions would, at first, be slight, but would gradually increase, until the whole of the solid material was resolved into vapour, and a star was formed. Concentration, however, would still go on, and the temperature of the star would rise, until, in time, the loss by radiation more than counterbalanced the gain by concentration, when the star would begin to cool. At last light would no longer be given off, and the star would end by becoming a dark cold body moving in space. Of course, some stars would attain a higher maximum temperature than others, and either a single or a double star might be the result of the condensation; but all would follow a somewhat similar development.

Now, as a matter of fact, the spectroscope shows us that stars in all these stages actually exist at the present day in the heavens. In some the temperature is increasing, in others it is decreasing; and, although small stars must run through their development quicker than large ones, this is quite insufficient to account for all the present differences. From which it follows that some of the stars are much older than others. The sun was amongst the earliest of formed stars. When it was born the sky must have presented an almost uniform blackness. There was no Milky-Way; no Orion nor Southern Cross; no Pleiades nor Dog-star. All these, and many others, have been added since; not altogether, but one after the other, through the long ages during which the sun was undergoing development. Judging by the relative ages of the stars, it seems probable that the process of concentration of the original cosmic dust commenced near the Solar System, and spread outwards to the Milky-Way. But, however this may be, the process is not yet over. Many nebulæ have not yet condensed into stars. Swarms of meteorites still traverse space, and, even in the neighbourhood of the Solar System, they are so abundant that the earth alone is estimated to collect more than twenty millions each day.

However, slow as the process of condensation is, it is not endless. In time all the meteoritic dust will be collected into stars or planets, and in time the law of dissipation of energy will bring all these bodies to a uniform temperature. So, at last, the movements due to the original unequal distribution of matter will cease, and the life of the universe will come to an end. We know of no process of rejuvenescence by means of which dissipation of energy, and the force of gravitation, might be counteracted. Several attempts have been made to refute the theory of dissipation of energy. but all have failed. The ether, which pervades space, is the only part of the Universe which shows no sign of evolution. It alone remains unchanged.

A casual glance at the stars gives us the impression of immutability. We still speak of the fixed stars in much the same way as our forefathers used to speak of the everlasting hills. But we know that they are not fixed. We know that the nearer stars, including the sun itself, are in swift movement; and we infer that all are so. But we can see no connection between their movements. Single stars, or small groups of stars, are rushing through space in various directions, and we cannot detect any common centre of gravity which holds them in control. The stars have not yet attained the regularity of movement that gravitation must bring about in a very ancient system, and this idea of the comparative youth of the Universe is strengthened when we remember that large numbers of the primitive meteorites are still wandering in space uncondensed into stars. If it be true that the sun is one of the oldest stars in the Universe, and if, as geologists think, the earth is not more than a hundred millions of years old, then it may very well be that the creation of the cosmic dust out of which the stellar Universe has been formed, took place less than two hundred millions of years ago. But, although it may be possible to place a limit to the age of the Universe, we can fix no time for its duration. It is impossible to form an estimate of the hundreds of millions of years that will pass before the end approaches. Still, a time must come when all energy will be equilibrated; and when, possibly, the visible Universe may resolve itself into invisible, motionless ether.

In the Solar System we can study the development of a meteoritic swarm in greater detail. Here we find that the whole of the meteorites did not collect into a single mass, but that several planets, as well as the sun, were formed simultaneously. It has been shown by Professor G. H. Darwin that the effect of many collisions among a swarm of meteorites would be to gradually eliminate orbits of great eccentricity until, in time, a regular system would be developed, when the whole of the meteorites would travel nearly in the mean plane of their aggregate motions. The larger of the meteorites would tend to settle towards the centre, while other aggregations might easily occur at different distances from the centre. And of these, the outer planets would be larger than the inner ones, because, in the more distant regions, where the attraction of the central sun was less, the movements of the meteorites would be slower, and there would be a greater tendency to agglomeration than where the movements were more rapid. As meteorites contain but little oxygen, hydrogen, carbon, silicon, and alkalies—substances which are all abundant on the surface of the earth—large numbers must have been fused together to form the earth, and the lighter substances must have collected near the surface. Consequently, the collisions between these meteorites must have occurred with sufficient rapidity to melt the whole mass. For, after a solid crust had been formed, all the meteorites which fell on the earth would remain on the surface, as they do now.

As with the Solar System, so, also, in the earth itself we can trace distinctly a physical evolution. The discovery of tidal friction gave an independent proof that the earth had had a beginning not infinitely remote, for, if that had been the case, the tidal friction would have reduced the time of the earth's rotation on its axis to that of the moon. Also, we have sufficient geological evidence to show that not more than one hundred millions of years ago the earth was in a molten condition, and, probably, shone with its own light. As cooling went on, the silicates crystallised out, forming a solid crust over the still molten, metallic interior, and the earth then became a dark body. At that time, all the water above the crust was in a state of vapour, which, subsequently, fell as hot rain, forming a boiling ocean. With this rain the denudation of the primitive crystalline rocks commenced, and their *débris* was deposited on the bed of the ocean as sedimentary rocks. Gradually, the continents were formed, the new ranges of mountains following each other in orderly succession, the great oceans becoming narrower and deeper, as well as more and more salt. These processes are still going on, but, as the earth is cooling, the internal energy which uplifts the mountains must be diminishing, and, in time, it will be insufficient to counteract the denudation. Then the whole of the land will be swept into the sea, and the waves of the ocean will roll over the surface of the earth unopposed. Unless, indeed, before that time arrives, the ocean should have been frozen into a mass of ice.

or should have sunk slowly into the ground. All these things are approaching, but which of them will come first it is impossible to say.

Organic Evolution.

When, during the course of physical evolution, the ocean had become sufficiently cool for the existence of protoplasm, minute living organisms appeared on its surface. These increased in size, varied in many directions, and, in time, discovered the bottom of the sea, on which they established themselves, changing from swimming to crawling creatures. Gradually, these organisms managed to live in safety among the rough waters of the sea coast, and then they spread over the land. First the plants, and then the animals, which came to feed on the plants.

Once established on land, and breathing air, improvements in the circulatory system of the higher animals became possible. The purified blood was kept separated from the impure blood, and increased rapidity of physiological processes heated the body, so that, in the birds and mammals, a stream of pure, warm blood was poured upon the brain. Thus stimulated, the brain developed rapidly, and the psychological evolution, thus inaugurated, has reached such a height in man as to place him mentally apart from the rest of the animal kingdom.

Biological evolution differs from physical evolution in being brought about by the transmission of bodily variations from one generation to another. And, in psychological evolution, mind is transmitted from parent to offspring, as well as the organ in which it is to be manifested. Intelligence, however, depends not only on the structure of this organ, but on early associations and education, by which means the wisdom of one generation is handed down to the next.

Psychological evolution consists of two parts. The first is intellectual, and is found in all the higher animals, as well as in man. The second is ethical, and is exclusively human.

Intellectual evolution, like biological evolution, is due to competition between different individuals and the action of selection. We probably see the first germs of ethical evolution in parental affection, which, among gregarious animals of sufficient intelligence, widened into social sympathy, and this, in man, gave rise to the social or civic virtues.

This advance also appears to have been, or, at any rate, may have been, due to selection, and the result was the emergence of what is called utilitarian morality. Morality, in the strict sense of the term—that is, formal morality—also appears to have arisen from sympathy, but not by means of selection. The long and constant use by man of formal morality has made it instinctive, and has thus given rise to the conscience.

How sympathy gave rise to the conscience is a difficult problem, about which we know very little at present, for few people have taken up the study of ethics from an observational basis. Darwin asks: Why does man regret, even though trying to banish such regret, that he has followed a natural impulse rather than a higher ideal; and why does he further feel that he ought to regret his conduct, while such a course never occurs to animals? And he answers: It is because the higher impulse, due to sympathy, is continuous; while the lower one, due to selfishness, is temporary. And, comparing the transient impressions of past indulgence with the ever-present feeling of sympathy, he feels that he was mistaken in following the lower impulse. And it is this that causes him regret, or even shame.*

But the process, as described by Darwin, evidently implies a considerable intellectual capacity, and, what is still more important, the exercise of free will. For no one could regret following a lower impulse unless he felt that he had the power to choose a higher one. Ethical development, therefore, could only commence at a stage far above the highest apes, and, probably, above the earlier forms of man. Meantime, while this growth of sympathy was taking place, the evolution of religion, as already described, would have been going on, and the priest would have assumed a position of great importance. It is he who would draw up the standard of right and wrong, and thus morality would be reinforced, and stimulated by the religious feeling.

It, therefore, appears that ethical and religious development were at first separate, but quickly coalesced, until, in Christian countries, they are completely blended. But this mutual dependence is not so pronounced everywhere. The Chinese and Japanese have high codes of morals with very indistinct notions of religion; while the Hindus have very strong religious feelings, combined with weak ideas of morality. However, it is not possible to give even the slightest outline of ethical evolution without mentioning the religious element. The important point to remember is that ethical development is due to a conflict of wishes in the individual himself, and is possible only because man has the

* Descent of Man, 2nd. ed., page 112.

power of choosing one of these wishes, and acting upon it; that is, to the exercise of free will. It seems to me that free will would be useless to any being who did not possess a moral sense, for its only use is to cultivate morality. The exercise of this free will by ignorant man leads to much injustice on the earth; but that is part of his education, and no doubt the end will be found to justify the means.

Now, we cannot think that the evolutionary process, of which I have given you a mere sketch, is confined to the earth alone. We must suppose that, whatever may be the object for which the Solar System was called into existence, it is for the same purpose that the various stellar systems exist. And, in all probability, long after the sun is cold and dark, other stellar systems, each in its turn, will take up the development of life and mind. But they, also, in time, will become cold and lifeless, until, at last, the process, so far as it is connected with the material Universe, will be over. But is it not possible that evolution may still go on after life has perished? This is a point to which I will return presently.

Design in Nature.

Evolution is evidently due to the action of mind. There are some who still maintain an opposite view, but I think that their numbers are fast diminishing. It seems to me that no one who has a competent knowledge of biology and palæontology can possibly accept the doctrine that living organisms are the outcome of chance. Darwin distinctly repudiated the idea, and thought that variation in animals and plants could not be explained by a mechanical theory of the Universe. I must here try to make my meaning clear. We apply the word chance to those phenomena which are irregular in their appearance, and which are due to causes too complicated for us to unravel. We call throwing dice chance, because we cannot foretell what will happen. Similarly, if we say that evolution is due to chance, we mean that the Author of Nature could not foretell the results of the action of the forces he was setting in motion. Now, is the universe due to design, or is it due to what we may call a lucky throw? Has it been brought about intentionally or unintentionally? That is the question.

It may be possible to imagine a cloud formed by meteorites, which are moving rapidly in all directions, but are unable to escape from the cloud, gradually changing, by mechanical laws, into a sun with its attendant planets. But we cannot imagine how the action of any mechanical causes could clothe one of those planets with vegetation; fill that vegetation with various kinds of animal life, and, at last, give rise to a being with sufficient intelligence to ask how and why it was all done. The idea that physical forces called into existence indiscriminately, and without any ulterior object, could, by their interaction, evolve the earth and all that is on it, is, evidently, quite incredible. But this general statement leaves only a vague impression on the mind, and, in order to clear our ideas, I will give you two examples, one taken from inorganic, the other from organic, nature, and treat them in some detail.

In the first place, let us consider the formation of the earth itself. It is evident that no organic development of importance can ever take place on the sun; for, when it has cooled sufficiently to make the formation of protoplasm possible, the temperature of its surface will be rapidly reduced to a point below which protoplasm could not live, so that there would be no time for life to develop. From this we learn that biological evolution can only proceed on a cool body, the surface temperature of which is kept nearly equable by radiation from another hot body. As these conditions must last for a long time, the hot body must be large, and at a proper distance from the cool body. But much more than this is required for the development of life. If living organisms were intended to progress from the ocean to the land, in the way I have already mentioned, provision must be made for the continuous existence of land from the close of the Cambrian period, and this land must be well watered. Consequently, the surface of the earth must consist partly of land and partly of water, in due proportion; and the actual amount of water necessary will depend upon the size of the earth. The rain, falling on the land, constantly washes it down into the sea, and some agency must exist for renewing the land by elevation. This elevation depends upon the mobility of the crust, which again depends upon the internal temperature of the earth. This, therefore, it is necessary to conserve. Again, the mass of the earth must be sufficiently great to retain on its surface by gravitation the water-vapour, which would fly off and leave the world dry if the mass was too small. And, once more, the materials necessary for supporting life and building up organisms must be present.

From these considerations, it follows that, to secure a long development of life, the mass of the earth must be considerable, and that the cooled crust must be a bad conductor of heat. That is, it must be formed of oxides, and not of unoxidised metals. There must also be a certain relationship between the quantities of the several elementary substances of which organisms are composed. It is necessary that there should be a certain quantity of hydrogen for the water—not too much, nor too little—as well as what was required for the tissues of plants and animals. Silicon and aluminium are necessary to form a non-conducting crust. Oxygen is necessary for the water, and to combine with the silicon and aluminium; while enough must remain over for the respiration of animals. Carbon must be in sufficient quantity in the atmosphere for the plants, but it must not be so abundant as to poison the animals. And calcium is necessary for the skeletons of animals, without which they could not have grown to any size. Too much lime, however, would have taken all the carbon out of the atmosphere, and there would be none left for the plants. A little more hydrogen or carbon, or a little less oxygen or silicon, would have rendered the earth uninhabitable. Even the right proportion of the elementary substances would have proved useless if the earth had been too small, or if the temperature of its surface had been much hotter or colder than it is. The latter depends upon the distance and temperature of the sun, and has nothing to do with the size and composition of the earth. Also, if man was ever to become civilised, gold, copper, and other metals in accessible positions were necessary, although they are of no use in the economy of animals and plants. Gold, however, would be almost useless to man if it was abundant, while iron would be equally useless if it was as rare as gold. But we know that these, as well as the other substances, exist in their right proportion.

We cannot believe that all these various and complicated adjustments were brought about by a fortuitous concourse of meteorites. When a writer of stories wrecks his hero on an uninhabited island, on which, from time to time, he finds everything he wants to make himself comfortable, we think, as we read, that the story cannot be true, because all these useful things could not possibly have come to the island by chance. It is just the opposite with the story of the earth. In this case we know that the statements are true. We know that all these useful things were found when they were wanted. First, the silica and alumina for the earth's crust; then, the carbon, nitrogen, and other materials for the protoplasm; then, copper, iron, and gold for man. Here, also, we say that this cannot be due to chance, and the only alternative is design.

It is possible that, in the meteoritic hypothesis, we may find an explanation of the relations between the size of the earth, its internal temperature, and its distance from the sun, although this is not likely, as there is no uniform gradation among the planets in these matters. But, even if the temperature of the surface and of the interior of the earth were necessarily well adapted for the development of life, still, the proportions between land and water might have been unfavourable; or if this also was suitable, there might not have been a due proportion of the various elementary substances to allow the continuous existence of life. For these different factors are in no way related.

It may be urged that, among an almost infinity of worlds, we might expect to find an almost infinite number of different combinations, and it so happens that the earth contains exactly that combination necessary for organic development. But the objection is not a valid one, because each system of sun and planets in the Universe has, no doubt, been developed under identical physical laws, and from identical substances. They are, more or less, repetitions of each other, so that the number of systems makes no difference, and the earth can only be contrasted with the other planets belonging to our Solar System. Now, have the other planets a similar composition to the earth? As they shine with light reflected from the sun, the spectroscope does not give us any information on this point, and we can only speculate. As the composition of the sun differs considerably from that of the earth, we have no reason for supposing that all the planets are similar. On the contrary, if the meteoric hypothesis be true, and if the meteorites which now fall on the earth are samples of the meteoritic cloud out of which the Solar System was formed, the planets cannot have identical compositions, because the meteorites differ considerably from each other, and no two aggregations of them would give rise to similar bodies. If, on the other hand, the present meteorites are not surviving examples of the original cloud, but have been drawn into the Solar System after it was formed, then it is impossible to form any opinion on the chemical composition of the planets.

If, however, we were to suppose, for the moment, that the chemical composition is uniform throughout the Solar System, it would not help us much, for the proportions which would be suitable for the earth would not be suitable for a planet which was either larger or smaller than the earth. This is evident from the fact that the ratio of the surface to the volume varies with the size of the planet. Indeed, from physical considerations alone, we may feel sure that, at the present time, living protoplasm could not exist in any part of the Solar System, except on the surface of the earth.

We have, therefore, in the composition, size, and position of the earth, overwhelming evidence of design. And, as we can prove that carbon existed in the Archean Era, before life appeared, and that gold, iron, and copper existed long before man, we must also allow that the results of evolution had been foreseen and provided for.

Next, let us examine the principal concatenation of events which led up to the production of civilised man. The human hand and foot were developed from organs adapted for climbing trees, and it was necessary that the early primates should take to trees at once before their limbs became specialised for terrestrial life. To induce them to climb trees, fruit and birds must have been in existence, for succulent fruits have been developed through the agency of birds. So that the previous existence of birds and flowering plants, which alone form succulent fruits, was necessary for the development of the hand. Again, man could not have attained civilisation if he had not been able to domesticate animals and to cultivate food-plants. Ruminant mammalia were, therefore, required, and these can only exist in large flocks through the peculiar growth of the leaves of grasses on which they feed. Most leaves grow very rapidly after the bursting of the bud, and then cease to grow altogether. The consequence is that if the leaves of one of these plants are continuously cut, or pulled off, they are not reproduced, and the plant dies. But, in the grasses and their allies, the leaves continue to grow at their bases all through life, so long as the temperature and moisture of the soil are favourable, and cutting and biting off their ends does the plant good, instead of harm, for it exposes the newly-grown parts of the leaves to the sun. Thus, large herds of animals are enabled to live together without destroying the vegetation; and it was this that tempted primeval man to leave the forest and live on the open land.

Now, hoofed mammals required a long time for their development, and if they had not been a very early branch of the eutherian stock, they would not have been ready for man to domesticate at the close of the Pleistocene Period. We have, thus, no less than five different groups of plants and animals which must precede man in a certain order, to allow the possibility of human civilisation. Phanerogamous trees and birds must precede the earliest primates. Grasses and ruminants must follow; yet they, also, must precede man. Now, we find that this is just the order in which they did appear. Phanerogamous trees are known first in the Carboniferous Period; mammals in the Lower Jurassic; birds in the Upper Jurassic; the primates and primitive hoofed mammals in the Lower Eocene; grasses in the Oligocene; ruminants in the Miocene; and man in the Pliocene.

The Mesozoic mammals were all quite small, and we do not know the structure of their feet, so we cannot say whether they were arboreal or not; but, with this possible exception, we find that the different classes came into existence just when they were wanted.

We must remember that these groups of plants and animals form widely separated branches of the tree of life, and that the necessary correlations, of which I have been speaking, lie outside the jurisdiction of natural selection, which, although it regulates the development of each branch, has no power of co-ordination between two branches unless one forms the food for the other. So that there is no reason at all why they should have been developed in the particular order in which they appear.

For example, the origin of birds depends chiefly on the development of highly complex papillæ in the skin, from which the feathers are formed. If these had not been developed in the naked skin of a reptile, flying birds would never have come into existence. And, if there had been no birds, or even if their origin had been delayed until the Miocene Period, there would have been no monkeys nor man. So, also, if no ruminants had been developed, this would not have prevented the appearance of apes, or even of man; but man would have remained in the stage of a hunter all his days, and could not have lived in large communities.

Now, if there had been only two of these groups, we might reasonably have said that it was by mere chance that the one was developed before the other. But when we see that there were more than two highly complex combinations, all of which happened in the particular order required for progress, it is evident that the probabilities are in favour of this particular, either by guidance or by pre-arrangement. I see no escape from this conclusion.

SECONDARY CAUSES.

But granted, what perhaps no one seriously disputes, that evolution is due to intelligent design, the difficult question arises: Has all been brought about by unalterable secondary laws imposed on matter at the creation of the Universe? Or can we recognise any evidence of guidance in a particular direction without which the design would have failed?

When we think of the whole work that has been accomplished by evolution, we are overwhelmed by its vastness. The results of organic evolution, particularly, are so marvellous that, to our limited intelligence, the forces to which they are due seem to have been constantly directed in their course. The human mind is more disposed to accept the idea of guidance than that of pre-determination, as it seems to us to be the less impossible of the two, and the more easy to understand. We, ourselves, wait upon circumstances, see how things are going to shape before we move; and we fancy that the world must have been made, and must be carried on, on the same principle. But the study of nature gradually causes this belief to fade away. The more we learn, the more we see that secondary law extends much further than we had expected, and we begin to think that all may be due to secondary laws.

We cannot doubt but that the most complicated cases of inheritance—such as the growth of the train feathers of a peacock, or the gorgeous wings of a butterfly—are due to secondary laws, although the processes are quite incomprehensible to us. We believe these to be due to secondary laws, because we see them taking place in exactly the same order over and over again; and, in the case of the peacock, we know that if we pull out the feathers, new ones, similar to the old, will replace them. So that we can bring these laws into play whenever we choose. It is not sufficient, therefore, to say that an action is not due to secondary law because it is so wonderfully intricate, or because it is incomprehensible to us. We must be able to show, either that the action is antagonistic to known natural laws, or that the result could not be due to a combination of any natural laws that we have already discovered. That is, we must show a discontinuity in the phenomena. Can any such breaks be discovered?

The origin of the material Universe, which was the starting-point of the present evolutionary process, appears to us to have been a new departure in natural law. But we cannot feel certain about it, for we do not know, and never can know, what went before. But with the origin of life on the earth it is different. The intimate structure of organic beings, as well as their order of development on the earth, point to the conclusion that they are all derived from a common ancestor, and that living protoplasm was formed once, and once only, on the surface of the sea. Now, in the origin of living substance on this planet we have a case which is generally recognised as a break in continuity. It is generally allowed that it was an action which is not only incomprehensible by us, but one which conflicts with our knowledge of natural laws. That an unstable chemical compound, endowed with the power of directing energy independently of any outside agent, should have been brought into existence by the action of known physical laws is an impossibility. The processes of assimilation and fission, on which all progress depends, are quite distinct from anything which had gone before. And, as every living cell is imbued with what we call instinct, which directs its energies, it follows that, in physiology, action and reaction are not equal and opposite. Indeed, every organism inherits from its parents a store of energy which directs growth, and which appears to be inexhaustible. It is drawn upon during the whole period of growth, which, in some plants, lasts all through life, and yet abundance is left for transmission to its offspring, no matter how numerous they may be. The store increases, instead of diminishes, and we cannot tell why. Until some explanation can be given, it is not only permissible. but reasonable, to view the origin of life as due to some guiding action of natural law, especially when we remember what that break in continuity has led to.

Again, it has been often pointed out that the genesis of consciousness is as great a mystery as the genesis of life, and that it seems to be equally opposed to the law of conservation of energy. In the lower animals, and in some of the lowest plants, we see physiological processes producing movements which appear to be intelligent, but which, in reality, are no more so than the movements of the leaves of a sensitive plant. And it is generally allowed that for the exhibition of consciousness a brain-cortex is required; but how matter in the brain-cortex becomes self-conscious we cannot understand. However, it is possible to suppose that mind is a necessary concomitant of life, so that the origin of the two may be one and the same problem. Also, as consciousness may be lost—as in habit—and regained by attention, it is possible that consciousness may be a constant function of mind, but one that cannot become efficient until a large number of specially-formed cells are accumulated in a brain-cortex. I cannot, therefore, see that the genesis of consciousness in animals necessarily marks a break in continuity, notwithstanding that its origin is quite incomprehensible to us.

Free will in man is so contrary to what we know of the laws of nature, that some metaphysicians believe there is no such thing. However, I must confess that I am one of those who think that the possession of free will by man is a truth as fundamental as self-existence. Everyone, I think, knows that, by means of his imagination, he can, at his will, strengthen one set of impulses and weaken another; and that he can, within limits, control his actions. Consequently, he knows that he is not altogether an automaton. If it could be shown that the hypothesis of necessity explained matters which the common-sense view could not do, then I might be inclined to believe in it. But such is not the case, and it seems to me that what the metaphysicians have really done is to prove that free will in man could not possibly have arisen through the action of physical causes. Here, therefore, we have another possible break in continuity. Life, and perhaps free will, could not have arisen from antecedent conditions alone, and so the idea of the continuous action of secondary causes fails.

When we try to follow the subject further, we are beset with innumerable difficulties arising from the complicated nature of the problem. However, it seems probable that the whole of biological evolution may be due to the working of natural laws which we already know, but the action of which we cannot trace out in detail. Nevertheless, we must remember that we have, as yet, no theory of variation that fits all the facts. At present, variations appear to be as capricious and unamenable to law as did the wind and rain to our forefathers. And, until they are reduced to order, and we understand how and why they arise, we must be careful not to push the doctrine of secondary causes too far. Mr. Herbert Spencer would account for everything by what he calls "equilibration"; but that is merely a word, and not an explanation. Possibly in the future, when we understand why variations occur, it may be found to be a useful word, but, as used by Mr. Spencer, it is only a cloak to hide our ignorance.

But this doubt as to how far secondary law extends need not disturb us. If we are satisfied that we see in the progress of evolution, or in the origin of life, or in the existence of free will in man, a convincing argument for the belief in design, it is enough, and we may allow, without compunction, that it is impossible to say how far back secondary law extends.

Effects of the New Teaching.

This new doctrine of evolution has changed the whole aspect of Natural Philosophy. We are now compelled to assume as first cause a power outside of nature, without which the material Universe could never have come into existence. For, in the first place, if this Universe has in itself no power of rejuvenescence, it and its Creator cannot be one and the same. The mind which moves the Universe cannot have come into existence with it; nor can they perish together; and, secondly, while the origin of life on the earth remains as evidence of discontinuity, it is impossible to believe that the evolutionary process is due to an uninterrupted original impulse, such as we must suppose would result from an effort in nature to evolve itself. And we must further believe that the mind which originated this gradual development of matter from the simple to the complex must be sufficiently powerful to direct the stupendous forces of nature; sufficiently intelligent to foresee their results when set in motion; and sufficiently moral to have conceived the moral evolution of man.

It is true, as Pantheists urge, that our only experience of mind is in connection with matter. But, so far as we know, mind is connected only with one kind of matter, called protoplasm, which cannot possibly exist throughout the Universe. Consequently, mind must either be absent from large portions of matter, or it must be associated with that matter in some way which quite transcends our experience. So that we have no more experience of mind universally distributed through matter than we have of mind distinct from matter. And the argument for Pantheism breaks down.

The Purpose of Evolution.

I come now to another aspect of the problem. As years pass on, we shall, no doubt, know the story of evolution in much greater detail than we do now. Mistakes will be corrected, and many new facts will be discovered. But nothing can alter its main outline, and a more complete knowledge will not make it more impressive. How it was brought about, and by what means it moves, are, perhaps, above our comprehension. What little we have learnt about these things is chiefly the work of three men—Sir Isaac Newton, Lord Kelvin, and Charles Darwin—Gravitation, Dissipation of Energy, and Selection—that is all we know at present.

There still remains the question—"Why was the Universe called into existence?" What does it all mean? For, if the fundamental doctrine of Theism is established, it necessarily follows that the Universe exists for some purpose towards which evolution is working, and, so far as the earth is concerned, it seems possible that we may arrive at some conception of what that purpose is.

We have already discovered that the physical evolution of the Solar System was followed, as soon as the earth was sufficiently cool, by the production of protoplasm and the biological evolution of living organisms. These we know soon divided into plant life and animal life; and, when the brain was sufficiently developed, animals showed the commencement of a psychological evolution of mind. At first this latest development of evolution was entirely intellectual, and was chiefly employed in the preservation of the race. At a later stage, a higher development took place, and a moral evolution commenced. Physical evolution, biological evolution, and psychological evolution are still going on. So far as the earth is concerned, physical evolution has reached, probably it has passed, its optimum, for the earth cannot in the future be better fitted for the development of life than it is now. Biological evolution has also reached its optimum in man, whose body has been practically stationary since the middle of the Pleistocene Period, and cannot now be affected by natural selection. Indeed, ever since the beginning of the Neolithic Age, man has been engaged in combating natural selection by endeavouring to alter the surrounding conditions to suit himself. This he does by making artificial warmth, building houses, making clothes, and cultivating land.

Psychological evolution, however, has not reached its optimum. The development of the human mind is but in its infancy. Man's origin dates back only some tens of thousands of years, while he has several millions of years before him. During that time it is impossible to predict what will happen; but, so long as the external conditions are favourable for the working of the brain, we may feel sure that psychological evolution will continue.

Any other kind of evolution besides those of matter, life, and mind, is unimaginable, because we know of nothing else on the earth to evolve. The physical evolution was evidently intended to prepare the way for the biological evolution which led up to man. And the brain of man was thus prepared for the psychological evolution which is still in progress, and which, as I have said, appears to be the last form which evolution can take. So that the development of man's moral nature must be the purpose towards which evolution tends on the earth.

This idea is by no means new. In the middle of the eighteenth century, Immanuel Kant said that "the cosmic evolution of nature is continued in the historic development of humanity and completed in the moral perfection of the individual." And, a little later, Goethe, another pioneer of evolution, said that the sole purpose of the world appeared to be to provide a physical basis for the growth of spirit. However, our ideas on the subject are much clearer now than was possible a hundred years ago, and what was then a speculation has now become a demonstrated truth.

But, if we believe in a purpose at all, we must believe that everything which has contributed towards realising that purpose was designed to do so. If the carbon in the earth's atmosphere was intended for the building up of organic beings, so also were iron and gold intended for the use of man. And, further, there are numerous things in the world which, by their variety or beauty, so excite our admiration or curiosity as to induce us to examine them closely, and thus they have helped to lay the foundations of science. This appears to be the only use these things have in the world. As examples, I may mention crystals, and the beautiful colours and shapes of many animals. Attempts have been made to show that all the latter are either of use to their possessors, or else that they have been of use to some ancestor, and are, therefore, in no way connected with the evolution of man. They are thought to be merely side branches, which led to nothing, from the main stem of evolution. These attempts to make the utilitarian doctrine universal were never agreed to by Darwin, and, to the best of my judgment, they have not been established.*

We all recognise what science has done for civilisation. But how did the scientific study of nature begin? And why is it carried on? No doubt it is largely due to man trying to make himself more comfortable by improving his surroundings. But this is the work of applied science only, and for workers in pure science mere utility has no charms. It is the wonderful and the beautiful in nature which are, and always will be, the moving forces of pure science. Utility has never been the only agent which excites men's minds to observe and to reason, and all the great laws of nature have been discovered without any reference to it. Without the beauty, and wonderful complexity, of natural objects, man would never have risen above the level of an intelligent beast. Biologists, too, often forget that wonder and admiration are the principal moving forces in psychology. And as we may feel sure that beautiful objects were intended to do the work they have done, it follows that the wonderful and the beautiful must be recognised as prospective agents in biology.

But, if all these elaborate arrangements have been designed for the purpose of constraining man to evolve his own mind, there must be some reason for it. If it is part of the

* See Jour. Linn. Soc. Zoology, XXVI., p. 330; and Ann. Mag. Nat. Hist. Ser. 7, Vol., XII., p. 221.

scheme that each of us should do his best to cultivate his intellect and his moral sense, it must be for some ulterior object, which we do not yet know. We see some men and women devote themselves to the welfare of mankind. They go through the whole ethical evolution, and follow strictly their consciences, refusing to do wrong even under great temptation. And then they die. Is that the end? The whole progress of evolution, from the creation of the cosmic dust, has for its goal the production of these men and women, and, if they have perished, all appears to have miscarried. Was man given life, thought, and freedom of action for nothing? I cannot think so, because I cannot believe that evolution will have no permanent effect. I cannot believe that, after the material Universe has passed away, the universal mind, which ordered it, will be exactly as it was before psychological evolution began. If mind is indestructible, the evolved human mind must re-act on the universal mind and change it. And thus I feel constrained to believe that psychological evolution may continue after the death of the body in which the mind is temporarily encased.

If evolution was gradually leading to a state of perfect happiness on earth, if we might suppose that a millennium was approaching, then we might possibly believe that this millennium was the final purpose of terrestrial evolution, however inadequate it may appear to be. But there is no evidence of a millennium even in the very far distance. So long as man exists, ethical and intellectual evolution will both be going on, and they will always be in antagonism. The struggle for wealth and power will never cease, and, while it continues, there can be no millennium. The wolf will live as long as the lamb, and the two will never lie down together. So we must look elsewhere for the object of evolution.

Indeed, psychological evolution is not making towards happiness. Birds and other animals are as happy as man. Civilised man cannot boast that he is happier than the savage. The greatest happiness of the greatest number may be the ideal of the politician, but it has never been the ideal of the moralist. With him happiness may come as an adjunct, but it cannot be a prime motive for action. His ideal is duty. Consequently, ethical evolution seems to be leading up to something which is not displayed on earth, and which we can only conceive as a further development of psychological evolution when mind is freed from matter.

It will be objected that we cannot even imagine a spiritual life unconnected with any material substance. That is quite true; but it proves nothing. As I have just said, we know that physical evolution prepared the way for life, and that biological evolution prepared the way for the development of mind. In each case the evolution had a prospective purpose, which could not have been predicted by an intelligent onlooker. Indeed, the intelligent onlooker might have been sufficiently self-confident to affirm at each stage that no further evolution was possible. And it seems to me highly probable that psychological evolution on the earth may also have a prospective purpose. That it also will lead to a further evolution, which we cannot even imagine, but which must be connected with a spiritual existence beyond the grave.

And thus, at the dawn of the twentieth century, we come back to the old belief, held by the rude men who inhabited Europe in the Neolithic Age, that man's spirit does not die with his body. But we hope that we have surer grounds for that belief than had our ancient ancestors, who, as I have already pointed out, founded their opinion solely on their dreams.

Summary.

I will now, in conclusion, shortly summarise what I have said. We have seen that natural philosophy was, at first, polytheistic, and then become dormant for many centuries. After the revival of the study of nature, scientific teaching was decidedly Pantheistic, but it has now come round to Theism, and this last change was brought about by the establishment of the doctrine of evolution. It appears highly probable that the material Universe is not eternal, but will, in time, come to an end. The earth, and, consequently, the sun, is probably not much more than one hundred millions of years old; and, as the sun is one of the oldest of the stars, it is probable that the origin of the Universe does not date back for two hundred millions of years. What went before, and what will come after, we can never know; but we may believe, with some confidence, that there is no natural process of rejuvenescence—no possibility of the present Universe coming back again to its original starting-point.

Now, for anyone who believes that mind has been the organiser of energy, there can only be two competing theories of the Universe—Pantheism (now usually called Monism) and Theism (now often called Dualism). But either there is some process of rejuvenescence which has not yet been discovered, or Pantheism is impossible. As reasonable men and women, we must follow the best available evidence, and I do not see how it is possible for anyone to believe in Pantheism, so long as the origin of life remains unexplained. Consequently, Theism is left as the only possible theory of the Universe. And I have, I hope, shown that there is sufficient evidence of design in nature to convince us that evolution has not been due to haphazard effort, but to deliberate action, leading up to some ulterior purpose which it is the great wish of man to fathom.

We know that the sun is in its old age, and that in a few more millions of years it will cease to have any vitalising effect on its planets; also, we know that biological evolution has nearly run its course on the earth. The race of life is over, and man has won. No other animal can ever arise to compete with him, for he could destroy it long before it became formidable. Psychological evolution alone is in the ascendant, and this has yet much to do, especially in the domain of morals. Ethical evolution—founded on free will, which changed the human mind into the human soul—is the highest and last form of evolution possible on the earth, and, consequently, so far as terrestrial evolution is concerned, the development of the human soul must be the object for which we are seeking; and, if this is so, there ought to be no difficulty in believing that everything which, either directly or indirectly, has been instrumental in the development, was designed for that purpose.

But if all has been planned for the development of the human soul, there must have been some reason for planning it. There must be some further purpose, which is hidden from us. We cannot believe that the ultimate object was the happiness of man on earth, for there is no evidence that psychological evolution has increased his happiness. It is not the pursuit of pleasure, but the feeling that duty comes before pleasure, which is the moving force in ethical evolution. So we come to recognise that the ultimate purpose of evolution cannot be fulfilled on the earth; and we are thus led to believe that our spirit will not perish with the body, but will, in some way or other, lead a new existence. And as we know that on the earth better has constantly succeeded better, so we may hope it will be in the spiritual world.

Such seems to be the teaching of the modern doctrine of evolution. It is a philosophy which does not come to a close on this earth, but points forward, and dimly shows us, from a study of the past, what we may expect in the future. Without any doubt, it teaches us that man has been introduced on to the earth for some special purpose, and it appears that that purpose can only be attained by the exercise of his free will. This being so, we infer that human beings have been formed to educate the mind, and fit it for a future spiritual existence, unconnected with the material earth.

No doubt we are at present merely at the commencement of our researches in Natural Philosophy, and during the coming century we may look forward to great advances in knowledge. But, in my opinion, we can never know more than we do now about the future immaterial life, and with that knowledge we must be content.

REPORTS OF RESEARCH COMMITTEES.

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REPORT OF THE COMMITTEE

ON

THE MAGNETIC SURVEY OF NEW ZEALAND.

THE survey has been continued by Mr. Coleridge Farr, with the assistance of Mr. H. F. Skey, and the number of stations at which observations have now been made is about 180.

The self-recording variation instruments have been installed in a specially-constructed cellar in the Christchurch Botanic Gardens. The cellar has double walls, the outer wall being 1 foot in thickness and the inner 9 inches. These are separated by an air-space of 3 inches. The materials used in the concrete have been tested, and are non-magnetic, and the nails used in the wooden superstructure and the door fastenings are all of non-magnetic metal. The roof also is of non-magnetic slate. The driving-clock of the instruments has been altered, so as to be capable of driving the drums at either of two speeds, viz., one revolution in 34 hours or one revolution in 1 hour 36 minutes. This latter speed is a close approach to that desired by the International Magnetic co-operation of 24 cm. per hour, viz., 23·25 cm. The arrangement, which has received a very thorough testing by being done continuously for about 80 hours, consists of an additional escape-wheel of two teeth only, separated by 180°, working into an anchor, the teeth of which subtend 90° at the centre of the escape-wheel. To avoid excessive knocking, the driving-weight has been diminished, but is still amply sufficient. The alteration from one speed to the other can be effected easily in 10 seconds.

A new magnetic absolute house has also been built, with two stone pillars of Oamaru oolite, capped with marble, and also office buildings, with a room attached for the Seismograph. A Milne horizontal pendulum, Seismograph No. 16, has been installed in the room. The beam has been adjusted to have a period of 15 seconds.

An order has been sent to England for apparatus for observations of atmospheric potential, and a complete set of meteorological instruments will shortly be installed.

The observatory has been made the base station of the British National Antarctic Expedition, and an agreement has been made between the Expedition and Mr. Coleridge Farr to run the Eschenhagen variation instruments to be installed in the south, and the Kew pattern magnetograph at the Christchurch Observatory, at the high speed during the whole 24 hours of the arranged seven days. This will be commenced on 1st March in Christchurch, and as soon as possible in the south, and will be continued as long as circumstances permit in the south and in Christchurch until the Expedition returns. A notification of the arrangement, signed by the Commander of the Expedition and by Mr. Coleridge Farr, has been sent to all the directors of the observatories.

The work in connection with the observatory and the Expedition has caused a temporary cessation of survey operations, but these will be re-commenced almost immediately. A report on the work already done has been sent to Dr. Glazebrook, and with a request for a renewal of the loan of the absolute magnetic instruments used in it.

REPORT OF COMMITTEE OF AUSTRALASIAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE ON THE QUESTION OF UTILISING THE DIAMOND-DRILL BORES OF AUSTRALIA FOR THE PURPOSE OF DETERMINING UNDERGROUND TEMPERATURES.

In view of the information acquired as to the condition of the drill bores and the theoretical and practical difficulties attendant on the determination of underground temperatures from such bores, the Committee suggests that no further steps be taken by the Association in this matter for the present.

E. G. HOGG, *Secretary of Committee.*

REPORT OF THE SEISMOLOGICAL COMMITTEE OF THE AUSTRALASIAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The Seismological Committee was re-elected at the meeting of the Association held in Melbourne, January, 1900, as previously constituted, with the addition of Mr. E. G. Hogg, M.A., for Tasmania; Mr. Davidson, for Queensland (in place of Dr. R. L. Jack); and Mr. P. Baracchi, as Secretary. It was subsequently arranged that Mr. G. Hogben would continue to fill the position of Secretary conjointly with Mr. P. Baracchi, the former acting in respect of New Zealand, and the latter in respect of the Australian States.

The Committee regrets to report the death of one of its members—Mr. A. B. Biggs, of Launceston, Tasmania—which occurred in September, 1901.

The organisation of Seismological work in the Australian States on a uniform and efficient system has proceeded slowly, owing to the difficulty of securing a sufficient number of willing and reliable observers at suitable places scattered over an area covering some millions of square miles; but considerable progress has been made during the last two years in some of the States, and it is expected that, with the assistance of the Postal and Telegraph Departments now under the Federal Government, the completion of the required net of stations recording seismic phenomena in accordance with prescribed scientific methods will, by degrees, be extended over the whole continent of Australia and Tasmania.

Seismographs of the form recommended by the Seismological Committee of the British Association (Milne Horizontal Pendulum) have been installed at the Sydney Observatory, Perth Observatory, and Melbourne Observatory. The one at Perth has been in use and registering regularly since October, 1901. The one at Melbourne, after long delays and difficulties in obtaining a suitable place for efficient installation, is now ready to commence its routine work; and the same may be said in regard to the Sydney instrument.

In future the records obtained by these instruments will be supplied regularly to the Secretaries of the Seismological Committee of the British Association, in accordance with the general scheme laid out by that Committee.

It is very desirable that the other Federal States, more especially South Australia and Tasmania, be provided with

Milne Horizontal Pendulums, and the Committee recommends that the General Council of this Association may be induced to approach the Governments of these States with a view to securing the early installation and maintenance of this kind of instruments at their respective observatories.

Records of seismic disturbances occurred in the various States during the last two years, and are shown in the following separate reports:—

Queensland and *Tasmania*.—No returns.

South Australia.—Extract from letter of Sir Charles Todd, Government Astronomer, and list of recorded earthquakes, appended.

New South Wales.—The Government Astronomer, Mr. H. C. Russell, states that no records of earthquakes were reported to him; none felt at the Sydney Observatory.

Western Australia.—Letter from the Government Astronomer, with list of earth-tremors recorded by the Milne Horizontal Pendulum, appended.

Victoria.—List of earthquakes appended.

New Zealand.—Special Reports by the joint Secretary, Mr. G. Hogben, appended.

P. BARACCHI.

A.A.A.S. SEISMOLOGICAL COMMITTEE, 1900-1.

N.Z. Division.

After preliminary testing for the necessary instrumental adjustments, the Milne Seismograph No. 20, in charge of Mr. George Hogben, M.A., Wellington, has been in regular working since 1st October, 1900, and it has afforded many records of an interesting character. Many of these records are evidently identical with records of seismic disturbances in various parts of the world, as shown by instruments of the same type, or by the Rebeur-Ehlert instruments at Strassburg and Hamburg, or by other seismographs whose records are referred to in the monthly circular issued by the Kaiserlichen Haupt Station fur Erdbebenforschung, at Strassburg. The most notable of the coincidences are those relating to the following:—

(1) E.Q. of 8.10.'00, No. 4 on Strassburg list, October, 1900, which began at S., 36 mins. later than at Wellington; amplitude 25 mm. at S., 22 mm. (period of pendulum 16½ secs.) at W.

(2) E.Q. of 10.10.'01, No. 6 on Strassburg list, October, 1900, No. 4 on Hamburg list, October, 1900; origin in Alaska; observed also at Victoria, B.C., Toronto, and most European stations; began at Wellington 3 mins. before Strassburg.

(3) A series of tremors without marked shocks, but rapid, and of large amplitude, up to 13½ mm., lasting from 21 hrs. 41 mins. on 5.2.'01 to 15 hrs. 11 mins. on 7.2.'01.

It will be necessary that all available records of these and other evidently-identical shocks should be carefully compared before reliable conclusions can be drawn from them. Enough, however, has been recorded to show that comparison will be possible for many earthquakes and series of tremors that travel round or through the crust.

The instrument at Wellington gave a very complete list of observations for the recent earthquake (16th November, 1901), at Cheviot, South Island, New Zealand. As shown by the seismograph, the maximum disturbances began suddenly, and lasted for 2 mins.; the earthquake proper lasted for 11¾ mins., and the large vibrations for 59¼ mins. long. The amplitude cannot be exactly measured, but the markings went right across the paper; so that the amplitude exceeded 40 mm. Shocks of slighter character and tremors lasted for several days, and at intervals there were slight shocks for a month afterwards. One of the most notable features of the earthquake was a tilt of the surface amounting to 4 seconds of arc nearly westwards (E——W.), 3·6 seconds of which took place at the time of the chief shock.

Instrument No. 16, set up at Christchurch under the charge of Mr. Coleridge Farr, B.Sc., was not in going order until about the 20th November, so that the principal Cheviot shock was not recorded by it. After that time, however, it gave many records, several of which agree with those of the Wellington instrument. The magnetic instruments, especially the H.F. and V.F. instruments, gave records synchronous, or nearly so, with those of the seismographs. It should be stated that the Wellington instrument is installed on rock, which, however, is much marked by cleavage, and the Christchurch instrument on alluvial shingle. Both booms are in the meridian, with the free end pointing true north.

Many changes of level have been exhibited by the Wellington instrument; some sudden, as in the case of the Cheviot shock; others gradual or periodic, apparently. It is too early to speak with certainty as to the existence of a diurnal (or semi-diurnal) period, and of a six-monthly period; but the records are sufficiently definite to warrant very careful observation in the future, with a view to determine the fact or otherwise of such periodic movements. On 10th August, 1901, there was shown on the Wellington instrument a most remarkable series of records, four or five in number (one apparently consisting of two overlapping series of vibrations). The first, fourth, and fifth sets of vibrations appear to be repetitions of the same earthquake movements that have reached the place of observation by different paths; the second and third apparently overlap and confuse one another. At the time of writing, the Strassburg circular for August has not been received, and there has, therefore, been no opportunity of comparing the Wellington records with those from other parts of the world. The amplitude of the second (the largest) set was very large, over 40 mm. The amplitude of the first, fourth, and fifth sets was, respectively, 6, 5, and 4 mm.

Messrs. Farr and Hogben have agreed with the observers on the Antarctic ship *Discovery* to keep all three instruments at a natural period of 15 secs., as nearly as possible, and to record all observations in the form annexed (A).

This is identical with that used by the stations of the International Seismological Committee, except that the last two columns are added; and it gives all that is asked for by the Seismological Committee of the British Association. It is recommended that it should be used at all stations in Australasia.

Local earthquakes are also observed by the telegraph operators at about 130 selected stations in New Zealand (by the courtesy of the Post and Telegraph Department). Books of forms B are issued for use to the various stations. We propose to continue this system, which has afforded results in the past good enough to ensure the determination of all the chief earthquake origins in and near New Zealand. The records of the Milne Seismographs it is proposed to deal with by the issue of a monthly or quarterly circular in the form A, which will be published, it is hoped, in a complete form once a year in the Transactions of the New Zealand Institute. It is suggested that a summary of the most interesting results should appear in the Proceedings of the Australasian Association for the Advancement of Science.

Further, that photographic copies of important records should be exchanged between the various seismological stations of the world, and the best of them printed for general information.

(*a*.) A list of all earthquakes and tremors recorded in your State since 1st January, 1900, in the form given below, preferably:—

Name of Place.	Latitude.	Longitude	Greenwich civil time.	Description of phenomena.

(*b*.) An account of any work, investigations, experiments, or observations bearing on the subject carried on at your observatory during the last two years, with description of the instruments used (especially experiences with the Milne Horizontal Pendulum).

(*c*.) A statement as to whether an organised and regular seismological service exists in your State under your control; and, if so, what are the conditions, methods, and rules under which the work is carried on by the organisation.

(*d*.) Any other information, notices, opinions, &c.

South Australia.

Abstract of Sir Charles Todd's letter to the Secretary, accompanying the attached List of Earthquakes:—

. . . . I am sorry to be able to supply such meagre information, but I have been unable to obtain any funds for the purchase of Milne's Seismograph, even for the Adelaide Observatory. If from your experience you can strongly recommend the mounting of one at the observatory, I should be glad if you would obtain a recommendation to that effect from the Committee. This would perhaps help me. . . .

The answer to queries are as follows:—

(*a*) List of Earthquakes attached.

(*b*) None.

(*c*) No, except that observers are requested to fill up form approved by the Australian Association for Advancement of Science.

(*d*) None.

Note.—Both letters of Sir Charles Todd and of Mr. Cooke refer to the list of queries (*a*) (*b*) (*c*) (*d*) attached herewith.

P. B.

EARTHQUAKES IN SOUTH AUSTRALIA SINCE 1ST JANUARY, 1900.

Name of Place.	Latitude.	Longitude.	Greenwich Civil Time.	Description of Phenomena.		
	S. ° ′	E. ° ′	1900.			
Beltana	30 50	138 34	Jan. 15 5·44 p.m.	Rossi-Forel Scale	4	Falling plaster
Ditto	...	...	Feb. 2 4·15 p.m.		3	
Ditto	...	...	„ 14 3·47 p.m.		3	
Ditto	...	...	Mar. 6 3·59 a.m.		3 to 4	Numerous slight tremors for two days before
Balaklava	34 9	138 26	May 19 10·21 p m.		3	Tins and crockery rattled
Blinman	31 7	138 41	„ 29 5·48 a.m.		4 to 5	Building severely shaken
Port Darwin	12 28	130 51	„ 31 10·58 p.m.		3 to 4	
Carrieton	32 26	138 32	June 26 8·10 p.m.		4	Shook building ; windows rattled
Orroroo	32 43	138 37	„ 28 8·15 p.m.		3 to 4	
Appila Yarrowie	33 3	138 26	Aug. 22 2·28 a.m.		3	
Blinman	31 7	138 41	Oct. 31 10·25 p.m.		3	
			1901.			
Appila Yarrowie	33 3	138 26	July 1 9·20 p.m.		4	
Blinman	31 7	138 41	Sep. 28 7·57 a.m.		5 to 6	Ornaments shaken off shelves

C. TODD, *10th December, 1901.*

Western Australia.

From the Government Astronomer.

Dear Sir,

(*a.*) Herewith a list of the only earth tremors recorded in this State since 1st January, 1900. These are never felt by people, but were recorded on a Milne Seismograph, which was mounted at the beginning of October, 1901.

(*b.*) and (*c.*) The only seismological work carried on in this State is a record, by means of a Milne Seismograph, of any tremors experienced in Perth.

(*d.*) The superior sensibility of the Milne over older forms of instrument appears to have been demonstrated on 16th November, when the record here had an intensity of 8·2 m.m. This I take to be the earthquake which caused so much damage in the Cheviot district of New Zealand, and yet I understand, from a telegram received from you, that your instrument (old form) showed no trace whatever.

Yours faithfully,

W. ERNEST COOKE.

To P. Baracchi, Esq.,

Secretary Seismological Committee, A.A.A.S.

10th December, 1901.

EARTH TREMORS AT PERTH (W.A.).

7h. 43m. 21·74s. — 31° 57′ 09·6″.

G. Civ. T.	Prelim. Trem.	Commencement Decided Motion.	Maximum Motion.	Finish.	Intensity in millimeters.
1901.	h. m.	h. m.	h. m.	h. m.	
Oct. 8	2 12	3 32	3 42	4 40	2·0
19	8 59	10 10	10 23	11 15	5·5
29	7 59	8 02	8 16	9 06	3·7
31	6 05	6 17	6 25	6 45	2·1
Nov. 13	10 23	10 33	10 37	11 05	9·6
15	20 21	20 27	20 53	21 36	8·2
25	0 25(?)	1 54	2 01	5 05	2·1
Dec. 2	14 03	14 18	14 22	14 34	1·5
2	(2nd shock)	15 06	15 13	15 36	1·0
5	17 39	17 48	17 55	18 36	7·0
6	Clock driv	ing badly	..	..	4·6

EARTHQUAKES.

New Britain, Lat. 5° S., Long. 151° 40′ E.

Extract from the *Age*, Wednesday, 10th October, 1900.

"News to hand from New Britain states that, on Tuesday, 11th September, the island was visited by an earthquake, which for severity and persistent repetition has never been equalled in the islands. The deadly oppressiveness of the morning caused a panic amongst the natives, who rushed to the sea for safety, many standing waist-deep on the reefs. A terrific shock happened at 7·30. The earth felt as if it had been suddenly lifted up several feet and dumped down again with a thud. Houses creaked and groaned, and the residents fled into the open. People and trees were swayed and whirled about, as if caught in an immense whirlpool. The disturbance lasted about three minutes. Several minor vibrations followed. During the upheaval the sea receded fully 50 feet from the shore, and after an interval of ten minutes rushed in again. So great was the volume of water which receded that the German mail steamer *Stellin*, which was lying at anchor at Reperstshoh, distinctly touched bottom several times, to the great consternation of those on board."

Earthquakes in the Solomon Islands.

Solomon Islands, Lat. 6° S., Long. 156° E.

Extract from the *Argus*, 9th October, 1900 (Tuesday).

Brisbane, Monday.

"Captain P. Tornaros, coast pilot on the Norddeutscher-Lloyd steamer *Munchen*, which arrived yesterday, gave some interesting information of successive earthquakes at Herbertshohe, where he waited for 14 days for the arrival of the *Munchen*. On Sunday, 16th inst., the *Munchen* steamed down to Malapia, a fine little harbour, nine miles distant, where Messrs. Hernsheim & Co. have a station. The island is purely volcanic. One of the craters was active, and the beach of the island was almost wholly covered with lava. On the 17th they went to Ralum, midway between Matapi and Herbertshohe. On the 18th the morning was very close. The lead had been put over the stern, and the five fathoms mark was just awash, the water being beautifully clear. While the engineer, chief officer, captain, and passengers were discussing the peculiarity of the atmosphere, a severe shock of earthquake was felt, lasting for fully a minute. Everyone thought the ship was aground. Looking towards the shore, they saw the people rushing out of their houses. After an interval of 20 minutes, another shock was felt for about 20 seconds, and at irregular intervals shocks continued all day until 9 p.m., 32 distinct shocks being felt. The water receded out of the bay after the first shock, leaving the boats on dry land. The natives rushed out for fish, myriads of which were lying high and dry, but their sport was short-lived, as a tidal wave rolled in. Luckily for them, the wave was not of great force or volume. After the first shock the lead over the stern showed the three-fathom mark awash, but the water came gradually back, and half an hour after six fathoms was obtained. The vessel was then shifted out half a mile into deep water. Captain Tornaros learned afterwards from Mr. Hernsheim that they believed the island had been lifted four feet. There were fumes of brimstone in the south. Some idea may be obtained of the warmth of the water at the base of the volcano from the fact that, when one of the officers of the *Munchen* pulled through it in a boat, the paint was taken off as if by caustic soda."

MELBOURNE OBSERVATORY LIST OF EARTHQUAKES.

Greenwich Mean Civil Time.		Place.	Lat. S.		Long. E.		Description of Phenomena.
1900.	h. m.		°	′	°	′	
Jan. 15	17 45	Beltana	30	50	138	34	Sharp shock. Lasting about 15 seconds. Appeared to be travelling from N. to S.
Feb. 2	16 15	Beltana	30	50	138	34	Sharp shock. Apparently travelling N. to S.
14	15 47	Beltana	30	50	138	34	Sharp shock. Apparently travelling N. to S.
24	14 45	Armadale	37	51	145	3	House and furniture quivered. Lasted 4 to 6 seconds. Came from S.E. direction.
24	14 45	Toorak	37	51	145	2	
March 6	3 59	Beltana	30	50	138	34	Sharp shock. Apparently travelling S.W. to N.E.
11	Between 17·30 & 18	Warrnambool	38	23	142	30	Slight shock.
18	17 44	Blinman	31	7	138	41	Slight shock. Rumbling noise. Apparent direction S.E. to N.W. Lasted 7 seconds.
21	21 40	Wirrabara	33	2	138	18	Severe shock. Shook buildings.
April 17	16 35	Kiandra	35	52	148	32	Shook buildings. Lasted 12 seconds. Travelled N.E. to S.W.
May 26	0h. or 12 (?)	Mansfield	37	4	146	6	Distinct shock. Direction N. to S.
27	2 30	Warragul	38	10	145	56	Severe in some localities, but intervening ground but little affected. Appeared to travel from E. to W. Lasted 35 seconds Motion appeared to be perpendicular.
27	—	Warragul, "Carbethon"	38	10	145	55	House shook and windows rattled. Course seemed to be E. and W.
27	2 25	Grantville	38	25	145	32	Loud rumbling noise. Distinct shock. Lasted several seconds.
27	2 30	Leongatha	38	34	145	57	Slight earth tremor.

27	2 25	Korumbarra	38	25	145	51	Loud rumbling noise, followed by severe shock. Lasted over 6 seconds.
27	2 30	Camberwell	37	51	145	7	Jug in basin on wash-stand moved several times. Shock appeared to travel towards East.
27	2 30	Brunswick	37	47	144	59	Rocking motion. Produced feeling akin to sea sickness. Noise resembling gale of wind.
27	2 30	South Yarra (Punt Hill)	37	50	145	0	Motion "up and down."
27	—	Melbourne (City)	37	49	144	59	Shock felt.
27	—	East Melbourne	37	49	145	0	Shock felt.
27	2 33	South Yarra	37	50	145	0	Shock felt.
27	About 7 30	St. Kilda	37	52	145	0	Shock felt.
27	2 35	Beaconsfield	38	3	145	22	Sharp shock. Lasting about a minute.
27	2 30	Dandenong	37	59	145	13	Several residences rattled. Shock lasted about 6 secs.
27	2 30	Dandenong, "Cumberoona"	37	57	145	12	Earthquake. Slight.
27	About 2 30	Drouin	38	8	145	51	Buildings shaken. Severe shock. Appeared to travel from N.W.
27	2 30	Ferntree Gully	37	53	145	18	Distinct shock.
27	About 2 0	Foster	38	39	146	13	Two distinct tremors in quick succession, lasting fully 15 seconds. Houses shook. Crockery, &c., rattled. People hurriedly left houses.
27	Shortly after 2 0	Jeetho	38	21	145	48	Very severe shock, causing houses to shake, and empty railway trucks on siding to rattle loudly.
27	About 2 25	Jumbunna	38	28	145	42	Two great thuds, making houses almost rock. Roar like explosion deep below surface. People left houses. Produced headaches and feeling of sickness. Quantity of stone displaced in mine. Shock appeared to travel from W. to E.
27	2 25	Korumburra	38	25	145	51	Severe tremor. Rolling motion. Noise as of thunder. People left houses. Apparently travelled W. to E.
27	2 15	Outtrim	38	30	145	47	Shook houses and furniture, and broke ornaments on mantelpieces. Shock severely felt in Mine. Duration 8 to 10 secs.

MELBOURNE OBSERVATORY LIST OF EARTHQUAKES—*continued.*

Greenwich Mean Civil Time.		Place.	Lat. S.		Long. E.		Description of Phenomena.
1900.	h. m.		°	′	°	′	
May 27	About 2 30	Pakenham	38	3	145	22	Pronounced shock. Lasted 28 to 30 secs.
27	About 2 30	Poowong	38	19	145	48	Distinct shock all over District. Windows and doors rattled.
27	1 45	Stony Creek	—		—		Severe shock. Lasted nearly 10 secs.
27	2 30	Sassafras	37	52	145	22	Made houses creak. Shook articles off shelves. Lasted about 10 secs.
27	—	Poowong, North	38	13	145	48	Church shook. Lamps swayed to and fro as people were leaving after morning service
27	2 42	Archie's Creek	38	39	145	46	Tremor. Sound as of distant thunder. Duration 10 secs. Apparent direction S.E. to N.W.
27	2 30	Krowera	38	30	145	29	Houses shook. Books thrown from shelves. Duration about 15 secs. Appeared to travel S. to N.
27	2 30	Jendivick	38	2	145	53	Slight shock.
27	About 2 30	Garfield	38	5	145	40	Strong shock.
27	2 30	Narre Warren	38	2	145	21	"Earthquake. W. to E."
27	2 30	Ardeen	38	41	146	9	Houses shook. Crockery rattled.
27	About 3 0	Beenak	37	52	145	40	"Earthquake. E. and W."
27	2 30	Bunyip South	38	7	145	38	Place shaken violently. Rumbling sound like thunder. Produced feeling of nausea. Direction from W. to E.
29	5 48	Blinman	31	7	138	41	Shook buildings throughout. Low rumbling noise. Apparent direction N.W. to S.E. Duration 10 secs.
31	22 58	Port Darwin	12	28	130	51	Sharp shock.
June 5	Between 10h. & 10 30	Meredith	37	51	144	5	Buildings vibrated. Rumbling sound. Lasted 2 or 3 seconds
5	Ditto	Steiglitz	37	53	144	11	(same as above)

5	Between 10h & 11h.	Anakie	37	56	144	15	"Oscillation of buildings lasted several minutes"
26	About 20 10	Carrieton	32	26	138	32	Very distinct shock. Lasted about 10 seconds
		Hammond	32	32	138	22	
		Bruce	32	28	138	12	
	a.m.	Orroroo	32	43	138	37	
Aug. 8	(Sydney time)	Rockley	33	45	149	39	Houses shook.
		Oberon	33	43	149	53	
		Burraga	33	48	149	43	
22	2 28	Melrose	32	47	138	11	Shook windows &c., Report like thunder followed by rumbling sound. Duration 7 or 8 secs. Apparently travelling E. to W.
		Booleroo Centre	32	48	138	25	
Sep. 4	9 10	Jamieson	37	18	146	9	Heavy shock. From N.W. to S.E. Lasted about 10 secs.
16	About 15 0	Warnambool	38	23	142	30	Slight tremor.
Oct. 6	5 0	Cooma	36	12	149	9	Slight shock.
6	and 13 30	Cooma	36	12	149	9	Slight shock.
8	4 48	Myrtleford	36	34	146	43	Slight shock.
8	4 45	Cheshunt	36	42	146	27	Slight shock.
31	22 25	Blinman	31	7	138	41	Slight shock. Apparently travelling N. Lasted 5 secs.
1901. April 27	a.m. (S.A. time.)	Wankaringa	32	16	139	25	Sharp shock. Direction S.E. to N.W. Duration about 25 secs.
May 22	—	Broome	17	57	122	15	Volcano Kloet in eruption during (22nd—23rd W.A. time). Three heavy reports heard in Socrabaya
June 15	About 22 5	Princetown	38	41	143	9	Houses slightly shaken. Loud noise like double clap of thunder, lasting thirty secs. Apparently travelling Westward
15	22 5	Rivernook	38	42	143	10	
26?	—	Ingham	18	39	146	10	Shook houses and rattled furniture. Pictures fell from walls. Lasted 10 seconds.
26?	—	Nungalla	18	53	146	15	
26?	—	Halifax	19	0	146	25	
26?	—	Cardwell	18	15	146	3	

MELBOURNE OBSERVATORY LIST OF EARTHQUAKES—*continued.*

Greenwich Mean Civil Time.		Place.	Lat. S.		Long. E.		Description of Phenomena.
1901.	h. m.		°	′	°	′	
July 1	21 20	Appila-Yarrowie	33	3	138	26	Severe shock.
9	10 10	Blinman	31	7	138	41	Slight shock. Duration about 2 seconds. Travelling S.
22	18 30	Cooma	36	12	149	9	Three shocks. First very severe. Lasted 35 secs. Shook crockery, &c. Travelled in Westerly direction.
22	18 35	Cooma	36	12	149	9	
22	20 6	Cooma	36	12	149	9	
Aug. 11	—	Port Dawin, Victoria River	12	24	130	53	Terrific explosion, followed by rumblings and severe vibrations. Sick man thrown from hammock. Shock felt and heard some miles away.
23	22 0	Black Rock	32	51	138	45	Shock. Lasted about 4 seconds. Direction W. to E.
Sept. 28	7 56	Blinman	31	7	138	41	Severe shock. Lasted 30 secs. Apparently travelled N.W.
Nov. 15	20 15	Canterbury	43	42	171	3	Most severe shock at 15d. 20h. 15m. Succeeded by numerous other shocks. Many buildings wrecked. Child killed by falling *débris*. Numbers of people thrown from beds. Corpse thrown out of coffin. Spire of Christchurch Cathedral cracked in two places, and part near top shifted. Numerous earth fissures caused in places far distant. Many springs dried up, and numbers of fresh ones started to flow. Maximum vibrations lasted 2 minutes. Earthquake apart from after tremor lasted $11\frac{3}{4}$ minutes. Altogether tremor lasted 71 minutes. Earth's surface tilted towards West 3·92 secs. of an arc (nearly 4 seconds).
15	20 15	Cheviot	42	50	173	15	
15	20 15	Christchurch	43	33	172	40	

18	21 30	Cheviot	42	50	178	15	Very heavy shock.
20	—	Cheviot	42	50	173	15	Very heavy shock.
22	—	Cheviot	42	50	173	15	Slight shock.
—	—	Curtis Land [Island]?	30	4	180	8	"Wellington, Dec. 6th—A steamer from Kermade reports that while there terrific volcanic eruptions were taking place at Curtis Land, [Island]? which seemed a veritable Inferno. This outburst may have something to do with the recent outbreak at Cheviot"
18	16	Walhalla	37	57	146	27	"Rumble of earthquake."
19	15 40	Walhalla	37	57	146	27	Distinct shock. Travelling N.W.
19	15 40	Moondarra	38	0	146	22	Very severe shock. Several barns and sheds destroyed.

PROCEEDINGS OF THE SECTIONS.

Section A.

ASTRONOMY, MATHEMATICS, AND PHYSICS.

PRESIDENTIAL ADDRESS.

By R. W. Chapman, M.A., B.C.E., Adelaide.

I have selected as the subject of my address to you on this occasion, a matter which, if an encyclopædia were to be written dealing with the subjects set down for consideration by this section, would probably occupy but a very small amount of room in the book. It is, however, a subject which has considerable local application; and in attempting something like a general review of the matter, I find that it is quite big enough to handle within the confined limits of a President's address. I propose to deal with—

Tidal Theory and some Applications.

Before the discovery of the laws of universal gravitation, the existence of a rational theory as to the cause of the tides was out of the question, and we find accordingly that the theories in vogue up to the time of Newton may be described as both wild and varied. Thus Timæus ascribes them to the discharging of rivers into the sea. Aristotle, Heraclides, and others considered that they were due to winds set up by the sun or moon, striking the water. Plato set them down as bodily oscillations of large bodies of water within the earth; whilst Apollonius, in common with many old Greek philosophers, regarding the earth as an animal, thought the tides were due to the earth's breathing. This suggestion also occurs in Chinese writings. The close connection between the motions of the moon and the tides, especially in the North Atlantic, could not but impress the earlier thinkers on this subject; but most of them were, perforce, content to ascribe it to some occult quality on the part of the moon. Descartes applied his vortex theory of the universe to the tides, and his theories had considerable vogue. A quotation from Bernhardus Varenius, who wrote his *Geographia Generalis* in 1650, well shows the condition of men's minds with regard to this subject in his time. Varenius writes:—

"*To explain the Cause of the Swelling and Swaging of the Sea, vulgarly called its Flux and Reflux*:

"There is no Phenomenon in Nature that has so much exercised and puzzled the Wits of Philosophers and learned men as this. Some have thought the Earth and Sea to be a living Creature, which, by its Respiration, causeth this ebbing and flowing. Others imagined that it proceeds, and is provoked, from a great Whirlpool near Norway, which for six Hours absorbs the Water, and afterwards disgorges it in the same space of Time. Scaliger, and others, supposed that it is caused by the opposite Shores, especially of America, whereby the general Motion of the Sea is obstructed and reverberated. But most Philosophers, who have observed the Harmony that these Tides have with the Moon, have given their opinion that they are entirely owing to the Influence of that Luminary. But the Question is, what is this Influence? To which they only answer that it is an occult Quality, or Sympathy, whereby the Moon attracts all moist Bodies. But these are only Words, and signify no more than that the Moon does it by some means or other; but they do not know how: Which is the Thing we want."

Galileo and Wallis explained the tides as due to the different speeds in space of different places on the earth's surface, the side away from the sun moving eastward with a greater velocity than the side towards the sun; but they could not clearly explain why there should be two high waters and two low waters daily instead of one. Galileo thus looked upon the tides as giving us evidence of the rotation of the earth.

Our modern tidal theory is founded essentially upon the work of Newton, who first clearly explained the nature of the tide-generating force in his *Principia* in 1687. He showed that the difference of the forces which the moon exerts upon a particle at the earth's surface and upon a particle at the earth's centre constitutes a force which tends to move the particle at the surface relatively to the earth's centre. This difference constitutes the Tide-Generating Force. At any particular spot this can be resolved into horizontal and vertical components. The vertical component simply has the effect of slightly altering the apparent weight of a body, so that, at a point on the equator directly under the moon, a mass of one ton has its weight diminished by about 1·85 grains, owing to this cause. Such a slight vertical force cannot produce any motion, as it will not lift a body away from the surface. On the other hand, the horizontal component, although it is also very small, and its maximum value is only three-fourths of the vertical force just noted, is unresisted by gravity, and is thus capable of producing movement in the waters of the ocean. Similar tide-producing forces are set up on the same principle by the action of the sun. The sun, however, being so far away, exerts upon the different parts of the earth an attraction which is much more uniform than that of the moon, so that the tide-producing forces due to it are smaller. Newton, and, after him, Bernoulli, Euler, and Maclaurin, in their developments and extensions of his theory, assumed that the surface of the ocean at any instant is one of equilibrium under the action of gravity and the tide-producing forces. On this assumption the ocean, under the influence of the moon alone, would take the form of an ellipsoid of revolution with its major axis pointing towards the moon; similarly, the sun alone would cause it to take the form of a somewhat less elongated ellipsoid with its major axis directed towards the sun. The actual tide is given by the superposition of the two ellipsoids. In this form, however, the Newtonian theory fails very considerably when compared with actuality, and, as has been pointed out by Lord Kelvin, the conditions assumed could only be satisfied by an earth completely covered with ocean. With a constant amount of water in the oceans, the theory could not hold with a distribution of land and water such as we actually have. According to the theory, at spring-tides the morning and evening tides should be of nearly equal height at a point on the equator, but very different in height for ports in other latitudes. We find, however, that this "diurnal inequality" is very small indeed at ports in the North Atlantic—nothing approaching what the equilibrium theory would lead us to expect. Moreover, spring-tides occur at an interval after full and change of moon, instead of exactly at the full and change.

Laplace, in 1774, attacked the problem in his *Mécanique Céleste.* He investigated the nature of the waves set up in an ocean covering the entire earth by the action of the tidal forces. As the basis of his work, he stated the principle of Forced Oscillations "That the state of oscillation of a system of bodies in which the initial conditions of motion have disappeared through the resistance which this motion experiences is co-periodic with the forces which animate it." In other words, the ocean is forced to oscillate synchronously with the tide-generating forces. "From this I concluded," says Laplace, "that if the sea is actuated by a periodic force expressed by the cosine of an angle which increases uniformly with the time, there results from it a partial tide, expressed by the cosine of an angle increasing in the same manner, but in which the constant involved in this angle and the co-efficient of this cosine may be, by virtue of accessory circumstances, very different from the same constants in the expression for the force, and can be determined only by observation. The expression for the actions of the sun and moon upon the sea can be developed in a convergent series of similar cosines. Whence arise as many partial tides as, by the principle of the co-existence of small oscillations, being added together, constitute the tide which is observed at a port." Laplace determines three principal classes of oscillations—1st, those independent of the rotary motion of the earth; 2nd, those dependent on the earth's rotation, and having a period of about one day; 3rd, those dependent on the earth's rotation, and having a period of about one half-day. The excess of one high-water over the adjacent one, which we have already referred to as the diurnal inequality, he shows is due to oscillations of the 2nd class. According to Newton's theory, this difference in height between the two daily tides should be large at such a port as Brest, where, as a matter of fact, it is scarcely sensible. Newton explained the discrepancy by the *inertia* of the water, whereby the effects of one oscillation were, so to speak, carried over into the next. But Laplace showed that it really depends upon the law of the depth of the sea, and that, if the ocean were of uniform depth over the whole earth, it would vanish completely. It was thought at the time that this gave the explanation of the non-existence of diurnal inequality in the European ports whose tides had been recorded; but, as tides in other parts of the world came to be examined, it was found that the North Atlantic tides were peculiar in this respect, and that elsewhere, as a general rule, the two daily tides are of unequal height. So that this result differs as much from actuality as Newton's. Amongst other important deductions made by Laplace in the course of his work was the proposition that the movements of the earth's axis are the same as they would be if the sea formed with the earth a solid mass. This was contrary to the opinion of most mathematicians at that time, and D'Alembert, in his work on the precession of the equinoxes, had advanced the opinion that the fluidity of the sea took from it all influence upon this phenomenon. Laplace further examined the tidal oscillation of the atmosphere, and found that the attraction of the sun and moon could not possibly produce the constant movement from east to west which we observe in the Trade winds, but that small oscillations in the height of the barometer are produced whose extent at the equator he calculated at a half millimetre.

All the work which has since been done in the development of tidal theory has necessarily been based upon the grand fundamental work of Newton and Laplace. "Amongst all the grand work which has been bestowed on this difficult subject," writes G. H. Darwin, "Newton, notwithstanding his errors, stands out first, and next to him we must rank Laplace. However original any future contribution to the science of the tides may be, it would seem as though it must perforce be based on the work of these two."

Sir John Lubbock, in the years 1830 to 1840, did a great deal of work in the way of co-ordinating and examining large masses of data obtained from English tidal observations. He was the first to introduce the term "co-tidal line." Afterwards Whewell constructed charts showing co-tidal lines, in general finding that these lines meet the shore at very acute angles. The work of Lubbock and Whewell enabled trustworthy tide-tables to be computed for British ports.

Airy wrote a very important review of tidal theory for the *Encyclopædia Metropolitana*, and made most important contributions to the study of the progress of waves along canals, and of the effect of friction upon the progress of the tidal wave. Amongst the many interesting results obtained by him, the following, which refer to an equatorial canal encircling the earth, may be here noticed:—

1. If the depth of the canal be less than about 13 miles, and the water be considered frictionless, the attraction of the moon would cause low-water underneath the moon and high-water in the quadratures. This depth is such that a free wave would naturally take more than a day to go completely round; consequently, the tidal forces must be so distributed as to continually hurry it on, so as to force it to get round in the time. This gives us the above disposition.

2. If the depth of the canal were greater than about 13 miles, in which case the free wave would naturally oscillate

more rapidly than the forced tidal wave, we should have high-water under the moon and low-water in the quadratures. With this position of the wave the tidal forces are continually acting to retard it, and make it move more slowly.

3. With the first canal the effect of friction is to cause the high-water to reach any particular place *earlier* than it would if the water were frictionless.

4. With the second canal the effect of friction is to cause the high-water to reach any particular place *later* than it would if the water were frictionless.

After all, however, although the investigations of Airy into the behaviour of the tidal wave in canals, as those of Laplace upon the tidal oscillations of an ocean covering the whole earth, are of very great interest, they are of little value in enabling us to calculate the tidal effect at any particular port. The depth of the sea is so irregular, and the disposition of land and water is so exceedingly complex, that the calculation of the height and time of the arrival of high-water at any particular spot on the earth's surface from astronomical considerations alone, appears quite beyond the possibilities of mathematics. Laplace's dynamical theory as to the origin of the tidal wave is now generally accepted; but, although it may enable us to calculate the height and progress of the tidal wave under certain very simple ideal dispositions of land and water, we cannot determine the progress of the wave under the complex conditions which actually exist.

In order, then, to be able to predict the tides at any port, we have to depend upon previous observations at that port; but how to determine the order which we know must prevail in the apparent chaos which seems to exist at many ports is not a particularly simple problem. It has been best solved by the application to tidal records of the methods of Harmonic Analysis, as first suggested by Lord Kelvin. The systematic methods of procedure have been elaborated by Adams, and particularly by G. H. Darwin. The basis of the method is due to Laplace, according to whose dynamical theory the height of the water at any place may be expressed as the sum of a certain number of simple harmonic functions of the time, the periods of these being known from astronomical considerations. If the moon were to move in a circle round the earth in the plane of the earth's equator, and at a constant distance from us, a semi-diurnal tide would be produced on the waters of the earth, which would be in the form of a regular simple wave exactly repeating itself each lunar day. Instead of this simple condition of things, however, the lunar tides are complicated by the facts that the moon's orbit is elliptical instead of circular; that the plane of the orbit is inclined to the plane of the earth's equator; that this inclination is not constant; and that the sun disturbs the moon, producing evection and variation. These irregularities in the moon's motion are all reflected in the lunar tide, but their combined effect is exactly equivalent to the superposition of a number of strictly periodic waves of simple type. So that the effect of the moon upon the oceans may be considered to be that it produces not one tidal wave, but a number of waves, some of which are semi-diurnal, others diurnal, two fortnightly, and one monthly, and that the actual result is due to the compounding of all these separate constituents. In a similar way the tidal wave due to the sun may be split up into a number of component waves. Our actual tides are due to the combination of all the lunar and solar components. For purposes of tidal calculation, we replace the actual sun and moon by a number of imaginary satellites, which would together produce an equivalent tidal result, but such that each separately produces a simple sine wave. At first sight it may appear that there is no simplification in doing this, but that we are rather making the problem more complex by the introduction of so many attractive forces. The simplification, however, consists in the fact that each of these satellites revolves in a circular orbit either in the plane of the equator or parallel to it. So that if we could manage to separate out and measure the wave produced by one satellite, we could determine what the height and position of that wave would be at any subsequent time, because it recurs at regular fixed intervals. Theoretically, an infinite number of such satellites would be necessary to produce exactly equivalent effects to the actual sun and moon, but practically only 20 of them produce a measurable and observable effect; and in most places it is only necessary to take into account some nine or ten. The use of the fictitious satellites is not necessary, but is a great convenience. The different component waves we may divide into three types—the semi-diurnals, whose periods, or time from one high-water to the next, are about half a day; the diurnal, with periods of about one day; and the long-period tides, whose periods are a fortnight, month, half-year, and year.

By means of a self-registering tide-gauge we may be placed in possession of a continuous record of the height of the water at a place. The irregular wavy curve so obtained represents, then, the compound effect of all the different component simple waves. If we could separate out one of these components, and record it on a tide-gauge, it would mark a wavy curve on the paper such that each wave would be an exact replica of the one before it. But, unfortunately, we cannot do this; neither can we calculate what should be the dimensions of any particular component at any place. It is possible, however, if we are in the possession of the records from a tide-gauge extending over a sufficiently long period, to disentangle the various components, and so determine their actual values and phases at the place from which the records are taken. The work involved in the analysis is laborious, but not difficult, and once the components have been well determined, we are in the position of being able to predict what their resultant effect will be at any future time. The method furnishes us with by far the most satisfactory way of obtaining tidal predictions for any port, and for such purposes it is coming into very general use where systematic predictions are issued. In addition, however, the accumulation of results of such analyses at different places is gradually furnishing us with data that will in the future enable the progress of the tidal wave over the earth's waters to be studied in a very much more thorough way than it can be at present.

Systematic work of this kind is now carried out by the United States Geodetic Survey, the Indian Government, the French Hydrographic Service, the Director of the Observatory at Batavia (amongst the islands of the East Indian Archipelago), and, less systematically, at a number of other places. The published results are already considerable.

Once the tidal components of a port have been determined the tidal curve for a whole year in advance may be very quickly obtained from a tide-predicting machine. This is a mechanical contrivance for compounding simple harmonic waves, the form in use by the Indian Government being that invented by Lord Kelvin. The United States have a different type, devised by Ferrel. These are both very expensive instruments, costing, I believe, well over £2000, so that the construction of such apparatus would not be justifiable unless it is to be used for predictions at a great number of ports. The two machines mentioned could easily do all the tidal prediction required for the whole world. At Adelaide the cheap and simple form of tide-predictor, invented by Captain Inglis, and previously described before this Association, is doing efficient work.

In places where the apparent irregularity has been so great as to make the work of tidal prediction quite hopeless by older and simpler methods, the accurate results obtained by the use of harmonic analysis have proved after all that the complexity of the motion was distinguished by a wonderful order.

Extreme accuracy in tidal prediction is out of the question, on account of the effect of wind and barometric pressure upon the height of the water. In calm weather, and with a steady barometer, tidal predictions should be accurate, but these conditions seldom exist. A committee of the British Association, appointed to investigate the effect of wind and atmospheric pressure on the tides, reported in 1896, after examining the tidal records of several British ports, that the height of the tides is affected by wind in about one case out of four, and that a variation of half an inch from the average barometric pressure causes a variation of about 15 inches in the height of the tide. They further reported that, although, as far as average results go, there can be traced a direct connection between the force and direction of the wind and the variation in the height of the tides; yet, that there is so much discrepancy in the average results, when applied to individual tides, that no reliable formula can be established for indicating the amount of variation in the height of the tide due to any given force of wind. Irregular actions of the wind will not affect the accuracy of an analysis, because, in averaging up over an extended period—such as one year—such actions will be practically eliminated. Regular diurnal meteorological effects, which are very marked in some places, will show themselves as a part of the ordinary solar tide. In spite, however, of irregular meteorological actions, which it is impossible to forecast, the predictions based upon this system are quite sufficiently accurate for practical purposes. At Port Adelaide, where the tides are very complex, by far the greater number of predictions have a smaller error than 10 minutes in time and 6 inches in height. During last year, out of 1348 predictions, 1022 were correct to less than 10 minutes.

Tidal prediction is the direct practical application of Harmonic Analysis, but is by no means the only reason for its being carried into effect. The analysis of tidal records at various places on the earth's surface may be expected to gradually furnish us with information as to the way in which the tidal wave travels over our oceans, such as we can get by no other means. Where tidal forces have uninterrupted sway, we may expect that the wave produced will be a forced wave, travelling round the earth with the same speed as the controlling forces. If we have an ocean in which such a forced wave occurs, and connected to it are other seas in which no forced wave occurs, it is clear that when the forced wave passes the entrance of a connecting sea it will cause a free wave to be propagated along that sea, with a velocity depending on the depth of the water. Now the only place on the earth's surface where the tidal forces have uninterrupted sway is in the Southern and Southern Pacific Oceans. There only is it possible for a wave to go right round the earth without being interrupted by land. Such a wave, when it came to the Southern Atlantic, would tend to spread itself, and to travel up the Atlantic as a free wave. But if the Atlantic were land-locked, we should have tidal oscillations generated in it. Thus it comes about that the actual tidal effect in the North Atlantic is a combination of the true forced Atlantic tide with a free tidal wave which travels up from the Southern Ocean. In smaller seas the free wave which has travelled from the great connecting oceans constitutes the principal effect observed. Thus it comes about that we have tidal waves proceeding in every direction. They may run N. to S. or S. to N., E. to W., as when approaching the eastern coast of Australia, or W. to E., as along a great portion of the northern coast. In the course of their travelling these free tidal waves, especially when they travel through shallow channels, undergo remarkable changes, of the exact nature of which we know very little. The loss of energy owing to friction will, however, be greater in those components in which the particles move most rapidly. We may therefore expect the semi-diurnal waves to be more diminished than the diurnal and long-period, and the semi-diurnal waves of large amplitude to be reduced more in proportion than semi-diurnal waves of small amplitude. Thus the tendency is, when the tidal wave has travelled freely for great distances, over comparatively shallow water, for the semi-diurnal components to become small and more and more nearly equal to one another, while the diurnal waves, not losing by friction to the same extent, become relatively large.

We might be inclined to expect that the relative sizes of the principal solar and lunar semi-diurnal waves would always be pretty well the same, or, at any rate, that the lunar tide would always be greater than the solar. Analysis shows, however, that this is by no means the case. Thus at Port Adelaide and Fremantle the semi-diurnal waves produced by the sun and moon are just about equal to one another. Investigations by the United States Geodetic Survey have shown that the same is true at Mazatlan, on the Pacific Coast of Mexico; whilst Van der Stok states that, at a port in the Dutch East Indies, the solar wave is actually greater than the lunar. This is possibly caused by the partial destruction of the lunar component, owing to the interference of two different tidal waves. On the other side of Australia we have more the ordinary condition of things. Thus at Sydney the lunar semi-diurnal is about four times as great as the solar. At Melbourne, the ratio appears to be exceptionally great about 7·8; at Port Darwin it is 1·9.

We should not, of course, expect that the short-period waves would travel in the same way as the long-period waves. Thus, if our knowledge were sufficient to enable us to draw co-tidal lines for the semi-diurnal waves, and also for the diurnal waves, we should expect that the two sets of lines would be very different. Our knowledge is not yet sufficient to enable this to be done over any extensive regions, but Van der Stok (Wind and Weather, Currents, Tides, and Tidal Streams in the Indian Archipelago) has endeavoured to draw the co-tidal lines for the two classes of waves in the Indian Archipelago. The result is very interesting, showing the two sets of waves proceeding by an entirely different track, and even in opposite directions.

The tidal work being done in Australia at present consists mainly in the recording of tides, and, in a few cases, of the preparation of tide-tables. Along the whole of the northern, western, and southern coasts of Australia, however, we have at present only seven self-recording tide-gauges. There is one at Port Darwin, there are two at Fremantle, and the others are at Port Adelaide, Port Pirie, and Port Augusta, in South Australia, and at Williamstown, Victoria. On the Tasmanian coast there are two—one at Strahan and the other at Hobart. To the energy of Mr. Russell we are indebted for the publication of the records from three tide-gauges in New South Wales, one at Fort Denison (Sydney Harbour), one at Ballina, and one at Newcastle. To him also we owe a most interesting series of records of the oscillations of Lake George. In Queensland there are four gauges—two on the Brisbane River and two on the Fitzroy. Tide-tables are published a year in advance, giving times and heights of high and low water, for Brisbane and Port Adelaide; in the Victorian and Tasmanian Almanacs the times of high and low water are predicted for Melbourne and Launceston; but I am not aware of the systematic publication of tidal predictions at any other ports. In answer to my inquiries, I have been informed at two ports that no attempt at prediction is made, because the tides are so irregular, and appear to be more influenced by the wind than anything else. The probability is, however, that a proper application of analysis to these records would show, just as it has done in other ports where similar opinions were once held, that the irregularity is really governed by complex but regular law, and that the dependence upon the wind is more fanciful than real.

Now that we have Federation, it seems to me that it would be a great gain to us in this matter if the whole of the tidal work for Australia were controlled from one central office. At present each State does a little in the way of securing tidal records, but, as a rule, very little use seems to be made of these; and while each State continues to act independently of the others, we cannot well expect to get a proper methodical treatment of the whole available records. What we want is a definite general scheme of procedure, which, as it is gradually worked out, will, as the years go by, give us more and more complete information about our tides and tidal currents. Such a scheme might well embrace the gradual extension of the records, their systematic analysis, and regular prediction, the work of the whole of Australia being carried out on a uniform plan. In the securing of records the method of the Indian Government commends itself. There, at certain ports of first-rate importance, tide-gauges are established permanently. At other ports the tides are gradually being recorded by tide-gauges, which are set up for five years, a period long enough to ensure that the analysis of the curves will give a very perfect knowledge of the tides of that port. When a tide-gauge has done its five years' duty at one port it is shifted on to another. As the records are systematically analysed, in this way a very perfect knowledge is gradually being obtained of the tides along the Indian coasts. Such a proceeding recommends itself as an eminently reasonable one, and might well, one would think, be to some extent copied along our coasts with advantage. The work of systematic analysis and regular tidal prediction could undoubtedly be done very much cheaper and very much better from a central Federal office. The value and interest attaching to a publication giving predictions for the principal ports of the Commonwealth would be very much greater than can possibly attach to one issued by a single State. The commercial importance of the proper conduct of this work in the interests of the shipping, the fact that it is the basis of all hydrography and of all charts, and the scientific importance of having a proper systematic method of work whereby our knowledge may be continually added to, are all, I think, weighty reasons in favour of my suggestion.

Many attempts have been made to directly measure the horizontal component of the tide-producing force. This will clearly tend to deflect a pendulum from the vertical in a regular periodic way. The amount of this deflection is excessively small. On a pendulum 10 feet long the maximum effect is about $\frac{1}{97000}$ inch. Still, the measurement of this would not present any insuperable difficulty if it were not complicated by other disturbances. If the earth were perfectly rigid, the observed deflection should coincide with the calculated; but, if the solid earth itself is deformed by the action of the tidal forces, the difference between the observed and calculated deflections would enable us to form some idea of the amount of the earth's deformation, and, consequently, of the rigidity of the solid earth. The most notable of these attempts was made by the Brothers Darwin in 1879, but it would seem that all such attempts are doomed to failure, principally on account of the instability of the earth whereon we stand. The pressure of a light wind on the walls of the house, for instance, tilts the ground, and alters the apparent direction of the vertical to a much greater extent than do the forces we seek to measure. Further, we now know that the tidal forces would produce indirect effects upon the direction of the vertical, especially near the sea-shore, which would frequently be considerably greater than the direct one. Thus, when it is high tide along a coast, the water is heaped up all along the shore to a depth of several feet greater than mean sea-level. This water will have a direct attractive effect upon a pendulum hung a little distance inland. Further, the weight of the thousands of extra tons of water on the coast must deform the surface of the earth in its vicinity, and consequently produce an apparent deflection of the vertical. The actual effect upon a pendulum would thus be a combination of the direct attraction of the water with the effect due to the warping of the soil under the influence of the weight of that water. This action of the tide upon the pendulum has been observed in several cases, and such effects are clearly co-periodic with the tide-producing forces. Thus, even if it were possible to determine periodic oscillations of a pendulum synchronising with the lunar tide-generating forces, we should not know how much of the movement was due to the direct action of those forces, and how much to the indirect actions I have indicated. It has been thought by Paschwitz and Ehlert that the records of the horizontal pendulum at Strassburg show, amidst their other and greater perturbations, a periodic oscillation corresponding to the direct action of the moon; but it seems unlikely, even if such periodic disturbances are well established and determined, that we shall ever be able to separate out the direct actions from the indirect, or even able in this way to directly measure the tide-producing forces.

The researches of Dr. S. C. Chandler have shown us pretty conclusively that the axis of rotation of the earth is not coincident with the axis of figure, and that the pole of the rotation axis moves in a small circle in a period of about 427 days, while at the same time the circle is carried round the pole of figure in about one year. Euler had previously proved that, if the earth be regarded as perfectly rigid, the period of the oscillation should be but 305 days. If the earth is capable, however, of yielding in any way to the forces set up when the position of the axis of rotation is slightly changed, the shape of the earth will undergo corresponding slight alterations. Newcomb has shown that the elasticity of the solid portion of the earth and the mobility of the ocean will each have the effect of prolonging the period, and S. S. Hough has demonstrated that, if the period is 427 days, the effective rigidity of the entire earth must be slightly greater than that of steel. One curious result of these investigations is that, if this is correct, there should be an alteration in the form of the ocean corresponding to the changes in the position of the axis, which should be evident as a minute tide, having a period of 427 days. Researches into the tides on the coast of Holland, on the Pacific Coast of the United States, and on the Coast of Maine, have apparently indicated the real existence of this tide, the three results being in fair concord with one another, and with Chandler's results. Examination of other tides is in progress. The determination of the earth's rigidity thus obtained by Hough is about the same as that deduced from the values of the fortnightly tide. The results so obtained, however, have not been very consistent.

It was pointed out by Newton that if the moon were originally fluid the tidal action of the earth upon it would cause it to bulge towards the earth, so that the diameter of the moon directed towards the earth should be greater than the equatorial diameter at right angles to it by an amount which he calculated at 186 feet. Using the data furnished by the computations of Laplace, the difference between the two diameters comes out greater than the estimate of Newton, being about 426 feet. The probable form of the moon is thus an ellipsoid, having its greatest axis directed towards the earth, and its least axis through the poles. Although the difference in the diameters is too small for direct measurement, the fact that the moon's figure is ellipsoidal, or at any rate that the distribution of its mass is like that of a uniform ellipsoid, is shown by the existence of an observable real libration, and also, as pointed out by Lagrange, by the continuance of the co-incidence which exists between the descending or ascending node of the lunar equator with the ascending or descending node of her relative orbit. Hansen, basing his calculations upon the discrepancies between the observed and computed longitudes of the moon, inferred that the moon's centre of figure was as much as 59 kilometres nearer to us than its centre of gravity; and Gussew, from measurements made on two of De la Rue's photographs, estimated that the elongation towards the earth was as great as 5·5 per cent. These results are quite at variance with the tidal theory, and also with estimates based upon the amount of the real libration, the elongation being far too great, and they were disputed by Newcomb. Recently, in order to determine this point, Dr. Franz has made a series of very careful measurements of a set of five photographs of the moon near the full, taken at the Lick Observatory. The photographs, taken under different librations, gave pictures of the lunar surface, such that in the intervening intervals of time the moon had apparently rocked through angles varying from 10° to 14°. Measurements upon the relative positions of objects near the moon's equator would suffice, under these conditions, to determine the departure of the moon's shape from the spherical, if it were anything like so marked as the work of Gussew and Hansen would lead us to suppose. The result of the very careful and elaborate measurements of Dr. Franz is quite contrary to that of these observers, and proves that the moon is sensibly spherical, in agreement with the tidal theory and the estimates formed from its real libration.

The investigations and speculations of G. H. Darwin with regard to the effect of tidal friction upon the earth and moon form one of the most interesting chapters in our present subject. The moon's attraction upon the waters of the earth, when disturbed by tidal action modified by friction, tends to slacken the speed of the earth's rotation, and, consequently, increase the length of the day. The reaction upon the moon tends to continually push the moon further from the earth, to make its orbit more and more eccentric, and to increase the length of the lunar month. Darwin shows that the present rate of increase of the day must be much more rapid than that of the month, and, looking forward into time, he estimates that ultimately the day and the month will become equal when each is as long as 55 of our present days. In other words, the action of the moon upon our tides will ultimately cause the earth to continually show the same side to the moon, just as the friction of the tides in the moon in ages long ago has caused the moon always to turn the same face towards us. When this stage is reached there will then be no tide due to the moon, but the sun will still produce tides on the earth. These will tend to still further retard the rotation of the earth, so that the day will become longer than the month. This will tend to pull the moon back again gradually closer and closer to the earth, until, possibly at the end of time, it ultimately falls into it. Looking backward, and applying the same reasoning, we see that there must have been a time when the moon was very much closer to the earth than it is now. These tidal actions would then take effect much more rapidly, for the tidal retardation produced by the moon varies as the inverse sixth power of the distance. Going further and further back in the life history of the moon, we can thus trace it to a time when it must have revolved round the earth with very great rapidity, and very close to it. From this it is a natural step to suppose then that the moon must have been thrown off by the rapidly-revolving earth when in a molten liquid condition. The brilliant mathematical investigations of Jacobi, Poincaré, and Darwin have shown the existence of forms of equilibrium for rotating masses of liquid which are not solids of revolution having the axis of rotation as the axis of figure. Such a figure becomes unstable at a certain speed, and tends to break up into two masses, which may be nearly equal to one another. It seems probable then, that the moon was in the beginning of time thrown off by the rapidly-revolving earth, and that its subsequent career has been principally controlled by the action of the tidal forces we have been dealing with. In our own solar system there is no other planet with a satellite so comparable with itself in mass as is the case with the earth and moon, and it is probable that only in the case of the earth and moon has tidal friction been the main factor in the evolution. Our own solar system, with its central controlling sun, so immensely greater than that of the attendant planets, is, so far as our actual knowledge is concerned, unique in type. But we are becoming acquainted with an increasing number of systems (the double stars), in which we have two bodies revolving round one another, always comparable, and frequently enough nearly equal in mass. Dr. See has called our attention to the important part which tidal friction must play in the life-history of such systems, the evolution of which must be on an entirely different plan to that of our own. Investigating in a very thorough way the orbits of 40 known binaries, Dr. See finds that the average eccentricity of their orbits is 12 times as great as the average eccentricity found in the orbits of the planets. If we can imagine two bodies, each as big as our sun, revolving round one another, each in a hot plastic condition, it is clear that the tidal effects produced must be enormous; and one of the results of tidal friction is that the eccentricity of the orbit is continually increased. So, that the high eccentricity of all these double-star orbits forms corroborative evidence of the truth of the theory. In many of the spectroscopic binaries the two stars appear to be revolving exceedingly close together, if not in actual contact, and as our knowledge of these double stars becomes greater, we may possibly be able to see presented to us in the heavens the whole of the different stages in the past life-history of the earth and moon.

It may appear to many that such speculations are unprofitable, in that they are incapable of verification. You all probably remember Herschel's oft-quoted analogy, in which he compares our position to that of a traveller in a forest. The traveller is not able actually to see the growth of the trees around him, but yet he may, by an examination of the trees in the different stages of youth and age, arrive at a very accurate notion of the way in which the tree grows. We are far at present from actually realising this conception; but, if we can, by a similar process of reasoning, arrive at a knowledge of the way in which in our earth and its companion moon have reached the present stage in their history, we shall surely have done something which may well be regarded as a magnificent triumph of human intelligence.

THE TIDES OF PORT DARWIN.

By R. W. Chapman, M.A., F.R.A.S., and Captain Inglis.

The tidal waves which produce the oscillations of sea-level along the N.W. coast of Australia come from the Indian Ocean, and appear to strike the outlying headlands of the coast at about the same time, the co-tidal line running pretty well parallel with the coast. The range of the tide along the W. coast of Australia, from Fremantle up to North-West Cape, is very small, the mean spring range at Fremantle being only $2\frac{3}{4}$ feet. But beyond North-West Cape the range of the tide gets very much greater, running up to as much as 36 feet in Cambridge Gulf. At Port Darwin the mean spring range is about 24 feet, but is sometimes as high as 30 feet. A tide-gauge of Lord Kelvin's pattern was set up at Port Darwin in 1892 by the South Australian Government, and good records are available up to 1897, since when it has been dismantled, awaiting the building of a new jetty. The records of the tide-gauge show a very marked diurnal inequality, especially at the low waters, the general sequence throughout the year, with some few exceptions, being—High High, High Low, Low High, Low Low. From December to July the H.H. follows the lower transit from the third quarter to the first quarter, and the upper transit from the first quarter to the third. During the other half of the year this is reversed. The Diurnal Inequality is greater at the Low Waters than it is at the High Waters throughout the year, the maximum effect occurring in December and January, when the diurnal inequality between the high waters is about $4\frac{1}{2}$ feet, and between the two low waters it amounts to as much as 9 or 10 feet. In June and July there is about 3 feet inequality between the high waters and about 7 feet between the low waters. In March and April, when the moon is from 8 to 10, or from 20 to 24 days old, three tides amalgamate to make one long high water. When approaching this stage the two high waters get more and more nearly equal, and the two low waters more unequal, until the H.L.W. equals the two H.W.s. In September and the first part of October two tides amalgamate and merge into one, the L.H. and H.L.

We selected the tide-gauge records for the year 1896 as the latest reliable ones, and subjected them to harmonic analysis, measuring the heights at hourly intervals. The results of the analysis are given below in the British Association notation. The largest components are the lunar and solar semi-diurnals, with amplitudes (semi-range) of $6\frac{1}{2}$ and $3\frac{1}{2}$ feet respectively. But no less than three of the diurnal tides have a semi-range greater than 1 foot. The solar annual, which may be largely meteorological, has a semi-range of 1 foot, whilst the semi-annual has half a foot.

RESULTS OF HARMONIC ANALYSES OF PORT DARWIN TIDAL RECORDS FOR THE YEAR BEGINNING MIDNIGHT PRECEDING 1ST JANUARY, 1896.

(Lat. 12° 38′ S. Long. 130° 51′ E.)

Component.	Semi range in feet.	K.
	′	°
S_1	0·16	169
S_2	3·44	193
S_4	0·05	128
S_6	0·01	184
M_1	0·05	315
M_2	6·56	144
M_3	0·05	26
M_4	0·13	279
M_6	0·06	167
N	1·04	121
L	0·41	216
ν	0·96	161
O	1·14	313
J	0·14	197
Q	0·34	324
μ	0·39	110
2SM	0·17	13
MS	0·16	30
P	0·44	1
K_1	1·91	336
T	0·24	165
R	0·83	97
K_2	1·02	204
Msf	0·47	29
Mf	0·13	333
Mm	0·04	284
Sa	0·97	76
Ssa	0·54	59

ON CERTAIN RELATED FACTORIAL EXPRESSIONS.

By EVELYN G. HOGG, M.A.

THE origin of the series of related factorial expressions given below may be stated as follows :—Let BC, the hypoteneuse of the right-angled triangle ABC, be divided in a point D so that the radii of the inscribed circles of the triangles ADB, ADC are equal and also let

$$BD : DC = m : n$$

Then the following relation among the quantities involved may be easily proved,

$$m^2 (2b^2 - bc) - 2bc\,mn + (2c^2 - bc)\,n^2 = 0 \ldots\ldots \text{(i)}$$

If now $b = 2c$, we get at once

$$m : n = 2 : 3$$

If this value for the ratio $m : n$ be now inserted in (i), the latter reduces to

$$8b^2 - 25bc + 18c^2 = 0.$$

$$\text{i.e.} \quad 2.2^2b^2 - (2+3)^2bc + 2.3^2c^2 = 0$$

$$(b - 2c)(8b - 9c) = 0.$$

The result of inserting in (i) the value $8b = 9c$ gives

$$7.8.n^2 - 2.8.9.mn + 9.10\,m^2 = 0$$

$$\text{i.e.} \quad 2\,(2n - 3m)(14n - 15\,m) = 0$$

By inserting in (i) the value $14n = 15m$, we have

$$2.14^2.b^2 - (14 + 15)\,bc + 2.15^2.c^2 = 0$$

$$(8b - 9c)(49b - 50c) = 0$$

By continued insertion in (i) of the ratios $b : c$ and $m : n$ obtained by equating to zero the factors of the various resulting expressions in b, c and m, n, the following series of identities may be obtained :—

$$48.\,49n^2 - 2.\,49.\,50nm + 50.\,51m^2$$
$$= 2\,(14n - 15m)\,(84n - 85m)$$

$$2.\,84^2b^2 - (84 + 85)^2\,bc + 85^2c^2$$
$$= (49b - 50c)\,(288b - 289c)$$

$$287.\,288n^2 - 2.\,288.\,289nm + 289.\,290m^2$$
$$= 2\,(84n - 85m)\,(492n - 493m)$$

$$2.\,492^2.\,b^2 - (492 + 493)^2\,bc + 2.\,493.^2c^2$$
$$= (288b - 289c)\,(1681b - 1682c)$$

$$1680 \cdot 1681n^2 - 2 \cdot 1681 \cdot 1682nm + 1681 \cdot 1682m^2 = 2(492n - 493m)(2870n - 2871m)$$

$$2 \cdot 2870^2b^2 - (2870 + 2871)^2bc + 2 \cdot 2871^2c^2 = (1681b - 1682c)(9800b - 9801c)$$

$$9799 \cdot 9800n^2 - 2 \cdot 9800 \cdot 9801nm + 9801 \cdot 9802m^2 = 2(2870n - 2871m)(16730n - 16731m)$$

$$2 \cdot 16730^2b^2 - (16730 + 16731)^2bc + 2 \cdot 16731^2c^2 = (9800b - 9801c)(57121b - 57122c)$$

$$57120 \cdot 57121n^2 - 2 \cdot 57121 \cdot 57122nm + 57122 \cdot 57123m^2 = 2(16730n - 16731m)(97512n - 97513m)$$

$$2 \cdot 97512^2b^2 - (97512 + 97513)^2bc + 2 \cdot 97513^2c^2 = (57121b - 57122c)(332928b - 332929c)$$

$$332927 \cdot 332928n^2 - 2 \cdot 332928 \cdot 332929nm + 332929 \cdot 332930m^2 = 2(97512n - 97513m)(568344n - 568345m)$$

$$2 \cdot 568344^2b^2 - (568344 + 568345)^2bc + 2 \cdot 568345^2c^2 = (332928b - 332929c)(1940449b - 1940450c)$$

$$1940448 \cdot 1940449n^2 - 2 \cdot 1940449 \cdot 1940450nm + 1940450 \cdot 1940451m^2 = 2(568344n - 568345m)(3312554)n - 3312555m)$$

$$2 \cdot 3312554^2b^2 - (3312554 + 3312555)^2bc + 2 \cdot 3312555^2c^2 = (1940449b - 1940450c)(11309768b - 11309769c)$$

In relation (i) for $\frac{m}{n}$ and $\frac{b}{c}$ write u and a respectively; it then reduces to

$$u^2a(2a - 1) - 2ua + 2 - a = 0 \text{ .... (ii)}$$

From (ii) we obtain

$$u = \frac{1}{2a - 1}\left\{1 \pm \left(1 - \frac{1}{a}\right)\sqrt{2a}\right\},$$

and hence $2a$ must be a perfect square.

The values of a found from the above series are

$$\frac{2}{1}, \frac{9}{8}, \frac{50}{49}, \frac{289}{288}, \frac{1682}{1681}, \frac{9801}{9800}, \text{ \&c.}$$

Hence a may be represented by one or other of the forms $\frac{x+1}{x^2}$ or $\frac{x^2}{x^2-1}$, and we get the following table:—

x	1	3	7	17	41	99	239	577	1393	3363
$\frac{x^2+1}{x^2}$	$\frac{2}{1}$	—	$\frac{50}{49}$	—	$\frac{1682}{1681}$	—	$\frac{57122}{57121}$	—	$\frac{1940450}{1940449}$	—
$\frac{x^2}{x^2-1}$	—	$\frac{9}{8}$	—	$\frac{289}{288}$	—	$\frac{9801}{9800}$	—	$\frac{332929}{332928}$	—	$\frac{11309769}{11309768}$

The values of x found so as to make $2\,\frac{(x^2+1)}{x2}$ and $\frac{2x^2}{x^2-1}$ perfect squares alternately, viz .,1, 3, 7, 17, 41 &c., are connected by the relation $x_n = 2x_{n-1} + x_{n-2}$

ON THE GEOMETRY OF AN AXIS OF HOMOLOGY.

By EVELYN G. HOGG, M.A.

§ 1. Given a triangle ABC and a point O whose trilinear coordinates are $\alpha_0\beta_0\gamma_0$, the equation of its axis of homology with reference to the triangle is

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

The axis of homology of any point $(\alpha'\beta'\gamma')$ on L will be

$$\frac{\alpha}{\alpha'} + \frac{\beta}{\beta'} + \frac{\gamma}{\gamma'} = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

subject to the relation

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

The envelope of (i) is the in-conic

$$S_1 \equiv \sqrt{\frac{\alpha}{\alpha_0}} + \sqrt{\frac{\beta}{\beta_0}} + \sqrt{\frac{\gamma}{\gamma_0}} = 0,$$

a conic having double contact with the conic

$$S_2 \equiv \frac{\alpha_0}{\alpha} + \frac{\beta_0}{\beta} + \frac{\gamma_0}{\gamma} = 0,$$

along the line $L = 0$.

The coordinates of the intersection of L and S_2 are $(\alpha_0, \omega\beta_0, \omega^2\gamma_0)$ $(\alpha_0, \omega^2\beta_0, \omega\gamma_0)$, where ω is one of the imaginary cube-roots of unity.

§ 2. Let AO, BO, CO, meet the axis of homology of O in $A_0B_0C_0$ respectively; the coordinates of $A_0B_0C_0$ are respectively

$$(-2\alpha_0, \beta_0, \gamma_0)\ (\alpha_0, -2\beta_0, \gamma_0)\ (\alpha_0, \beta_0 - 2\gamma_0)$$

and the axes of homology of A_0 B_0 C_0 are respectively

$$L_1 \equiv \frac{\alpha}{-2\alpha_0} + \frac{\beta}{\beta_0} + \frac{\gamma}{\gamma_0} = 0$$

$$L_2 \equiv \frac{\alpha}{\alpha_0} + \frac{\beta}{-2\beta_0} + \frac{\gamma}{\gamma_0} = 0$$

$$L_3 \equiv \frac{\alpha}{\alpha_0} + \frac{\beta}{\beta_0} + \frac{\gamma}{-2\gamma_0} = 0$$

Let the vertices of the triangle formed by $L_1 L_2 L_3$ be $A_1 B_1 C_1$. Since the sides of this triangle touch the conic S_1, its vertices and those of the triangle of reference lie on a conic.

The coordinates of $A_1 B_1 C_1$ being respectively

$$(-\alpha_0, 2\beta_0, 2\gamma_0)\ (2\alpha_0 - \beta_0, 2\gamma_0)\ (2\alpha_0, 2\beta_0 - \gamma_0),$$

it is seen by inspection that the points $A_1 B_1 C_1$ lie on the conic S_2.

In general, if any three points $(\alpha_1\beta_1\gamma_1)$ $(\alpha_2\beta_2\gamma_2)$ $(\alpha_3\beta_3\gamma_3)$ be taken on the line L, the vertices of the triangle formed by their axes lie on the conic

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

§ 3. Let any point $\alpha'\beta'\gamma'$ be taken on S_2; its axis of homology is

$$\frac{\alpha}{\alpha'} + \frac{\beta}{\beta'} + \frac{\gamma}{\gamma'} = 0;$$

and we also have

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

from which it follows that the axis of $\alpha'\beta'\gamma'$ passes through $\alpha_0\beta_0\gamma_0$. Hence the conic S_2 is the locus of points whose axes of homology pass through $\alpha_0\beta_0\gamma_0$.

Hence the line L and the conics S_1 and S_2 may all be regarded as having been generated from the point O $(\alpha_0\beta_0\gamma_0)$

The axis of homology of the point of intersection of the conics

$$\frac{\alpha_1}{\alpha} + \frac{\beta_1}{\beta} + \frac{\gamma_1}{\gamma} = 0$$

$$\frac{\alpha_2}{\alpha} + \frac{\beta_2}{\beta} + \frac{\gamma_2}{\gamma} = 0$$

is the line joining the generating points $(\alpha_1\beta_1\gamma_1)$ and $(\alpha_2\beta_2\gamma_2)$.

§ 4. If $\alpha_0\beta_0\gamma_0$ be the Symmedian point of the triangle of reference, the in-conic S_1 becomes the Brocard ellipse

$$\sqrt{\frac{\alpha}{a}} + \sqrt{\frac{\beta}{b}} + \sqrt{\frac{\gamma}{c}} = 0$$

The equation of the axis of the Symmedian point,

$$\frac{\alpha}{a} + \frac{\beta}{b} + \frac{\gamma}{c} = 0$$

is satisfied by

$$(-2a, b, c)\ (a, -2b, c)\ (a, b, -2c).$$

Let the lines joining the vertices of the triangle ABC to the Symmedian point meet the circum-circle of the triangle in $A'B'C'$; then the sides of the triangle $A'B'C'$ touch the Brocard ellipse. For the coordinates of $A'B'C'$ are respectively

$$\left(-\frac{a}{2}, b, c\right)\quad \left(a, -\frac{b}{2}, c\right)\quad \left(a, b, -\frac{c}{2}\right),$$

and the equation of $B'C'$ is

$$\frac{\alpha}{-2a} + \frac{\beta}{b} + \frac{\gamma}{c} = 0$$

i.e., $B'C'$ is the axis of homology of $(-2a, b, c)$, a point on the axis of homology of the Symmedian point.

§ 5. Since the axis of homology of any point on the conic

$$\frac{\alpha_1}{\alpha} + \frac{\beta_1}{\beta} + \frac{\gamma_1}{\gamma} = 0$$

passes through $\alpha_1\beta_1\gamma_1$, it follows that the axes of the two points in which $L = 0$ cuts this conic are the pair of tangents which may be drawn to the conic S_1 from $\alpha_1\beta_1\gamma_1$

Let $\alpha'\beta'\gamma'$ be the coordinates of such a point of intersection; the axis of this point is

$$\frac{\alpha}{\alpha'} + \frac{\beta}{\beta'} + \frac{\gamma}{\gamma'} = 0.$$

In addition,

$$\frac{\alpha_1}{\alpha'} + \frac{\beta_1}{\beta'} + \frac{\gamma_1}{\gamma'} = 0$$

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

Hence $\frac{1}{\alpha'} : \frac{1}{\beta'} : \frac{1}{\gamma'} = \beta\gamma_1 - \beta_1\gamma : \gamma\alpha_1 - \gamma_1\alpha : \alpha\beta_1 - \alpha_1\beta$

and substituting in the last of the above relations, the equation of the pair of tangents to S_1 from $\alpha_1\beta_1\gamma_1$ becomes

$$\frac{1}{\alpha_0(\beta\gamma_1 - \beta_1\gamma)} + \frac{1}{\beta_0(\gamma\alpha_1 - \gamma_1\alpha)} + \frac{1}{\gamma_0(\alpha\beta_1 - \alpha_1\beta)} = 0.$$

These lines are mutually perpendicular if

$$\alpha_1^2 \frac{\operatorname{Cos} A}{\alpha_0} + \beta_1^2 \frac{\operatorname{Cos} B}{\beta_0} + \gamma_1^2 \frac{\operatorname{Cos} C}{\gamma_0}$$
$$- \beta_1\gamma_1\left(\frac{1}{\alpha_0} + \frac{\operatorname{Cos} C}{\beta_0} + \frac{\operatorname{Cos} B}{\gamma_0}\right) - \gamma_1\alpha_1\left(\frac{\operatorname{Cos} C}{\alpha_0} + \frac{1}{\beta_0} + \frac{\operatorname{Cos} A}{\gamma_0}\right)$$
$$- \alpha_1\beta_1\left(\frac{\operatorname{Cos} B}{\alpha_0} + \frac{\operatorname{Cos} A}{\beta_0} + \frac{1}{\gamma_0}\right) = 0.$$

Hence the equation of the director-circle of S_1 is

$$\Sigma\, \alpha^2 \frac{\operatorname{Cos} A}{\alpha_0} - \Sigma\, \beta\gamma\left(\frac{1}{\alpha_0} + \frac{\operatorname{Cos} C}{\beta_0} + \frac{\operatorname{Cos} B}{\gamma_0}\right) = 0$$

This may be reduced to the form

$$(\beta\gamma \sin A + \gamma\alpha \sin B + \alpha\beta \sin C)$$
$$\left(\frac{1}{\alpha_0} \sin A + \frac{1}{\beta_0} \sin B + \frac{1}{\gamma_0} \sin C\right)$$
$$- (\alpha \sin A + \beta \sin B + \gamma \sin C)$$
$$\left(\frac{\alpha}{\alpha_0} \tan A + \frac{\beta}{\beta_0} \tan B + \frac{\gamma}{\gamma_0} \tan C\right) = 0,$$

showing that the radical axis of the director-circle of S_1 and of the circum-circle of the triangle of reference is the axis of homology of

$$(\alpha_0 \tan A,\ \beta_0 \tan B,\ \gamma_0 \tan C).$$

The equation of the pair of tangents to S_1 from $\alpha_0\beta_0\gamma_0$ takes the form

$$\left(\frac{\beta}{\beta_0} - \frac{\gamma}{\gamma_0}\right)^{-1} + \left(\frac{\gamma}{\gamma_0} - \frac{\alpha}{\alpha_0}\right)^{-1} + \left(\frac{\alpha}{\alpha_0} - \frac{\beta}{\beta_0}\right)^{-1} = 0$$

or $$\left(\frac{\alpha}{\alpha_0} + \frac{\beta}{\omega\beta_0} + \frac{\gamma}{\omega^2\gamma_0}\right)\left(\frac{\alpha}{\alpha_0} + \frac{\beta}{\omega^2\beta_0} + \frac{\gamma}{\omega\gamma_0}\right) = 0.$$

§ 6. Given five points on a conic, to construct the conic.

Take any three of the points ABC as a triangle of reference and let the axes of homology of the remaining points D, E with respect to this triangle intersect in O.

The axis of any point on the conic will pass through O, *i.e.*, the generating point of any line through O will be a point on the required conic.

Let LM be any line drawn through O cutting CB produced in a' and construct a point a such that $CaBa'$ is a harmonic range; let LM meet AB produced in γ' and construct a point γ such that $A\gamma B\gamma'$ is a harmonic range. Let Aa and $C\gamma$ intersect in F; then F is a point on the conic.

§ 7. Let the equations of any two in-conics be

$$\sqrt{\frac{a}{a_1}}+\sqrt{\frac{\beta}{\beta_1}}+\sqrt{\frac{\gamma}{\gamma_1}}=0$$

$$\sqrt{\frac{a}{a_2}}+\sqrt{\frac{\beta}{\beta_2}}+\sqrt{\frac{\gamma}{\gamma_2}}=0$$

These conics may be regarded as the envelope of the axes of homology of points lying on the axes of homology of $a_1\beta_1\gamma_1$ and $a_2\beta_2\gamma_2$ respectively. Hence the fourth common tangent to these conics is the axis of the point of intersection of

$$\frac{a}{a_1}+\frac{\beta}{\beta_1}+\frac{\gamma}{\gamma_1}=0$$

$$\frac{a}{a_2}+\frac{\beta}{\beta_2}+\frac{\gamma}{\gamma_2}=0,$$

viz., of the point

$$a_1a_2(\beta_1\gamma_2-\beta_2\gamma_1),\ \beta_1\beta_2(\gamma_1a_2-\gamma_2a_1),\ \gamma_1\gamma_2(a_1\beta_2-a_2\beta_1),$$

and the fourth common tangent is

$$\frac{a}{a_1a_2(\beta_1\gamma_2-\beta_2\gamma_1)}+\frac{\beta}{\beta_1\beta_2(\gamma_1a_2-\gamma_2a_1)}+\frac{\gamma}{\gamma_1\gamma_2(a_1\beta_2-a_2\beta_1)}=0$$

The equations of the in-circle and ex-circles of the triangle of reference being written

$$I_o\equiv\sqrt{\frac{a}{\sec^2\frac{A}{2}}}+\sqrt{\frac{\beta}{\sec^2\frac{B}{2}}}+\sqrt{\frac{\gamma}{\sec^2\frac{C}{2}}}=0$$

$$I_a\equiv\sqrt{\frac{a}{-\sec^2\frac{A}{2}}}+\sqrt{\frac{\beta}{\operatorname{cosec}^2\frac{B}{2}}}+\sqrt{\frac{\gamma}{\operatorname{cosec}^2\frac{C}{2}}}=0$$

and two others, the fourth common tangents to I_o and I_a I_b, I_c are

$$I_{oa} \equiv a\alpha + (b - c)(\beta - \gamma) = 0$$
$$I_{ob} \equiv b\beta + (c - a)(\gamma - \alpha) = 0$$
$$I_{oc} \equiv c\gamma + (a - b)(\alpha - \beta) = 0.$$

These lines intersect in the points

$$\cos^2\frac{A}{2},\quad \sin\frac{C-A}{2}\cos\frac{B}{2},\quad \sin\frac{B-A}{2}\cos\frac{C}{2}$$
$$\sin\frac{C-B}{2}\cos\frac{A}{2},\quad \cos^2\frac{B}{2},\quad \sin\frac{A-B}{2}\cos\frac{C}{2}$$
$$\sin\frac{B-C}{2}\cos\frac{A}{2},\quad \sin\frac{A-C}{2}\cos\frac{B}{2},\quad \cos^2\frac{C}{2}.$$

These points, the vertices of the triangle of reference, the centre of the in-circle and the point

$$\left(\cos^2\frac{A}{2},\ \cos^2\frac{B}{2},\ \cos^2\frac{C}{2}\right)$$

all lie on the conic

$$\frac{\sin\frac{B-C}{2}\cos^3\frac{A}{2}}{\alpha} + \frac{\sin\frac{C-A}{2}\cos^3\frac{B}{2}}{\beta} + \frac{\sin\frac{A-B}{2}\cos^3\frac{C}{2}}{\gamma} = 0.$$

§ 8. The conic S_1 will be a parabola if

$$\frac{1}{a\alpha_0} + \frac{1}{b\beta_0} + \frac{1}{c\gamma_0} = 0$$

i.e. if $\alpha_0\beta_0\gamma_0$ lie on the Steiner ellipse,

$$\frac{\operatorname{cosec} A}{\alpha} + \frac{\operatorname{cosec} B}{\beta} + \frac{\operatorname{cosec} C}{\gamma} = 0.$$

The equation of the directrix of the parabola being

$$\frac{\alpha}{\alpha_0 \tan A} + \frac{\beta}{\beta_0 \tan B} + \frac{\gamma}{\gamma_0 \tan C} = 0,$$

the directrix may be regarded at the axis of homology of a point D, whose coordinates are $(\alpha_0 \tan A,\ \beta_0 \tan B,\ \gamma_0 \tan C)$

Hence as $O\ (\alpha_0\beta_0\gamma_0)$ moves on the Steiner ellipse, the generating point D of the directrix will move on the conic

$$\frac{\sec A}{\alpha} + \frac{\sec B}{\beta} + \frac{\sec C}{\gamma} = 0,$$

a conic to be afterwards referred to as the secant-conic, and it may be at once verified that the focus $F\ (\alpha_0 \sin^2 A,\ \beta_0 \sin^2 B,\ \gamma_0 \sin^2 C)$ will trace out the circum-circle of the triangle of reference.

The line joining O and D has for equation

$$\frac{\alpha}{\alpha_0} \cos A \sin (B - C) + \frac{\beta}{\beta_0} \cos B \sin (C - A)$$
$$+ \frac{\gamma}{\gamma_0} \cos C \sin (A - B) = 0\,;$$

this line passes through the point P_1, whose coordinates are

$$\frac{\operatorname{cosec} 2A}{\sin (B - C)},\ \frac{\operatorname{cosec} 2B}{\sin (C - A)},\ \frac{\operatorname{cosec} 2C}{\sin (A - B)}$$

The line joining O and F has for equation

$$\frac{\alpha}{\alpha_0} \sin A \sin (B - C) + \frac{\beta}{\beta_0} \sin B \sin (C - A)$$
$$+ \frac{\gamma}{\gamma_0} \sin (C \sin A - B) = 0$$

and passes through the fixed point P_2 whose coordinates are

$$\frac{\operatorname{cosec}^2 A}{\sin (B - C)},\ \frac{\operatorname{cosec}^2 B}{\sin (C - A)},\ \frac{\operatorname{cosec}^2 C}{\sin (A - B)}.$$

The line joining F and D has for equation

$$\frac{\alpha}{\alpha_0} \cot A \sin (B - C) + \frac{\beta}{\beta_0} \cot B \sin (C - A)$$
$$+ \frac{\gamma}{\gamma_0} \cot C \sin (A - B) = 0$$

and passes through the fixed point P_3 whose coordinates are

$$\frac{\sec A}{\sin (B - C)},\ \frac{\sec B}{\sin (C - A)},\ \frac{\sec C}{\sin (A - B)}$$

Hence as O moves along the Steiner ellipse, the focus F traverses the circum-circle and the point D the secant-conic, while the sides of the triangle ODF pass through the fixed points $P_1 P_2 P_3$.

These points I propose to call the parabolic points of the triangle of reference.

The axis of P_1 has for equation

$$\alpha \cos A\,(b^2-c^2)+\beta \cos B\,(c^2-a^2)+\gamma \cos C\,(a^2-b^2)=0,$$

and is the line joining the orthocentre of the triangle of reference and the point $(a \tan A, b \tan B, c \tan C)$.

The axis of P_2 has for equation

$$\alpha \sin A\,(b^2-c^2)+\beta \sin B\,(c^2-a^2)+\gamma \sin C\,(a^2-b^2)=0$$

and is the line joining the centroid and the Symmedian point of the triangle of reference.

The axis of P_3 has for equation

$$\alpha \cot A\,(b^2-c^2)+\beta \cot B\,(c^2-a^2)+\gamma \cot C\,(a^2-b^2)=0$$

and is the line joining the points $(\tan A, \tan B, \tan C)$ and $(a^2 \tan A, b^2 \tan B, c^2 \tan C)$.

§ 9. The locus of the point whose axis of homology is parallel to $L=0$ is the conic

$$\frac{\alpha_0\,(b\beta_0-c\gamma_0)}{\alpha}+\frac{\beta_0\,(c\gamma_0-a\alpha_0)}{\beta}+\frac{\gamma_0\,(a\alpha_0-b\beta_0)}{\gamma}=0,$$

which will afterwards be referred to as the parallel-conic. It passes through the point O and the centroid of the triangle of reference.

If the orthocentre of the triangle of reference be the point $\alpha_0\beta_0\gamma_0$, the parallel-conic reduces to Kiepert's hyperbola,

$$\frac{\sin(B-C)}{\alpha}+\frac{\sin(C-A)}{\beta}+\frac{\sin(A-B)}{\gamma}=0.$$

§ 10. To find the equation of the pair of tangents to S_1 which are parallel to the line

$$\frac{\alpha}{\alpha_1}+\frac{\beta}{\beta_1}+\frac{\gamma}{\gamma_1}=0$$

The locus of points whose axes are parallel to this line is the conic

$$\frac{\alpha_1}{\alpha}(b\beta_1 - c\gamma_1) + \frac{\beta_1}{\beta}(c\gamma - a\alpha_1) + \frac{\gamma_1}{\gamma}(a\alpha_1 - b\beta_1) = 0$$

or $$\frac{L}{\alpha} + \frac{M}{\beta} + \frac{N}{\gamma} = 0,$$

when
$$L \equiv \alpha_1 (b\beta_1 - c\gamma_1)$$
$$M \equiv \beta_1 (c\gamma_1 - a\alpha_1)$$
$$N \equiv \gamma_1 (a\alpha_1 - b\beta_1)$$

Let this conic cut the line

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

in the points $\alpha'\beta'\gamma'$ and $\alpha''\beta''\gamma''$; then the axes of these point are the required tangents.

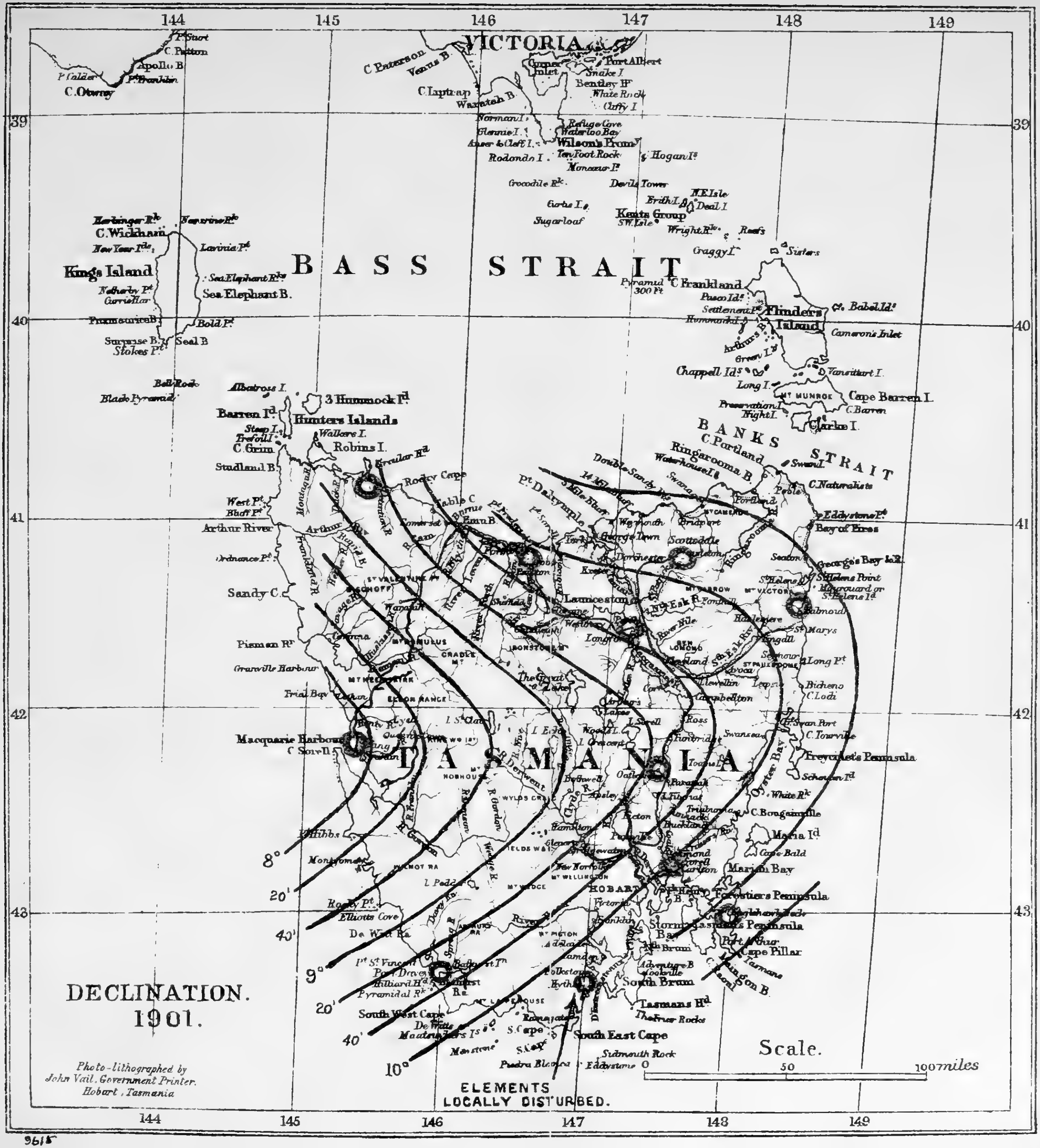
We have

$$\frac{\alpha}{\alpha'} + \frac{\beta}{\beta'} + \frac{\gamma}{\gamma'} = 0$$
$$\frac{L}{\alpha'} + \frac{M}{\beta'} + \frac{N}{\gamma'} = 0$$
$$\frac{\alpha'}{\alpha_0} + \frac{\beta'}{\beta_0} + \frac{\gamma'}{\gamma_0} = 0$$

Hence $$\frac{1}{\alpha'} : \frac{1}{\beta'} : \frac{1}{\gamma'} = \beta N - \gamma M : \gamma L - \alpha N : \alpha M - \beta N$$

and $$\Sigma \frac{1}{\alpha_0 (\beta N - \gamma M)} = 0$$

is the required equation.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Flinders Island
Cape Barren I.
Hunters Islands
Kents Group
C. Otway
Wilson's Promy
Launceston
HOBART
Macquarie Harbour
South West Cape
South East Cape
Tasmans Pen
Freycinet's Peninsula
Maria Id
Storm Bay
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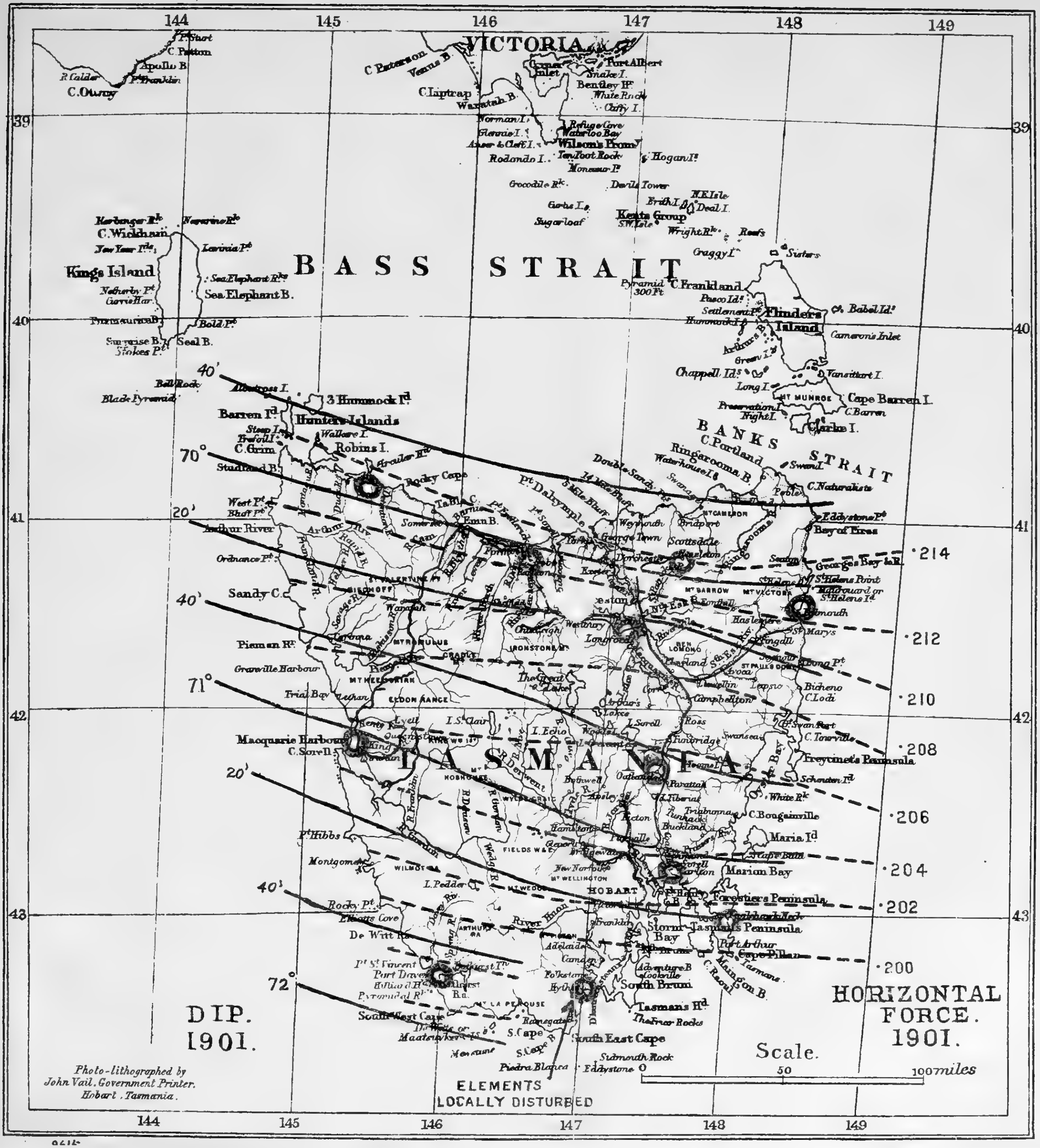

VICTORIA
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BANKS STRAIT
TASMANIA
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Flinders Island
Cape Barren I.
Hunters Islands
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Robins I.
Kents Group
Wilson's Promy
Macquarie Harbour
HOBART
Storm Bay
Tasmans Peninsula
Forestiers Peninsula
Freycinet's Peninsula
Marion Bay
Maria Id
South Bruni
Tasmans Hd
South East Cape
South West Cape
Port Davey
Rocky Cape
Sandy C.
Arthur River
Pieman Rr
Trial Bay
Granville Harbour
C. Grim
Studland B.
Eddystone Pt
Bay of Fires
C. Naturaliste
Ringarooma B.
C. Portland
Double Sandy Pt
George Town
Scottsdale
Longford
Campbelltown
Ross
Oatlands
Bothwell
Hamilton
New Norfolk
Bridgewater
Sorell
Bicheno
C. Lodi
C. Bougainville
C. Barren
Clarke I.
C. Otway
C. Wickham
Sea Elephant B.
Seal B.
C. Liptrap
Port Albert
C. Paterson
Hogan Id
Sisters
Babel Ids
Cameron's Inlet
Chappell Ids
Long I.
Vansittart I.
C. Frankland
Pyramid 300 Ft
L. Pedder
Montgomery
Pt Hibbs
De Witt Rr
Rocky Pt
Elliotts Cove
Maatsuyker I.
S. Cape
Piedra Blanca
Eddystone
Sidmouth Rock
The Friar Rocks
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Hobart, Tasmania.

A PRELIMINARY MAGNETIC SURVEY OF TASMANIA, 1901.

By Professors A. McAulay, M.A., and E. G. Hogg, M.A.

The record of magnetic work in Tasmania begins with the determination by Sir John Franklin in 1839 of the declination of Lachlan, a small township about 25 miles from Hobart. This he found to be 10° 10′. Nothing is known as to the instrument used by him in his determination.

During the period from 1842 to 1850 magnetic observations were made by the survey party sent out to Hobart by the Royal Society of London, under the superintendence of Lieutenant Kay, R.N. The results obtained may be summed up as follows:—The mean declination of Hobart varied from 9° 53′ 19″ E. in 1843 to 10° 0′ 37″ E. in 1848, giving an annual increase of about 1′ 27·6″. The dip decreased from 70° 42′ 18″ in 1842 to 70° 32′ 0″ in 1845; it then began to increase, and in 1848 had attained the value of 70° 35′ 42″. During the period under consideration the horizontal force passed through a minimum value in 1848.

In 1863 Dr. Neumayer visited Hobart, and found that the mean declination of Hobart was then 10° 25′ 9″, a quantity somewhat greater than it should have been if the rate of increase found by Kay had held good until 1863. It is known that Neumayer did not use the same station as Kay, and as both stations employed by these observers are in close proximity to the highly-magnetic greenstone, we may have here a solution of the slight discrepancy which appears to exist. Assuming that Neumayer's results are correct, and it is probable that this experienced observer had at his disposal more perfect instruments than those used by Kay, the mean annual rate of increase of the declination between 1843 and 1863 would be 1′ 36″, as against 1′27·6″ computed from Kay's observations.

The next determination was made in 1881 by His Excellency Sir J. H. Lefroy. He found the declination to be 8° 49′ 2″. If the rate of increase deduced from Kay and Neumayer's observations had held good up to 1881, the declination should have been 10° 53′ 48″ Though Sir Henry Lefroy worked with a prismatic compass, the discrepancy—amounting to more than 2°—between the observed and calculated values can hardly be put down to errors of observation, and suggests that, during the interval between 1863 and 1881, the declination passed through a maximum value, and was in 1881 proceeding towards a minimum. This view is borne out by the knowledge that in the 15 years preceding 1881 the declination was decreasing in the neighbouring State of Victoria at an average rate of 2′ a year.

The magnetic survey described in this paper was made possible by the grant by the Government of the State of the sum of £150 to defray necessary expenses, and by the loan by the University of Sydney, through the kind offices of Professor Pollock, of Kew instruments of the usual type as described in Stewart and Gee's Practical Physics.

The stations selected were eleven in number, viz., Scamander, Springfield (near Scottsdale), Longford, Latrobe, Circular Head, Strahan, Port Davey, Sorell, Eaglehawk Neck, Oatlands, and Southport. They were chosen so as to be well spaced over the Island, and at the same time avoid the greenstone or other igneous rock known or suspected to be magnetic.

All the stations enumerated, except Port Davey and Southport, had been previously visited by one of the writers. As to the geological fitness of the Port Davey site, there can be no doubt; the anomalous results obtained at Southport, to which further reference will be made, are possibly due to the proximity of a dyke of magnetic rock not outcropping at the surface. It may here be mentioned that the greenstone (diabase) which covers so large a part of the eastern half of Tasmania is highly magnetic.

A reference may here be made to the reasons why we did not select Hobart as a site of observation. It is obvious that, for purposes of comparison with previous magnetic records, a series of observations made at Hobart would be of great value; but, unfortunately, the Domain site employed by Lieutenant Kay is, from a geological point of view, by no means a good one. The magnetic greenstone outcrops in the Domain at no great distance from the site, and it is by no means improbable that dykes of greenstone may penetrate the Domain sandstones in close proximity to Kay's site. It is known that Dr. Neumayer, though he set his instruments up in the Domain, did not employ Kay's site; this may account in some measure for the result obtained by him. Other defects in Kay's site are the proximity of iron roofing and pipes placed in position since Kay's time. The greatest defect of all, however, is the disturbing influence introduced by the electric trams of Hobart. We were, therefore, reluctantly compelled to abandon the Domain as a magnetic site. The declination of Hobart (1901), as found by interpolation from determinations elsewhere, is about 9° 59′ E. The changes in the declination of Hobart since 1842 are shown in Plate I.

At each of the eleven selected sites absolute determinations of the magnetic dip, declination, and horizontal component of the earth's magnetic force were made. It was also necessary for us to determine in each the latitude and the longitude relative to Hobart of the site. At the exact spot where the theodolite was set up for astronomical work a mark has been left, and an exact description of the locality of each mark is given below. [The magnetic observations were not taken on this exact spot.] Where possible, the theodolite was set up so that a small Muntz metal cylinder, about 4 inches long and 1 inch in diameter, could be let into the solid rock. When this could not be done, a hole some 3 feet deep was dug; a good base of stones was put down, and well driven in; on the top of this was placed a block of cement, about 10 inches or a foot square and 6 inches deep, and in this the metal plug was inserted, the top of the plug being at a depth of about 1 foot from the surface of the ground. The hole was then filled up. The end of the cylinder was engraved "M.S., 1901," and the mark will below be called the M.S. mark. From each site a reading was taken of some well-defined distant object, which could, from the description given by us, be picked up by a surveyor, and the azimuth of this mark has been determined relative to the meridian passing through the site. At all stations, where practicable, azimuth readings were taken of well-defined points on prominent natural objects, such as mountains, in the hope that the information so collected might at some future time be of use in the compilation of the map of Tasmania.

The actual magnetic results obtained during the survey are best studied on the maps shown. The lines of equal dip, equal horizontal intensity, and equal declination have been plotted for us by Mr. F. M. Young, B.A., one of the vice-presidents of this section.

From the map it will be seen that, excluding the Southport observations for the moment, the magnetic dip varies between 69° 56′ 43″ at Circular Head and 71° 49′ 44″ at Port Davey, and that the lines of equal dip show themselves as roughly parallel. The horizontal intensity is greatest at Springfield, near Scottsdale, where its value is ·2140, and least at Port Davey, where it falls to ·1975, and the lines of equal horizontal intensity retain throughout the Island a roughly parallel course. The distribution of the lines of equal dip and equal intensity present appearances very similar to those shown on the magnetic map of Victoria prepared by Dr. Neumayer as a result of the survey conducted by him between 1858 and 1863. Dr. Neumayer's map is based on determinations made by him at 235 stations.

As regards their shape, the lines of equal declination came somewhat as a surprise to us when plotted, but we see no reason to believe that the map does not show their actual distribution with such accuracy as might have been expected from the small number of stations at our disposal. The declination (omitting the Southport determination) ranges from 10° 16′ 35″ E. at Eaglehawk Neck to 7° 57′ 19″ E. at Strahan.

As regards the Southport site, the abnormalities there shown do not present themselves merely in one of the magnetic elements, but in all three. Determination of the dip was made with three needles, the results being—72° 18′ 8″, 72° 25′ 1″, and 72° 29′ 20″. The differences between these readings are too great to be due to errors of observation, and that the instrument was in good order is shown by the fact that at a later date one of the writers made a determination of the dip at the Melbourne Observatory with this instrument, while Mr. Baracchi used his, and our mean results did not differ by more than 2′ of arc, though neither instrument was working too well, owing to the humidity of the atmosphere.

The declination at Southport is 11° 44′ 1″, while the horizontal intensity works out as ·1932, both results being quite discordant with the results obtained at other stations.

This again is not due to any error in the instrument, as in determining the horizontal intensity with it at Melbourne, the results obtained did not differ from those of Mr. Baracchi until the fourth place of decimals was reached. The cause of the discrepancy is probably to be found in some geological abnormality near the site.

Maps giving the positions of the stations with sufficient accuracy for the purposes of the survey were not available. Astronomical methods had therefore to be used. The Government permitted free telegrams to pass at any time between the survey party and the Hobart Observatory, and the privilege was fully used to attain Greenwich time. The chronometer used in the survey proved deficient, but we believe that in no case was the estimated time in error by as much as two seconds.

Besides the chronometer, the astronomical instruments were an Everest theodolite, a sextant, and an artificial horizon.

From examination of the amount of inconsistency in repeated observations, and a careful examination of the scales of the instruments, it appears probable that the accuracy of the astronomical work is of a slightly higher order than that which can be attained with the Kew magnetic instruments. It is probable that the deduced positions and azimuths are seldom in error by as much as 30″, and never by as much as 60″. But it is best to leave a record such that all the strictly astronomical work can be re-tested, and the accuracy of relative azimuths, according to our observations, may be tested with better instruments than were used in the present survey. For this purpose it will be necessary to pick up the M.S. marks, and re-observe all the terrestrial objects.

In view of these necessities of the future, the information given below for each station will be seen to be of permanent importance.

The picking up of the M.S. marks, even when buried, will probably prove easy, with the help of (1) a prismatic compass, (2) a sextant, (3) a fine steel probe to feel for the mark, (4) a measuring-tape.

No corrections have been made for diurnal variations, &c., as it has been thought that, when in the future the observations are repeated, there will probably be better means of making such corrections.

In the details given for each station below the azimuths are true, and are in all cases reckoned from the south point in the direction S.W.N.E. The various terrestrial objects observed at each station are partly denoted by capital letters and partly by small letters, the former being of the general nature of distant permanent marks, and the latter of near sub-permanent ones.

Such an entry as for Scamander below:—

"*Magnetic station* from M.S. mark.—Distance, 79 cos 10° 3′ feet," implies that the measured slant distance was 79 feet, and the angle of elevation or depression was 10° 3′. This sometimes is not the dip of the ground, but that from the theodolite telescope to the peg marking the magnetic station.

We desire to place on record our thanks to the Government of the State of Tasmania for the enabling grant of £150 made to us; to the State Treasurer, the Hon. Stafford Bird, for the telegraphic facilities afforded to us; to Mr. H. C. Kingsmill, Government Astronomer,

for the great trouble taken by him in signalling the time to us; to Mr. E. A. Counsel, Surveyor-General, for assistance in the matter of maps, plans, and tracings; to Mr. G. Richardson, Commissioner of Police; and to the many others whose advice and help was of service to us in carrying out the work of the survey.

We are also much indebted to Mr. E. L. Piesse, B.Sc., who was one of the survey party for a large part of the trip, and who not only, during that time, took more than his full share of the observations, but has since verified for all the earlier stations and some of the later ones the accuracy of the laborious astronomical calculations; and to Mr. F. M. Young, B.A., who also assisted in the work of observation, and has prepared the magnetic maps attached to this paper.

Station.—Scamander—Lat. 41° 26′ 42″. Long. 9h. 53m. 10·3s.

Date.	Time.	Element.	Magnitude.
Jan. 7	2·27-2·40 p.m.	Declination	10° 10′ 19″ E.
8	Vibration 7·54-8·5 p.m. Deflection 11·26 a.m.-0·27 p.m.	Horizontal Force	·2121
6	4·30-5·50 p.m. 10·30 a.m.-12 noon.	Dip	70° 7′ 23″

The prevailing rocks are indurated sandstones and clay-slates, dipping E. at a high angle, probably of Silurian age.

Azimuths from M.S. mark.—Left extremity, left pile, southernmost set of piles on bridge, *a*, 142° 2′ 17″. Right extremity, right pile, southernmost set, *b*, 143° 5′ 57″. Left extremity, left pile, northernmost set, *c*, 167° 50′ 22″. Right extremity, right pile, northernmost set, *d*, 168° 55′ 17″. Right chimney of hotel, left edge, *e*, 173° 33′ 57″. Right edge, *f*, 173° 42′ 12″. Right edge, bathing shed, lowest visible point, *g*, 192° 11′ 27″. West extremity of Paddy Island, H, 204° 16′ 27″. Saddle between two peaks (telescopic object), the peaks being about 1′ 5″ apart, I, 205° 41′ 19″. West extremity, easternmost islet off the large island, J, 210° 19′ 52″. [H and J are uncertain, owing to height of tide. They should be used only as finders of I, the permanent distant mark.]

Magnetic station from M.S. mark.—Distance, 79 cos 10° 3′ feet; azimuth, 192° 11′ 27″.

Directions for finding M.S. mark.—In the solid rock. Approaching River Scamander from St. Mary's, the road bends round sharply to the N.W., just as the bridge comes into sight, and discloses to the left a small gully. Proceeding up the gully a short distance, the M.S. mark will be found on the left-hand slope, at a height of about 16 feet above sea-level. Its exact position may be found by *a*, *b*, *c*, *d*, *e*, *f*, *g*, above.

Station.—Springfield, near Scottsdale. Lat. 41° 11′ 12″. Long. 9h. 49m. 57·3s.

Date.	Time.	Element.	
Jan.			
14	7·8-8·25 p.m.	Declination	10° 1′ 49″ E.
14	Vibration 4·34-4·45 p.m. Deflection 11·48 a.m.-1 [p.m.	Horizontal Force	·2140
13	2·45-3·45 p.m. 4·15-5·15 p.m.	Dip	69° 57′ 48″

The rock surrounding the site is a quartz-mica diorite. Its relation to the neighbouring sedimentary beds and granite is obscure.

Azimuths.—[For A and B see figure I., plate II.] Prominent depression near the highest point of Mt. Barrow, A, 17° 48′ 23″. Left edge of a prominent upright rock, B, 19° 5′ 48″. Huge granite-like boulder forming part of west boundary-fence of paddock containing M.S. mark, *c*, *about* 58° 13′. West end of roof of church, *d*, 186° 49′ 50″. Mount Stronech cairn pole (difficult object in hazy weather), E, 244° 29′ 20″. Apparent highest point of mountain peak, thickly wooded almost up to summit, F, 347° 41′. [A and F are finders for B and E.]

Magnetic station from M.S. mark.—Distance, 245·9 cos 7° 2′ feet; azimuth, 164° 7′ 21″.

Directions for finding M.S. mark.—In the solid rock. Proceeding from Scottsdale to Launceston, along the main road, after reaching a point 0·44 mile (by cyclometer) beyond Springfield Church of England Church, a huge granite-like boulder (*c* above) is prominently seen on the right. It forms part of the boundary-fence of the paddock containing the M.S. mark. To find the mark note *c* above, and also that the distance between *c* and the mark is 81 feet.

Station.—Longford. Lat. 41° 35′ 53″. Long. 9h. 48m. 33·7s.

Date.	Time.	Element.	
Jan.			
18	6·28-6·37 p.m.	Declination	9° 42′ 39″
17	Vibration 3·23-3·34 p.m. Deflection 4·50-6·0 p.m.	Horizontal Force	·2091
18	0·20-3·0 p.m. 3·10-4·10 p.m.	Dip	70° 25′ 22″

The prevailing rocks are gravels and clays of later Tertiary age. They are supposed to be of considerable thickness, and may rest either on Mesozoic sandstones or on greenstone (diabase).

Azimuths.—[For *b*, *c*, *f*, *g*, *h*, *j*, *k* see plan of Longford recreation ground, figure II., plate II.] Edge of a rock, nearly vertical at its base, on Western Tier, A, 63° 38′ 16″; *b*, 168° 18′ 26″; *c*, 178° 54′ 11″. Edge of Mt. Barrow rock (apparently the same as "Springfield, B"), D, 225° 18′ 36″. Middle of middle window of Roman Catholic Church, *e*, 231° 35′ 6″; *f*, 255° 11′ 56″; *g*, 264° 38′ 6″; *h*, 291° 38′ 36″. Corner of almshouse, *i*, 299° 3′ 51″; *j*, 316° 15′ 16″; *k*, 321° 56′ 36″. Left edge of a cottage chimney, *l*, 329° 6′ 26″.

Magnetic station from M.S. mark.—Distance, 158·5 feet; azimuth, 329° 6′ 26″.

Directions for finding M.S. mark.—Buried. See the azimuths above.

Station.—Latrobe. Lat. 41° 14′ 49″. Long. 9h. 45m. 46·4s.

Date.	Time.	Element.	
Jan.			
21	11·40-11·55 a.m.	Declination	9° 54′ 0″ E.
20 21	Vibration 5·20-5·40 p.m. Deflection 2·45-4·0 p.m.	Horizontal Force	·2122
20	11·55 a.m.-12·55 p.m. 1 p.m.-3 50 p.m.	Dip	70° 5′ 1″

The underlying rocks are mudstones and sandstones of Permo-Carboniferous age.

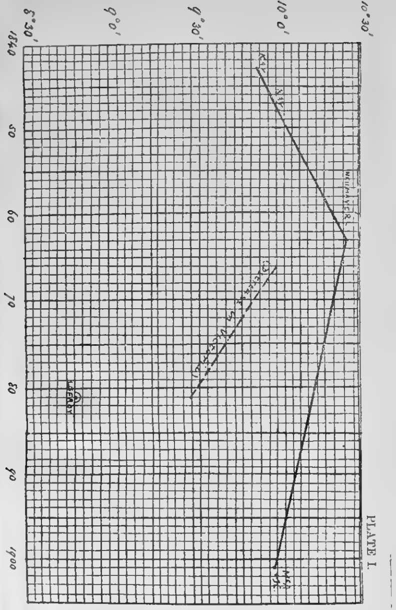

PLATE I.

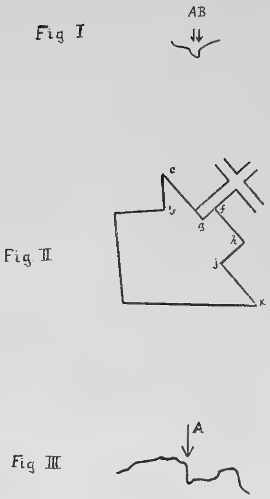

PLATE II.

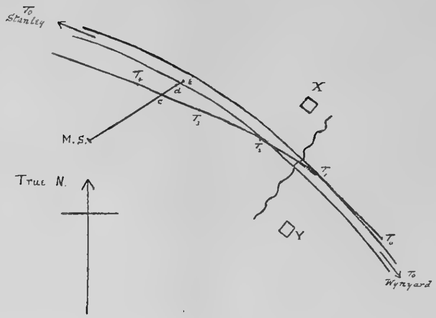

PLATE III.

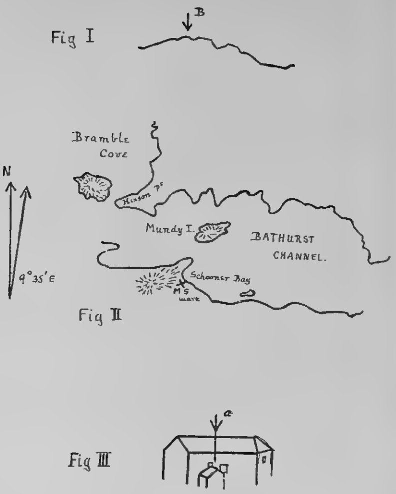

PLATE IV.

Azimuths.—Right edge of a rock on Mt. Roland (see figure III., plate II.), A, 30° 8′ 46″. Spike on gable of weatherboard house, *b*, 76° 31′ 39″.

Magnetic station from M.S. mark.—Distance, 102·6 feet; azimuth, 76° 31′ 39″.

Directions for finding M.S. Mark.—Buried. Proceed east from Latrobe towards Deloraine, along the main road, till the west boundary-fence of the racecourse recreation reserve is arrived at. Measure north along that fence (from S.W. corner) a distance of 430 feet 8 inches. From the point on the fence so reached measure exactly at right angles to the fence (towards the east) 112 feet 4 inches. The M.S. mark is at the point so found. In November, 1902, on uncovering the concrete block, it was found broken, and the Muntz metal mark had been removed. The square plan of the block was, however, quite plain.

Station.—Stanley. Lat. 40° 50′ 59″. Long. 9h. 41m. 17·5s.

Date.	Time.	Element.	
Jan.			
28	12·33-12·49 p.m.	Declination	9° 11′ 28″ E.
27	Vibration 6·21-6·32 p.m. Deflection 2·20-3·20 p.m.	Horizontal Force	·2131
27	10·0-11·0 a.m. 11·10 a.m.-12·15 p.m.	Dip	69° 56′ 43″

Considerable difficulty was experienced at this station in finding a site which, while geologically suitable, would permit of observations of the azimuth of a distant object of a permanent nature being taken. The site finally selected is some few miles east of Stanley, beyond the Black River.

The underlying rocks are indurated sandstones and schists, probably of older Palæozoic age.

Azimuths.—Telegraph wire insulator, *a*, 121° 23′ 11″. Cairn on Nut, B, 179° 8′ 26″; *c*, (described below in the "*directions*"), 237° 8′ 26″.

Magnetic station from M.S. mark.—Distance, 14·6 feet; azimuth, 301° 23′ 11″.

Directions for finding M.S. mark.—Buried. Proceed from Stanley towards Wynyard to the small creek (*f* in the figure, plate III.) 0·76 mile beyond the middle of the Black River bridge. X, Y, are cottages. T_0, T_1, are telegraph posts on the north side of the road; T_2, T_3, T_4, telegraph posts on the south side. *c*, *d* are two stout wooden pegs a chain apart, *c* being directly under the telegraph wire and *d* close by road.

e is at the middle of the road; f is where creek crosses road. The following azimuths and distances (latter in feet) should serve for finding the mark:—Azimuths: T_1-T_2, 125° 37′ 26″; T_2-T_3-T_4, 113° 49′ 26″; M.S.-*c*-*d*-*e*, 237° 8′ 26″. Distances: T_1 f, 55·2; f T_2, 187·0; T_2T_3 176·1; T_3c, 121·5; *ed*, 19·0; *dc*, 66·0; *c* to M.S., 262·0.

Station.—Strahan. Lat. 42° 9′ 33″. Long. 9h. 41m. 27s.

Date.	Time.	Element.	
Feb. 1	4·30-4·40 p.m.	Declination	7° 57′ 19″
Jan. 31	Vibration 7·22-7·33 p.m.	Horizontal Force	·2051
	Deflection 3·45-5·15 p.m.		
31	10-10·50 p.m.	Dip	71° 5′ 11″
	11-11·55 a.m.		

The underlying rocks are sandstones and conglomerates, probably of Silurian age.

Azimuths.—Middle point of front firing-mound 600 yards from butts, *a*, about 11° 33′. Apparently highest point of mountain range at S.W. corner of Macquarie Harbour (see figure I., plate IV.), B, 19° 17′ 1″. Corner of Customs House nearest to M.S. mark, *c*, 100° 21′ 56″. Middle point of front firing-mound 400 yards from butts, *d*, *about* 317° 37′.

Magnetic station from M.S. mark.—At this station there is no record of angle of depression, which was very considerable. *Horizontal* distance, 430·9 feet; azimuth, 224° 47′ 16″.

Directions for finding M.S. mark.—Buried. Use *a* and *d* to approximately locate the site. Then employ *c* and B for final identification. In November, 1902, the firing mounds were found shifted a few feet. Hence, *a* and *d* only very roughly indicate site. A small cairn was therefore erected 10 feet from M.S. mark in the line towards *c*.

Station.—Port Davey. Lat. 43° 20′ 11″. Long. 9h. 44m. 4·2s.

Date.	Time.	Element.	
Feb.			
4	6·40-6·57 p.m.	Declination	9° 34′ 58″
4	Vibration 5·27-5·38 p.m.	Horizontal Force	·1975
	Deflection 3·45-5·40 p.m.		
3	4-4·45 p.m.	Dip	71° 49′ 44″
	4·45-5·30 p.m.		

The prevailing rocks are indurated sandstones, quartzites, micaceous and talcose schists; they are usually classed as of pre-Cambrian age.

Azimuths.—N.E. corner of Schooner Bay (see sketch map figure II., plate IV.), *a*, 220° 30′ 56″. Cairn on Balmoral Hill, B, 275° 59′ 56″.

Magnetic station from M.S. mark.—Distance, 51·0 feet; azimuth, 227° 53′ 51″.

Directions for finding M.S. mark.—In the solid rock. On the west of Schooner Bay there are three well-marked ridges. The mark is on the middle one, near the medial line of the ridge, and at a height of about 27 feet above sea-level.

Station.—Sorell. Lat. 42° 47′ 38″. Long. 9h. 50m. 12·8s.

Date.	Time.	Element.	
Feb.			
15	2·50-3·8 p.m.	Declination	10° 1′ 36″ E.
14	Vibration 11·55 a.m.-0·6 p.m.	Horizontal Force	·2034
15	Deflection 4·10-5·40 p.m.		
14	10-10·35 a.m. 10·40-11·10 a.m.	Dip	71° 5′ 55″

The underlying rock is mudstone of Permo-Carboniferous age.

Azimuths.—Cairn on Mt. Rumney, A, 45° 32′ 40″ Right panel post on further (south) side of Bellerive-Sorell road, *b*, *about* 304° 18′

Magnetic station from M.S. mark.—Distance, 139·7 feet; azimuth, 243° 18′ 55″.

Directions for finding M.S. mark.—Buried. Proceed from Bellerive towards Sorell, along the main road. At a point ·36 of a mile beyond the 11th milestone a bye-road branches off to the left, leading to Mr. Findley's house. From the centre of the main road, along the middle of the bye-road, measure a distance 293 feet 6 inches; then measure a distance 47 feet 7 inches exactly perpendicular to the bye-road towards the right (north-east). The point so found is at the M.S. mark. A and *b* above will assist in exactly identifying the site.

Station.—Eaglehawk Neck. Lat. 43° 1′ 46″. Long. 9h. 51m. 44·6s.

Date.	Time.	Element.	
Feb. 20	3·48-4·10 p.m.	Declination	10° 16′ 35′ E.
20	Vibration 10·41-10·52 a.m. Deflection 12 noon-1·5 p.m.	Horizontal Force	·2014
19 21	2·35-3·20 p.m. 3·30-4·10 p.m. 9·30-10·6 a.m. 10·35-11·20 a.m.	Dip	71° 22′ 24″

The underlying rocks are mudstones and limestones of Permo-Carboniferous age.

Azimuths.—Left edge of chimney of Lufra House, *a*, 176° 35′ 42″. Right edge, *b*, 176° 36′ 52″. Overhanging rock near Clyde Island, C, 206° 14′ 57″. Furthest headland north, protuberance half-way up face, D, 216° 58′ 57″.

Magnetic station is in this case *at* the M.S. mark.

Directions for finding M.S. mark.—Buried. Proceeding along the road from the Neck towards the blow-hole for about 1¼ miles a weather-board two-storied house, "Pendennis," through the garden of which a small creek flows, is reached. The M.S. mark is about 300 yards S.E. of "Pendennis," the azimuth of "Pendennis" chimney from the mark being about 131°. This information, together with *a*, *b*, C, D above, will serve approximately to locate the mark. For further identification, a small cairn and stout pole have been erected. The M.S. mark, the pole, and D above are in line in the order named, and the distance between the cairn and the mark is about 54 feet.

Station.—Oatlands. Lat. 42° 17′ 10″. Long. 9h. 49m. 33·8s.

Date.	Time.	Element.	
Feb. 26	9·6-9·19 a.m.	Declination	9° 25′ 32″
26	Vibration 10·14-10·25 a.m. Deflection 2·27-3·25 p.m.	Horizontal Force	·2055
Jan. 3 4	3·10-4·30 p.m. 10·15-11·30 a.m.	Dip	70° 44′ 9″

The prevailing rock is a coarse sandstone of Mesozoic age.

Azimuths.—Apex of gable of a small shed in front of a larger shed (Railway shed, see figure III., plate IV.), *a*, 77° 16′ 9″. Church spire, *b*, 80° 7′ 53″. Left edge of plateau of Table Mountain, C, 109° 35′ 54″. Ball on top of round windmill, *d*, 131° 15′ 14″.

Magnetic station from M.S. mark.—[No exact record of angle of elevation.] *Horizontal* distance, 27·1 feet; azimuth, 2° 28′ 3″.

Directions for finding M.S. mark.—In the solid rock. Looking south-east over Lake Dulverton from the point where the main road from Hobart to Launceston crosses the lake, the M.S. mark is on the left shore of the lake, on the property of Mr. Weeding. The mark is near to one of the largest caves on that shore. From the mark the azimuth of an unusually large she-oak is about 29° 53′. The points *a*, *b*, C, *d* above should serve to identify the site.

Station.—Southport. Lat. 43° 25′ 17″. Long. 9h. 47m. 52·8s.

Date.	Time.	Element.	
March. 2	4·26-4·44 p.m.	Declination	11° 44′ 1″
2	Vibration 11·28-11·39 a.m. Deflection 9·30-10·30 a.m.	Horizontal Force	·1932
3	10·35-11·45 a.m. 12·10-1·35 p.m. 3·0-3·50 p.m.	Dip.	72° 24′ 10″

At the time of selecting the site, it appeared that the underlying rock was mudstone of Permo-Carboniferous age, but from the magnetic results obtained it seems extremely probable that there must be an intrusion of highly magnetic greenstone (diabase) near to the site. The M.S. mark was embedded in cement below the level of the ground.

The determinations of the magnetic elements at this station are valueless for the purposes of the survey.

Table of Magnetic Elements of Tasmania, Jan.-Feb., 1901.

Station.	Latitude S. of M.S. Mark.	Longitude E. of M.S. Mark.	H.	Dip.	Declination.
	° ′ ″	h. m. s.		° ′ ″	° ′ ″
Scamander	41 26 42	9 53 10·3	·2121	70 7 23	10 10 19
Springfield	41 11 12	9 49 57·3	·2140	69 57 48	10 1 49
Longford............	41 35 53	9 48 33·7	·2091	70 25 22	9 42 39
Latrobe	41 14 49	9 45 46·4	·2122	70 5 1	9 54 0
Stanley	40 50 59	9 41 17·5	·2131	69 56 43	9 11 28
Strahan	42 9 33	9 41 27	·2051	71 5 11	7 57 19
Port Davey	43 20 11	9 44 4·2	·1975	71 49 44	9 34 58
Sorell	42 47 38	9 50 12·8	·2034	71 5 55	10 1 36
Eaglehawk Neck..	43 1 46	9 51 44·6	·2014	71 22 24	10 16 35
Oatlands	42 17 10	9 49 33·8	·2055	70 44 9	9 25 32
Southport	43 25 17	9 47 52·8	·1932	72 24 10	11 44 1

The "M.S." mark is the Muntz metal mark (buried or otherwise) left by us at each theodolite station, as described above. Longitudes (relative to Greenwich) are on the hypothesis that the Hobart Observatory longitude, from which ours were obtained, is 9h. 49m. 19·54s. This, again, requires that the adopted value of the Melbourne Observatory longitude should be 9h. 39m. 54·00s.

H is the horizonal component of the earth's field of magnetic force in C.G.S. units.

THE SCOPE AND METHOD OF MATHEMATICAL PHYSICS.

By Professor R. C. Maclaurin, M.A., LL.M., Victoria University College, Wellington, N.Z.

These are the words of a distinguished French man of letters:—"When at Oxford, some years ago, during the meeting of the British Association, I met, amongst the few students still in residence, a young Englishman, a man of intelligence, with whom I became intimate. He took me in the evening to the New Museum, well filled with specimens. Here short lectures were delivered, new models of machinery were set to work; ladies were present, and took an interest in the experiments. On the last day, full of enthusiasm, 'God Save the Queen' was sung. I admired this zeal, this solidity of mind, this organisation of science, these voluntary subscriptions, this aptitude for association and for labour, this great machine pushed on by so many arms, and so well fitted to accumulate, criticise, and classify facts; but yet, in this abundance, there was a void. When I read the Transactions, I thought I was present at a congress of heads of manufactories. All these learned men verified details and exchanged recipes. It was as though I listened to foremen, busy in communicating their processes for tanning leather or dyeing cotton; *general ideas were wanting*."

I give you this quotation, not because I entirely agree with it, but because it draws attention to a possible defect that we might well remedy. Our aim is to advance science. Now, there are two ways of doing this. The first is to win small victories in the various departments. No one with a knowledge of facts would dream of disparaging this method, for it is mainly by its means that science has acquired that accurate knowledge of the world that is the secret of most of its practical successes. However, we must not forget that there is another method, and one that is certainly not less important than the first. That is, to discover and to disseminate the general principles—what we call "laws"—that sum up our experiences. Fortunately, there is no need to discuss the relative merits of these two methods—science cannot advance without both; but there are several reasons why discussions on general principles should be more frequent, at meetings such as this, than they are. (1) They are better suited for discussion than the record of experiments or of mathematical analysis. They afford more room for differences of view, and a conflict of opinion is invaluable in clearing and broadening our ideas. Of course, the solution of a differential equation, or the structure of a soap-bubble, *may* lead to a discussion, but if it is to be of interest, it will generally be so because of its bearing on some larger idea. (2) The more general principles should be of interest to a wider circle. It is in the search for, or in the working out of these general principles, or "laws," that most scientists spend their lives. It is well, then, that they should have the clearest possible views as to what these principles are, and discussion should conduce to clearness. (3) To-day science is confronted with a serious danger. Its tendency to specialise is evidenced in a thousand ways, among others by the splitting up into sections and sub-sections of associations such as this. This is doubtless necessary for the advancement of science; but if specialisation be not kept within proper bounds, the advancement may be bought too dear. The concentration of interest in smaller and smaller groups of facts will tend to narrow the intellect, and the scientist may lose his larger views and sympathies. This will react on the *man*, and make his outlook wrong. Thus, in the end, it will react on science. The danger is already quite apparent, and, if we do not take care, we may afford more examples of the absurd views of the world entertained by men that have never seen beyond a test-tube. I hope, then, that I need not apologise for discussing the scope and method of so comprehensive a subject as mathematical physics.

The first question in the catechism of a scientist should be, What is the chief end of science? This is a question about which there is far more loose thinking, even among men of science, than there ought to be; and, unfortunately, the looseness of thought leads into serious error when various great problems are being attacked. The answer that many men (perhaps most men) would give is that the end of science is to *explain* the world. What is the scientific "explanation" of this or that phenomenon?—is the most common of questions. Now, the first point that I wish to insist on (of course, with all due respect to my betters) is that, if we use words with their ordinary meaning, *science explains nothing.* If we are to talk of scientific "explanation," we must, to be clear-headed, keep before our minds the fact that we are using this term in an unusual sense. For what does one mean by "explanation"? I think that there will be a general agreement that it means the reference of the unknown to the known; and if this be admitted, a little consideration will show that, if we look deep enough, science *explains* nothing. In fact, as a rule, a scientific "explanation" inverts the process of tracing the unknown to the known, and prefers to describe the known in terms of the unknown. This might be illustrated from every branch of science. I shall not speak of the "affinities" by means of which chemists are wont to "explain" the reactions they meet with; everyone must have recognised that such terms are but the expression of our ignorance. I shall confine myself strictly to physics, of which I am less ignorant, and which is generally held to be the most highly developed of the sciences.

In statics we are accustomed to "explain" the various mechanical powers—the inclined plane, lever, pulleys, &c.—by reference to Newton's parallelogram law, which is certainly not less obscure than the thing "explained." In dynamics we "explain" everything by Galileo's or Newton's laws of motion, or by the conservation of energy, or by the law of gravity. It is surely absurd to speak of "explaining" so well-known a phenomenon as the fall of an apple by the statement that "every particle in the universe attracts every other particle with a force that varies directly as the product of the masses of the particles and inversely as the square of the distance between them." Look again at some of the older "explanations" that have now gone out of fashion, and are now-a-days sometimes laughed at by those who should know better. Take, for example, Stevinus' statement of the principle of the inclined plane. His well-known argument is based on what some call the "instinctive knowledge" that an endless chain hung over an inclined plane *will not move of itself*, "instinctive knowledge" being, of course, an inference from experience. To-day we should "explain" this by reference to some more general "law," *e.g.*, the doctrine of energy, or the impossibility of perpetual motion. It seems to me that Stevinus' statement is really better as an explanation. I do not deny that the modern method has a great advantage; but the advantage does not lie in its superiority as an explanation. Turn from dynamics to sound. There we "explain" well-known phenomena by waves in the air, with the attendant obscurities of elasticity, of Boyle's "law" and Charles' "law," the adiabatic "law," and all the rest. In heat, we "explain" the heating of a poker by the vibration of particles which no one knows by actual experience, or we make deductions from the first and second laws of thermodynamics. Law I.: "When mechanical energy is produced from heat, a definite quantity of heat goes out of existence for every unit of work done; and conversely, when heat is produced by the expenditure of mechanical energy, the same definite quantity of heat comes into existence for every unit of work spent." Law II.: "It is impossible for a self-acting machine, unaided by any external agency, to convey heat from one body to another at a higher temperature." Any "explanation" that refers phenomena to such "laws" as these can surely not be described as a reference of the unknown to the known. A similar remark might be made about Maxwell's law of partition of energy, and most of the so-called "laws" of thermodynamics. Lastly, in light and electricity, we "explain" everything by motions in the *ether*, which, for aught anyone can say, may be a mere figment of the imagination.

I have not cited all these examples of scientific method with the object of criticising our science. I have just as much respect for the doctrine of energy or the idea of the ether as most men of science. My object has been to point out, *not* that the method is wrong, but that its aim is certainly not *explanation*. What, then, is the end of science? Its end is the purely practical one of enabling us to master the world. We are confronted with countless phenomena, and it is incumbent on us to know as much as possible, and to be able to communicate our knowledge. Otherwise we cannot progress, for Nature never pardons blunders. While the world was very young, men might do with a knowledge of a few facts; there would be comparatively little necessity for helps to piece the facts together. But, as civilisation advances, the need for colligating principles becomes more and more pressing. In modern life scientific research is daily adding to the sum of things that we *must* know, if we are to live, and not slip back. Hence we must have some means of relieving our memories of the burdensome knowledge of isolated facts. This we require, not only for the practical needs of life, but also to satisfy our mental longing to grasp the whole world, or as much of it as possible. Thus we need general principles, or "laws" (if we prefer to style them so), that will string together our knowledge. It is the aim of science to lay down these general principles, and, having laid them down, to show that all the varied facts of experience are deducible therefrom. What is ordinarily termed scientific "explanation" consists simply in the reference of the facts of experience to these general principles; as soon as we can do this, we are satisfied (or ought to be).

Once the real end of science is grasped, it is easy to see that science advances mainly by proceeding from generalisation to wider generalisation. That this is so, and that its method consists in trying hypothesis after hypothesis until one is reached that fits in with all the facts, might be abundantly proved from history. Someone should write a history of science from this point of view. The work would be important, for the history of ideas is more important than that of events. It should also be interesting; most so-called histories miss out the most interesting parts; they tell us the results, but not how they were reached. The place to look for these things is in the lives of the pioneers of science; and it is a fascinating study to trace the growth of a great idea, the gradual evolution of a law, *e.g.*, the Copernican theory, Kepler's laws, Galileo's laws of motion, Newton's law of gravitation, the doctrine of the conservation of energy, the principle of action, the theory of the ether. Let me refer briefly to a few of these. We must all have been awed by the complex system of cycles and epicycles invented in the early days of astronomy to "explain" the motions of the planets. Perhaps we have even felt a secret sympathy for the Moorish King of Castile, who, on reading an astronomical work by one of his professors, exclaimed—"Were the heavens thus constituted, I could have given the Deity good advice had He consulted me at their creation!" Then came Copernicus, and changed all that. He was dissatisfied with the current "explanations," being convinced on theological grounds that ideal harmony and simplicity must characterise the motions of the heavenly bodies. He tried various hypotheses, until at length he hit upon the old suggestion of the Egyptians (never followed out by them), that the Sun is the centre of the planetary system. He spent 36 years in working out this idea, before he was satisfied that it fitted in with all his observations. Then he published his famous book "On the Revolution of the Celestial Bodies." In the preface to this he makes a remark that is very relevant to the present discussion:—"It is not necessary that scientific hypotheses be either true or probable; they accomplish their object if they reconcile the calculus with observation." Possibly he said this from motives of prudence. Considering the state of public opinion, we realise that he ran the risk of a heresy hunt, the consequences of which were more serious then than now. He may have thought it well to give himself a loophole of escape. At any rate, he was ready to admit that his hypothesis might be quite wrong; all he cared for was that it enormously simplified the description of celestial phenomena, rendering simple and intelligible many things that were formerly obscure and unconnected—the change of seasons, the varying brightness of the planets, their progressions and retrogressions, &c.

Look next at the development of Kepler's laws of planetary motion. He begins with the hypothesis that the distances of the planets from the Sun are determined by the six regular solids of geometry. "The Earth's orbit is the sphere, the measurer of all. Round it describe a dodecahedron; the circle including this will be (the orbit of) Mars. Round Mars describe a tetrahedron; the circle including this will be Jupiter. Describe a cube round Jupiter; the circle including this will be Saturn. Then inscribe in the (orbit of the) Earth an icosahedron; the circle described in it will be Venus. Describe an octahedron round Venus; the circle inscribed in it will be Mercury." This "law" seems fanciful enough; but the only sound objection that could have been advanced against it at the time was that it did not harmonise well with the results of experiment. Kepler was at first well satisfied. He declared that he "would not barter the glory of the invention for the whole Electorate of Saxony." His ardour was somewhat cooled by Tycho's advice, "first to lay a solid foundation for his views by actual observation." So he turned aside from these speculations, and next gave his mind to pondering over the *forms* of the planetary orbits. Naturally, he tried circles first, but Tycho's observations convinced him that, at least in the case of Mars, there was a considerable departure from the circular form. He therefore tried curves of all sorts, testing them by Tycho's observations, until he hit upon the ellipse. Thus he discovered his second law. His next step was to generalise both his laws by extending them to all the planets, and he found them still true. This great success revived his interest in the problem that had first aroused his enthusiasm—that of the planetary distances. He tried hypotheses of all sorts. He compared the planetary distances with the intervals of the notes on the musical scale, an idea suggested by the venerable notion of the music of the spheres. At last, in 1618, he conceived the idea of comparing the powers of the different numbers that represent the distances of the planets with the powers of the numbers representing their periodic times. Thus he hit upon his third great law; and those who realise the immense importance of this law in the development of dynamics and astronomy will forgive Kepler his exaggerated outburst of exultation at its discovery:—"What 16 years ago I urged as a thing to be sought—that for which I joined Tycho Brahé—for which I settled in Prague—for which I have devoted the best part of my life to astronomical contemplations—at length I have brought to light, and have recognised its truth beyond my most sanguine expectations. . . It is now 18 months since I got the first glimpse of light, 3 months since the dawn; a very few days since the unveiled sun burst upon me . . . . The die is cast—the book is written, to be read either now or by posterity, I care not which. It may well wait a century for a reader, as God has waited 6000 years for an interpreter of his works."

So much of Kepler. Many will readily admit that his laws "explain" nothing, but will add that the "explanation" was left to Newton. The absurdity of this has already been pointed out. The real function of the laws of motion and of gravity is to sum up a vast number of otherwise isolated facts; and, of course, when looked at in this light, they appear among the grandest of Nature's "laws." The building up of the law of gravitation gave employment to many workmen besides Newton; Kepler, Bouillard, Wren, Halley, and Hooke among the others. Let us see how near Hooke came to victory in his speculations. After maintaining that the planets "must have some other causes beside the first impressed impulse to bend their motion into these curves," he says that only two causes can be suggested for this curvature. The first is that the tendency towards the central sun is produced by a greater density in the ether near the sun. "The second may be from an attractive property of the body placed in the centre, whereby it continually endeavours to attract or draw it to itself." In 1674, in some observations on gravity, he says—"I shall hereafter explain a system of the world differing in many particulars from any yet known, but answering in all things to the common rules of mechanical motions." This depends on three hypotheses—(1) that all celestial bodies gravitate towards one another; (2) the law of inertia; (3) that the law of gravity is such that "those attractive powers are so much the more powerful in operating by how much the nearer the body wrought upon is to their own centres; but what these several degrees are I have not yet experimentally verified." This is very remarkable. The law of the inverse squares is alone wanting to complete the Newtonian "law," and this was supplied a few years later by Hooke himself. So it has sometimes been thought that Hooke ought to share the honours of the law of gravitation with Newton. However, it is important to bear in mind that Hooke did not fulfil his promise to prove that his laws could be applied to the motions of the planets; and this makes all the difference between success and failure. To occupy oneself with speculations about gravity after the manner of Hooke is largely a waste of time and energy. It serves no useful purpose. To prove, as Newton did, that a law may be laid down which strings together all our knowledge of the planetary motions, is rightly accounted one of the greatest achievements of the intellect. The one thing that makes the "law" of gravity worth discussing at all is that, as a matter of fact, it does "explain" the motion of the planets. Newton was the first to prove this, and so Newton rightly wears the crown of victory. Still, for all this, the law of gravity is no "explanation" in the sense of referring the unknown to the known. It is only an hypothesis. Newton's famous saying—"Hypotheses non fingo"—is often misunderstood. He is contemptuous of mere hypotheses—those that serve no useful purpose—but he does not mean to discourage altogether the making of hypotheses. He made a great many himself. It was a leap in the dark on Newton's part to go from the apple to the moon; a pure assumption to suppose that both were subject to the same "law." But he was not afraid to try it as an hypothesis, and he was ultimately rewarded (as we know) by finding that it fitted in with the facts. And Newton's *Regulæ Philosophandi* are really nothing more than suggestions for guidance in the framing of hypotheses:—Rule I.: "No more causes of natural things are to be admitted than are sufficient to explain the phenomena of these things." This is merely a statement of convenience. For practical purposes we want as few "laws" as possible. Rule II.: "Those qualities of bodies that can be neither increased nor diminished, and that are found to belong to all bodies within the reach of our experiments, are to be regarded as the universal qualities of all bodies. . . . If it universally appear, by experiments and astronomical observations, that all bodies in the vicinity of the earth are heavy with respect to the earth, and this in proportion to the quantity of matter that they severally contain; that the moon is heavy with respect to the earth in proportion of its mass, and our seas with respect to the moon; and all the planets with respect to one another; and the comets also with respect to the sun; we must, in conformity with this rule, declare that *all* bodies are heavy with respect to one another."

It may be supposed by some that the method of science has changed since Newton's day, and that, while the 17th century was content with hypotheses, the 19th and 20th centuries go deeper, and inquire into "causes." However, there is really nothing in the suggestion. We may be able to see further by standing on the shoulders of giants; but our method of advancing is just the same as that of our forefathers. Look at any guiding principle of modern science, *e.g.*, the ether theory, whose development has been the most striking feature in the advancement of physical science within the last century. The idea of an all-pervading medium filling space was little more than a wild speculation among the ancients. Among moderns, Descartes was the first to employ the idea in physical science, in connection with his theory of vortices. We all know that Newton toyed with the notion to help him over the gulf of space with his gravitating forces. Huyghens, however, was the first (in 1678) to expound what we now regard as correct views on the general nature of the elasticity of the ether, which he did in explaining his undulatory theory of light. The success of the ether idea in the field of optics gave it the *entrée* to other departments of science. "At one time," says Maxwell, "those who speculated as to the causes of physical phenomena were in the habit of accounting for each kind of action at a distance by means of a special æthereal fluid, whose function and property it was to produce these actions. They filled space three and four times over with æthers of different kinds, the properties of which were invented merely to save appearances." Gradually, however, the old method of scientific progress revealed itself in the working down from many ethers to one; the same for light, heat-radiation, electricity, and magnetism. In 1800 Young assures us that the existence of an *electric* ether has been demonstrated, and adds "whether the electric ether is to be considered as the same with the 'luminous' ether, if such a fluid exists, may perhaps at some future time be discovered by experiment." In 1806 Sir Humphrey Davy advanced the hypothesis that *chemical* and electrical attractions were produced by the same "cause." A little later Faraday did more than anyone else to advance the idea of an ether as the "explanation" of electric and magnetic phenomena; and in 1845 he made the very important discovery that a field of magnetic force rotates the plane of polarisation of light. Then came Clerk-Maxwell, with his electromagnetic theory of light, and his "Treatise on Magnetism and Electricity"; and, finally, Hertz taught us how to produce electric waves, and to examine their properties experimentally.

Now, we must not allow ourselves to be blinded by the brilliant success of the ether theory. There is nothing "explanatory" in the conception of an ether. The discarded action-at-a-distance theories of W. Weber, Gauss, Riemann. J. and C. Neumann. and others, would have been just as good as the ether theories *if only they had grouped together as many facts.* There is little or nothing in the *à priori* objection to action at a distance; it is just as intelligible (and unintelligible) as action in contact. It requires some courage to say this with Newton's words in one's ears; but we must guard against the bondage of authority in matters of science, whatever we think of it in other domains. How far the idea of an ether is from "explaining" anything is also well illustrated by considering the various modifications of ethereal structure that have been proposed. The story of these modifications shows very clearly that the one end of the ether theory is to string together as many facts as possible. Green (in 1838) was the first to treat the subject on modern lines and in a thorough-going fashion. He was not content with mere descriptive theories, but tried to bring the motion of the ether under the sway of older dynamical "laws." Naturally, he began with the hypothesis that the ether is like an ordinary elastic solid, capable of resisting compression and distortion. He found it possible to express everything in terms of three ethereal constants—the density, the rigidity, and the resistance to compression. It turns out that in such a medium any disturbance will give rise to waves of two perfectly distinct types, one involving change of volume without rotation, and the other rotation and distortion without change of volume. As nothing was known in optical phenomena corresponding to the condensational wave, the first serious difficulty was to endow the ether with qualities that would free it from this wave. Green attempted to solve the problem by assuming the resistance to compression to be infinitely large compared with the rigidity. However, when he came to extend his theory to crystalline media he was landed in serious trouble. Rankine, and subsequently Lord Rayleigh, came to the assistance of the theory, the latter suggesting a theory of the interaction of ether and matter. The results, however, were not satisfactory; in particular, the theory did not lead to Fresnel's wave-surface, which Glazebrook's experiments showed to be a very close approximation to the truth. So Lord Kelvin stepped in with his theory of a contractile ether—a medium that offers no resistance to compression, and, indeed, is such that it tends to move in the same direction as a displacement within it. Such a medium has the advantage of getting rid of the pressural wave (for if there is no resistance to pressure there can be no such wave), and it leads to a wave-surface in crystals that is approximately that of Fresnel. Then we have the revival in recent times of the method employed as long ago as 1839 by MacCullagh. He started out with the remark that the success of a dynamical "explanation" of optical phenomena must depend on the proper choice of a function representing the potential energy of the ether. If this be properly chosen, all the rest will follow by the aid of the principle of least action. He arrived at the well-known expression for the energy in terms of the rotation of the elements of the elastic medium, and added—"Having arrived at this value, we may now take it for the starting-point of our theory, and dismiss the assumptions by which we were conducted to it." His method is more philosophical than the more pretentious one that is usually followed, and the special form of his energy-function has the great merit of leading to the same equations as those required by the electromagnetic theory. Thus we have gradually modified our "explanation," until we have a medium before our minds that enables us to group together a vast number of optical and electrical phenomena. Finally, in order to make our theory still more comprehensive, we have found it necessary to consider the possibility of point-singularities (electrons) in the ether. With this addition to the older theory, we hope to be able to group together a still larger number of facts than before. Some even have faith that this idea will enable us to remove mountains of difficulties, and "explain" the whole world; but there is clearly little real explanation here.

After all that has been said, I hope it will be admitted that physical science does not include within its scope the *explanation* of phenomena. The great end it has in view is to sum up everything in one generalisation, and we have already more than a glimpse of the end. How, then, does the mathematical physicist set out towards this goal? We start with three categories, or fundamental ideas—space, time, and mass. It is useless trying to get behind these, and we can never resolve space into time or mass into space.

Mass we sometimes describe as "quantity of matter." We may find it possible to replace this by "quantity of ether," and to "explain" ordinary matter as a form of ether; but the three categories of space, time, and substance (whether matter or ether) we cannot further resolve. These are mental concepts—things derived from self-consciousness. We cannot get away from ourselves, and struggle against it as we will, our science is doomed to be tinged with anthropomorphism. Starting with the three fundamentals—space, time, and mass—we want further a *single* "law" connecting them, and one that will be comprehensive enough to group together *all* the facts of the physical world. We cannot say that we have got this, or we should have solved the riddle of the physical universe, so far as science could ever solve it. As a connecting-link between the fundamental ideas we might take the three laws of Newton. They are wide enough to satisfy our demands; but as we are in search of the greatest possible simplicity, we naturally try to reduce the number of these laws. We may replace them by two—the Law of Inertia, and Gauss' Principle of Least Constraint—or we may combine these two into one, as Hertz has done in his Law of the Straightest Path; or, finally, we may use the Principle of Least Action. Our aim is to "explain" everything, *i.e.*, to co-ordinate all our knowledge, by means of this one principle. There is still much to be done before the final victory is won. We have still to talk of chemical affinities, of cohesive forces, of the "law of gravity"; but we may be permitted to have faith that these and all other obscurities will be removed, and that some day the whole universe will be seen to be the expression of one great "law." "Give me extension and motion," exclaimed Descartes, "and I will construct the world!" "Give me space, time, mass, and the fundamental law of motion," says the modern physicist, "and I will construct the world, although I will not pretend to 'explain' it." And it should be observed that this method differs essentially from what is sometimes called the metaphysical method. I am not going to say anything against metaphysics. It would be an impertinence to do so; and, as a rule, the remarks of scientists about metaphysics are (to say the least) quite as valueless as those of metaphysicians about science. All that need be said is that physicists do not evolve the world from their consciousness. Our knowledge is strictly empirical. Our hypotheses are valued only in so far as they fit together our experiences; everywhere they must be put to this test, and if they do not satisfy it, they are abandoned. It may tend to clearness to illustrate this by reference to a discarded principle of science—the *horror vacui*. As late as Galileo's day this was the accepted "explanation" of many of the facts of physics. Now, I should like to say that in those days it was just as good an "explanation" as many of our modern laws of science. Whether we say that Nature abhors a vacuum, or abhors a loss of energy, we really explain nothing; and the *horror vacui* served the same purpose as the conservation of energy (of course, on a limited scale)—it co-ordinated a number of otherwise isolated facts. However, it has been discarded, and rightly so, for it was found in Galileo's time that the principle was not true. A pump was constructed with an unusually long pipe, and, in spite of all efforts, it would not work. Here was a case where Nature showed no abhorrence of a vacuum, and so the principle had to be abandoned. Of course, a similar thing might happen with some of our cherished laws; and possibly a few centuries hence men will laugh at our ideas of energy, as we have done at the *horror vacui* that gave so much satisfaction to our forefathers.

In conclusion, it may be well to consider briefly what is the use of a discussion such as this. (1) In the first place, we cannot easily over-estimate the importance of method in science. It is a commonplace to dwell on the extraordinary advance of science within the last few centuries, compared with that in all the earlier ages. No one with a knowledge of the intellectual powers of ancient and mediæval philosophers will ascribe their comparative failure to inferior mental capacity. The moderns have surpassed them, not in mind, but in method; and hence to the moderns belongs the victory. With this truth before us, we can scarcely account it a waste of time to ponder awhile as to what the method of science really is. (2) Secondly, if we understand our method, we shall be ready to welcome hypotheses from every source. A harmonising principle often strikes first on the ear of a poet, and art grasps truth more unflinchingly than science. "The rest may argue and reason—'tis we musicians know." Philosophy, too, may help us with a far-reaching idea, and it is a simple matter of history that many important "laws" of science have been suggested by theological theories that scientists would not entertain. (3) Again, we need not be troubled about the reality of our hypotheses. Questions of reality are outside our province. Our "laws" are like the virtual images of optics; they may be quite unreal, but serve a very practical purpose for all that. Thus the trouble that some scientists have given themselves about the "existence" of the ether is quite unnecessary, and the efforts to prove its existence by the construction of models are absurd. Such models may be useful in helping us to clear ideas as to what our hypotheses mean; but they cannot prove the existence of anything. (4) Fourthly, it is well for us to know our limitations. "Mathematics," says O. W. Holmes, "breeds a despotic way of thinking," and it would be much better for everyone if we stripped off from science "its panoply of pride." Our province is to investigate phenomena, and group them together by the aid of colligating principles. Beyond this we do not go, and we really explain nothing. We have deliberately clipped our wings to strengthen our legs, and any attempt at flight is likely to prove as ineffective as it is ungainly. Science can never solve the riddle of existence, or reach any hidden reality behind phenomena. Its "laws" are mere hypotheses, its categories of forces, atoms, ether, and the like but artificial machinery to help us to know the world. To use these mental concepts to explain consciousness is to move in a childish circle, and to employ them as premises for religious or irreligious conclusions is equally absurd. (5) Lastly, a clear understanding of the scope and method of our science should free us from one-sidedness, and bring us into sympathy with workers in other fields. The method of the philosopher and the artist is not, after all, so very different from that of the scientist. The aim of the artist is to bring to light "the simple concealing itself in the manifold;" and the philosopher spends his life in the search for wider principles that will bind together the laws of all the sciences. The sneers of some men of science at those pursuing different paths from theirs are simply childish, and the chief sufferer in the isolation of science from art and philosophy is the scientist. We should recognise all thinkers as members of a great brotherhood. All are toiling up the mountain of truth, and we need not be surprised if those who try to scale the high peaks of philosophy advance more slowly than the travellers over the lower ridges of science. And we that are lower down should be moved by the difficulties we have encountered to look with every sympathy to the toilers above. If we ever get as high, we may fare no better; and, like all worshippers in the temple of Isis, we may well be awed into humility by the inscription over the portal—"I am all that is, and that was, and that shall be, and no mortal hath lifted my veil."

ON CIRCULAR FILAMENTS OR CIRCULAR MAGNETIC SHELLS EQUIVALENT TO CIRCULAR COILS, AND ON THE EQUIVALENT RADIUS OF A COIL.

By Professor T. R. LYLE.

MEASUREMENT OF ELECTROLYTE RESISTANCE.

By Professor T. R. LYLE.

THE CONNECTION BETWEEN THE FLUIDITY AND CONDUCTIVITY OF THE *Na Cl* SOLUTIONS.

By Professor T. R. LYLE and R. HOSKINGS.

SOME EXPERIMENTS IN ELECTRIC WAVES.

By Professor A. POLLOCK and O. M. VONWILLER.

THE SPECIFIC INDUCTIVE CAPACITY OF A SAMPLE OF GLASS.

By Professor A. POLLOCK and O. M. VONWILLER.

VECTOR DISTRIBUTIONS OVER VOLUMES, SURFACES, AND LINES.

By Professor A. MCAULAY.

Section B.

CHEMISTRY.

PRESIDENTIAL ADDRESS.

By Professor A. Mica Smith, Ballarat, Victoria.

THE STUDY OF THE CHEMISTRY OF THE AIR AND WHITHER IT HAS LED.

Since the last meeting of our Association, two great centuries have met and parted: the one, full of honours and a hundred crowded years of magnificent scientific achievement, takes its place with its predecessors; the other bears us with it into a future of the most extravagant promise.

Many of the scientific discoveries in which the last century is so rich trace their springs—sometimes tiny enough—to the one or two preceding centuries, if not to still earlier times, and this is conspicuously the case with at least some of the discoveries concerning which I have the honour of addressing you to-day.

The commonest things are often in some respects the most important things. They are important because they are common, and common because they are important. Atmospheric air is one of these.

Early Fancies.

We can easily sympathise with our early ancestors in their attempt to understand the mystery of the atmosphere. The air is forced upon our attention; we cannot escape from it with life; a vast ghostly presence, enveloping our earth and ourselves in its embrace, interpenetrating all things, and, withal, endowed with human moods. Sometimes, for a brief space, still; now gently fanning our cheek, now moving in fitful gusts, now angered into a storm, now possessed with the fury of an enraged demon, uprooting trees and laying waste the country, scooping up and flinging aloft acres of soil, or many a ton of sea with its living inhabitants, and, when it has spent its fury and exhausted itself with slaughter, falling again to temporary calm. Now it blows, hot, now cold; now dry, now moist; now precipitating out of its substance rain or hail, or dew or snow—surely the very embodiment of waywardness and caprice. And yet this very waywardness of the fitful breeze, when read aright, is a most powerful demonstration of its conformity to the reign of law. Its great mobility enables it to respond with alacrity to the changing complexes of forces for ever acting on it, at every point, the resultants of these causing it to move along the lines of least resistance.

Can we wonder that, especially in the countries of the storm-wind, it nurtured a superstitious people, who felt themselves in the presence of a great mystery. It is a short step from "thou gentle wanderer, unseen, who bendeth the thistles of Lora," to a viewless active intelligence, and then to peopling it in a confused way with ancestral heroes and gods.

Such a vast intelligence with so many minds was too complex to be regarded as one, and so it may be that it came to be divided into many. In some lands these winds were regarded as deities, to be propitiated by sacrifice—powerful as friends, dangerous as enemies. Have we not the chilly Boreas, Eurus the swift and playful, the mild and vernal Zephyrus, the gloomy and rain-laden Auster, and their less-known companions, who were not so often successful in escaping from the Cave of Eolus. In another continent we meet with Mudjekeewis and his sons, in recognition of their close relationship; and, indeed, all peoples have their many winds of heaven.

There may be some, then, who like to regard our first conception of the air as of a vast unseen but ever-present intelligence—a natural object-lesson in spiritual existence—our first ghost, indeed; and the separation of the one into the many, presumably our first analysis of air! We know the air has been the origin of many an image and many an idea, and has given rise to many a myth. My object to-day, however, is to roughly outline the results of our study of its composition, and to indicate what this study has done for us in quite other directions.

Speculations of Ancient Philosophers.

But there were philosophers who, from times before history, set themselves the task of finding out the mystery of the world around them, and solving the riddle of the universe. The recorded results of their efforts would seem to warrant the conclusion that the human intellect, unaided by modern experimental methods or systematic scientific research, was, somehow, enabled to reach conclusions which foreshadow some of our most important modern scientific conceptions—conceptions that have been evolved by the modern scientist only after the most painstaking and laborious investigations.

One of the oldest of the physical conceptions of the universe that has come down to us seems to be the theory of the four elements—usually attributed to Empedocles, but how much older it may be no one can say—and it comes to us with the seal of Aristotle upon it. It has often been pointed out that if, for the terms *air*, *water*, *earth*, and *fire*, we read—*gas*, *liquid*, *solid*, and *energy*—as a study of the views of those who held the four-element doctrine seems to fairly justify—then we have a first proximate analysis of the world of matter endowed with energy which is true for us to-day. It applies equally to the human body—to the microcosm as to the macrocosm—the breath of life, water with the canal traffic, the solid flesh and bones. and the inner fires yielding heat and other energies.

The atom as originally conceived, or adopted, by Leucippus and Democritus, and recorded by Lucretius—differing atoms, but all in constant motion—will pass for the atom of many a chemist of to-day. The vortex-atom of Lord Kelvin even finds a rude prototype in the vortical motion and the Homœomeries of Anaxagoras. The Hindus, it is stated, bequeath to us the conception of a universal gravitation. Many will agree that the Protyl of Crookes has been more than once anticipated.

The principle of the conservation of mass has been stated by Democritus—nothing can come from nothing, and nothing can be destroyed; and all changes are brought about by combinations and separations of atoms. Aristotle's *ether* was a fifth element, the idea of which appears to be traceable to a much earlier Hindu philosophy.

If we read further we find an earlier La Place; and the more we read the more we are astonished at the remarkable anticipations of modern views that these old writings reveal. And when we find it stated that air is the origin of all things—that all things come from air, and can all pass into air again, *air* standing for *gas* or *vapour*—does this not fit in with the beliefs of the hour?

But even assuming for the moment that a fundamental physical conception may be reached by the prophetic vision of genius, which seems to arrive at its results *per saltum*, without the laborious process of syllogistic reasoning; even assuming this, the result may be of little or no value. It may, it is true, be a mental seed of great potency and promise; but, if it lacks a suitable habitat, it may rest a seed through the ages, as if in an Egyptian tomb. There are ideas also that, even after careful planting, may take long centuries to develop into maturity. If we had had a perfect definition of chemistry, or light, or electricity, for instance, in concise and accurate language, who would have understood it? Or, if understood in a measure, would it have helped us forward? Definitions and first principles may be too far away from us to be of use to us. We may view them across a gulf. Sound progress comes by adding to what is known the unknown which lies next to it.

The first thing the modern scientist looks for is proof-demonstrations; but these old philosophers offer us none. Someone argues that they are dealing with theories, and if those theories had been proved, they would have ceased to be theories, which is true. Then the scientist asks for arguments based upon experiment; but still none are forthcoming. And, lastly, the scientist wants to know at least how they arrived at their conclusions; but this, except to some extent in special cases, we shall probably never know. Their conclusions were apparently derived from observation and reasoning alone—too much reasoning and too little observation, say some. They seem to have largely employed the powerful but treacherous method of reasoning from analogy. It seems most likely that these theories which have come down to us through the centuries have not been hastily formed, but, on the contrary, have been carefully thought out and deliberately thrashed out in school and market-place, and have run the gauntlet of many exceptionally acute minds from generation to generation. They attempted too much, these ancients; they aimed too high, as we all know now. They tried to understand the whole system of the universe, instead of devoting themselves first to the study of a small and simple portion of it. But, above all, they did not experiment. Even Socrates taught that thought alone, without observation even, let alone experiment, was sufficient to lead us to the real nature of external things. It *was not* considered *impious* to assume the place of deity, and attempt to construct the universe afresh in idea out of their own consciousness; but it *was* considered impious, forsooth, to examine into the nature of the simplest matter close about them, by natural means, and endeavour to discover the principles regulating its constitution and behaviour! They framed a cosmogony, starting with the heavens and coming down to the earth; we start with the earth and rise to the heavens—from the simplest mechanical powers to celestial mechanics.

We tried to begin at the beginning; they rather began at the end.

When we consider the remarkable sagacity of their speculations, we are almost tempted to believe that they reached as far as observation and reasoning alone could lead them. But this is not so. Systematic observation of nature, without any aid from experiment, has very great possibilities. How much about light, for instance, could be learnt without the aid of any further experiment than what nature daily and hourly provides for us? We may remind ourselves that the natural world is an experimental (say demonstrational) chemical, physical, physiological, &c., laboratory for all who are there to see; with constantly-varying conditions of experiment, within the natural limits; and we can acquire much sound science by observing accurately, and learning to interpret our observations. We are not satisfied, however, with simply walking through these laboratories, where so much work is being carried on by unseen fingers, but we insist upon handling the appliances, devising the experiments, arranging their terms, and putting our own questions straight to nature.

There is a deep-seated tendency in all of us to regard with filial leniency the mental limitations of our fathers before us, who, through no fault of their own, were born and flourished in the dark ages of 50 or 40 or 30 or 20 years ago. How much more is this attitude of mind intensified when we patronise even the most stalwart intellects amongst those we are accustomed to call the ancients? We have been finding out a good deal about these ancients lately, and we are likely to find out a very great deal more. We have been digging for information about them—uncovering long-buried cities, sweeping away Egyptian sand, rifling chambers at the foot of hidden Egyptian shafts, dredging Tibers and Grecian seas; puzzling over writings on stone and brick, relics of a long past; discovering the hiding-places of forgotten MSS.; tracking old Zeus, father of gods and Lord of the Air, to his Cretan cave; digging amongst the roots of language; and in many another way have been living backward into the past faster than we have been living forward in time.

I think it is coming to this, that the further we reach back, the more respect have we for our long line of human ancestors. There were intellectual giants in those days, as now; the men of those times looked pretty much as we look; they lived and moved as we do to-day; and, in philosophy, as in the affairs of daily life, they seem to have thought our very thoughts. Indeed, we may regard these men not as ancients, but as virtually our contemporaries.

We are storming the self-same citadels at this time that these men stormed.

If the solution of these problems are forever beyond us, as some delight to tell us—at an infinite distance from us—then we can be no nearer them now, with all our science, than were our ancestors before us. But, although we may be looking out upon the same world that is always fresh and young, with its yearly miracle of the spring, and its round of seasons, and canopied by the same universe of stars, we regard the problems presented to us from a very different standpoint. We have made so many of the thoughts that nature embodies, our own. Just as "the greater the light the greater the circle of surrounding darkness," so the splendid scientific triumphs of the last century, whilst enlarging our circle of light, have left us truly with an enormously extended horizon of the unknown.

And, happily, it must increase. It is the ideal condition for the scientific man, for who would envy a scientific Alexander, possessed of the whole knowledge of the universe—a universe of knowledge—and with nothing left to investigate.

We have now to pass to the introduction to modern science, so as to find what information an appeal to experiment has brought us with respect to the composition of atmospheric air.

Experimental Research ending in Discovery.

Van Helmont (1577-1644) seems to have been the first to use the term *gas*, and to point out the existence of more than one kind of *air*. He distinguished "*gas sylvestre*" (carbonic acid gas) from common air, and recognised it as the deadly gas of the Grotto del Cane, and that the same gas resulted from combustion, and was the product of putrefaction. In addition to this, he makes note of an inflammable gas, the result of the natural decomposition of waste animal substance, and which he called "*gas pinque*." But these important discoveries found no sympathy and awakened no interest, as far as we know, because they were mere by-products of his search for a universal medicine. It was reserved for Black (1728-1799) to *fix* this air, and demonstrate its nature by the use of the balance in a research that will be for ever memorable. In the meantime, all these observations of Van Helmont lay buried and forgotten; but a new era was close at hand, an era in which all these questions were to be investigated for their own sake, wholly apart from any gain—a scientific age—ushered in for this department by Boyle (1626-1691) and his distinguished contemporary Mayow.

The Hon. Robert Boyle writes—"The schools teach the air to be a warm and moist element, and consequently a simple and homogeneous body. Many modern philosophers have, indeed, justly given up this elementary purity in the air, yet few seem to think it a body so greatly compounded as it really appears to be."

This may be taken as representing the views of the day when Boyle entered upon the scene. "Our atmosphere, in my opinion," he continues, "consists not wholly of purer aether, or subtile matter which is diffused through the universe, but in great number of numberless exhalations of the terraqueous globe; and the various materials that go to compose it, with perhaps some substantial emanations from the celestial bodies, make up together, not a bare indetermined feculancy, but a confused aggregate of different effluvia. One principal sort of these effluvia in the atmosphere I take to be saline, which float variously among the rest in that vast ocean; for they seem not to be equally mixed therein, but are to be found of different kinds, in different quantities and places, in different seasons." He further writes—"I conjecture that the atmospherical air consists of three different kinds of corpuscles; the first, those numberless particles which, in the form of vapours or dry exhalations, ascend from the earth, water, minerals, vegetables, animals, &c.; in a word, whatever substances are elevated by the celestial or subterraneal heat, and thence diffused into the atmosphere. The second may be yet more subtile, and consist of those exceedingly minute atoms, the magnetical effluvia of the earth, with other innumerable particles sent out from the bodies of the celestial luminaries, and causing by their impulse the idea of light in us. The third sort is its characteristic and essential property—I mean permanently elastic parts."

Read by the light of our modern knowledge and views, this is surely a remarkable conjecture, but no more so than his other acute observations and his projected experiments.

Mayow (1645-1679)—"The atmosphere consists of particles of two kinds of gases, at least; one of these, termed 'nitro-aerial particles,' is necessary for the support of life and for the combustion of inflammable bodies; while the other, left after this constituent has been removed, is incapable of supporting either life or combustion. The portion which is necessary for life enters, during respiration, into the blood. It is the chief cause of motion in animals and in plants." (See Ramsay.)

These "nitro-aerial particles" he also finds in saltpetre or nitre.

Both Boyle and Mayow reached very near the truth. They had a wide grasp of their subject, and their works are full of shrewd observations and well-devised experiments.

Black had discovered or rediscovered fixed air (1755) (carbon dioxide), examined its properties, fixed it with caustic alkalies, and made use of the balance in his investigation. He knew that this "air" or "gas," that could be fixed as a solid carbonate, was the same as that given off by the lungs, by combustion, found naturally at the Grotto del Cane and similar places, given off by mineral springs, and resulting from certain fermentations.

Rutherford, in 1772 (apparently anticipated by Scheele), isolated nitrogen (mephitic air, phlogisticated air, spent air) by absorbing the carbon dioxide produced by respiration or combustion in a confined space of air, finding the residue incapable of supporting respiration or combustion.

Nitrogen appears to have been isolated and examined independently by Cavendish.

Priestley, in 1774 (and Scheele, according to recent disclosures, somewhat earlier—1772), isolated oxygen by heating mercury oxide, and studied the properties of this oxygen (dephlogisticated air, fire air, life air), finding it possessed of increased power of supporting respiration and combustion. They both knew that atmospheric air consisted of a mixture of these two gases. Another significant fact elicited was that a candle burning in a confined space of air produced an amount of fixed air (carbon dioxide) exactly equal in volume to the amount of oxygen that had disappeared.

Lavoisier (1743-1794), in his ever-memorable researches, collected the results of the phlogistonists, repeated some of their experiments, and above all made an appeal to the balance.

He caused the oxygen in a given volume of air to combine with mercury as oxide of mercury, measured the diminution in volume, weighed the oxide of mercury produced, extracted the oxygen from it by heat, and found its volume to equal the volume lost by the air (about $\frac{1}{6}$ of the original volume). Lavoisier thus removed the oxygen from the air, isolated it, and examined its properties.

He established these points:—

1. "Substances burn only in pure air.
2. "This air is consumed in the combustion, and the increase in weight of the substance burnt is equivalent to the decrease in weight of the air.
3. "The combustible body is, as a rule, converted into an acid by its combination with the pure air, but the metals, on the other hand, into metallic oxides." (See Ramsay.)

It is a wholesome exercise to follow the steps of this vigorous investigation into the nature of combustion that began with Boyle in the middle of the 17th century, and finished with Cavendish and Lavoisier and their associates towards the end of the 18th century. It was a scientific crusade, in which many acute thinkers and able experimentalists took part; and, when we consider the large issues involved, it constitutes one of the most deeply interesting, indeed exciting, chapters of scientific history. As the history of this crusade has been so recently and so ably told by Ramsay and others, it will suffice if I simply refer in passing to some of the chief steps that led us into the full light. I shall have to point out that, about 100 years later, towards the end of the century that has just closed, this investigation into the composition of the atmosphere was taken up afresh, and pursued with an address and a success that reminds one of that brave struggle with the mystery of the air that illumined and will forever make memorable the closing quarter of the 18th century.

When we make these brilliant investigators repeat again before us their classical experiments, as in a mental cinematograph, we are filled with an admiration of their experimental skill, as well as of their remarkable sagacity; at the same time, it is often very tantalising. They are all attacking the same problem; how difficult it is we can scarcely realise to-day. Now it is Boyle, with the wide outlook of genius, who is so near the central truth; now it is the lamented Mayow, who has almost discovered oxygen in his "fire-air," when he drops by the way; again, it is the botanist Hales, who has his gases separated out, and only requires to discriminate between them by a few simple tests; then Priestley (1733-1804) and Scheele, and Cavendish (1731-1810), who did so much brilliant and solid work that will endure; and, had they not been handicapped by the weight of that incubus—the Phlogistic Theory—they would doubtless have put the finishing-touches to their work. How hard some theories die! There must have been some wonderful fascination, either in this theory itself, or in its authors, that commanded the loyalty of these exceptionally shrewd men. It fell to the lot of Lavoisier, of tragic memory, to throw off the spell of this theory, and to supply the true interpretation of the results obtained by these scientists. No one need grudge him this honour. The building was raised especially by Black, and Priestley, and Scheele, and Cavendish, but Lavoisier, by decisive experiment and lucid explanation, opened it to the world.

Over and above their genius, their strength lay in the beautiful spirit of research with which they were all imbued, and in the rigid experimental methods adopted. I picture them as engaged in threading the same intricate maze (nature may be regarded as a complicated labyrinth), but, instead of moving to and fro at random, as so many of their predecessors had done, they settled down to systematic examination, surveying and plotting and mapping out the puzzle step by step, each blind passage marked so as to save traversing it again, all working at different places, perhaps, but all with the same end in view; and the plans of each one's work published—open to all. This is scientific work. It was only a question of time when all these parts would piece together, and the final passage be disclosed. And this is doubtless true for all future work, and may well encourage the humblest scientific worker.

Immediate Results.

The series of investigations ending with the brilliant experimental work and interpretations of Cavendish and of Lavoisier conclude the first part of the solution of the mystery of the air. The demonstrations referred to entirely justified the conclusion that atmospheric air was, in the main, a mixture of oxygen and nitrogen in more or less constant proportion, together with carbon dioxide, vapour of water, and, according to Scheele, a trace of ammonia. All these investigators, however, were perfectly persuaded that the composition of the air was much more complicated.

The science thus born began to grow apace, and occupied itself with great enthusiasm in tracing these discoveries out to their consequences. These consequences were stupendous. New branches of science appeared. The new ideas stirred every known science to its foundations, and, indeed, brought for each a new birth. To follow these inquiries out would be to write a history of chemistry and its applications; even in confining our attention to those on which the chemistry of the air had the most direct bearing, we are very liable to become too much involved in other sciences.

The part played by the oxygen of the air in combustion and calcination—production of metallic oxides—led off into fertile fields of further chemical discovery.

The geologist found in its conclusions a new agent for the breaking up and reconstructing of the earth, and evolved the branch science of chemical geology. There were, however, especially two great branches of inquiry that were laid conspicuously and temptingly open for investigation, and which soon attracted the services of able men; these were the relations between atmospheric air and the lives of the plant and the animal.

Relation to Vegetable Life.

When we find Van Helmont, over 300 years ago, growing a willow tree 164 lbs. in weight from water alone, and finding that the earth in which it grew had not appreciably altered in weight, we must not be hard upon him if we find him adopting fantastic explanations; for it doubtless is a very puzzling result. Stephen Hales took up chemistry to explain his botany, and, in 1727, he published the results of ingenious experiments, demonstrating that air was inspired by plants, from which he tried to recover it. "The air is very instrumental in the production and growth of animals and vegetables," he writes.

Priestley studied very carefully the effect of plants on the surrounding air, and came very close to a complete explanation of the process. He seems, indeed, to have reasoned out and believed what he did not succeed in completely demonstrating. He saw clearly that animal respiration was closely related to combustion; and he set out on the quest for that natural provision which he was convinced must exist for restoring health to the atmosphere vitiated by the varied processes of animal respiration, combustion, and organic decay. He gave a clear demonstration that plants "reverse the effect of breathing, and tend to keep the atmosphere sweet and wholesome," and he recognised the great significance of this action. Ingenhousz showed that this action was due to the green parts of plants, under the influence of sufficiently intense light, and that the roots, always, and the green parts, in darkness, have an action similar to that of animals.

It was, however, reserved for the younger Saussure to present a complete quantitative demonstration of these facts—that the green parts of the plant, under the action of sunlight, decompose the carbon dioxide of the air, build the carbon and the elements of water into their structure, and liberate the oxygen. This justified the at once apt and poetical description of plants, as "the air-woven children of light." This work is being reviewed, and the investigations extended, by Dr. Horace T. Brown, who has already thrown much interesting light upon many phases of this question. The plant respiration appears to take place through the stomata rather than by osmosis, and some of the carbon seems to be derived from the soil.

Very great attention has been directed of late years to the question of the fixation of the nitrogen of the air, and recent investigation is bringing us nearer the solution—the economic preparation of nitrogenous plant food from the nitrogen of the air. We should then have a virtually unlimited supply of nitrogenous plant food to replenish the enormous impoverishment of the soil by the growth of wheat and similar foodstuffs.

Relation to Animal Life.

The effect of the animal upon the air had also been clearly demonstrated, and the study of this question branched out into long series of investigations of the utmost importance, both to the individual and to the community. Quantitative determinations had to be made of the rate of combustion of the human body, expressed in terms of carbon; the amount of impurity communicated to the air by each individual, from which the amount of air required per individual could be calculated. It opens upon the important subject of ventilation—of the home, of public buildings, of the school, the factory, the church, the mine. The science of ventilation is charged with the supply of fresh air without draught, or without undue draught, and is expected to devise means for meeting this demand. It is daily forced upon our attention that this is a problem of the utmost difficulty still awaiting a satisfactory solution. In principle so easy, in practice so seemingly beyond our reach. But it is a problem that is always with us, and one that can and must be solved, and its practice must be controlled and enforced by legislation. One of the first cares of every government should be to see that the people are supplied with fresh air, pure water, and wholesome food. Fortunately for the future of our race, the whole world is alive to this to-day.

More Exact Analyses.

Whilst these developments were being pursued with scientific zeal, another band of workers were determining afresh the original data, and passing them through the crucible of more and more refined experiment. This department alone represents a hundred years of laborious work. Gay Lussac and Humboldt (by explosion with hydrogen), and a number of other chemists in Britain and on the Continent, repeated the analyses, and found the composition of the air to scarcely vary from 21 per cent. of oxygen and 79 per cent. of nitrogen by volume. Later, more accurate endiometric methods were devised, especially by Bunsen, and extensively employed by himself, Lewy, Angus Smith, and many others, in the course of extended researches; 20·97 to 20·84 per cent. of oxygen, with probable error of 0·03, may be taken as Bunsen's numbers, varying very little from Cavendish's results.

The weight determinations by Dumas and Boussingault gave for normal air freed from moisture and carbon dioxide 23 of oxygen to 77 of nitrogen, and there it remained.

But, as we have seen, the normal atmosphere was known to contain aqueous vapour, carbon dioxide, and ammonia. These constituents were similarly determined, with the greatest exactness, by volume and weight methods. The aqueous vapour was naturally found to vary very considerably, the amount for saturation varying with the temperature; the carbon dioxide, for so long regarded as constituting four parts in 10,000 of air, by volume, has been, by more rigid methods of analysis, reduced to three parts, or even less, per 10,000 of normal air. The ammonia, in combination, has yielded, say, five parts per ten million of air, by volume; nitrous and nitric acids, probably as ammonia salts, occur in only minute traces. All these experimental results may be regarded as a wider confirmation, by more exact experimental determinations, of the results obtained towards the end of the 18th century.

In 1840 Schönbein of Bâle discovered *ozone*, an oxidising agent of great energy, and which proved later to be an allotropic modification of oxygen. This interesting substance, with its phantom brother *antozone*, has been the subject of much controversy. *Antozone* had to retire in favour of another equally interesting substance, *peroxide of hydrogen*. Ozone, however, retained its popularity from the moment of its discovery, and has been generally acknowledged to exist in atmospheric air, playing the rôle of purifier.

Although the characteristic odour produced by certain natural electric phenomena seems evidence of its presence, at least for the time, some doubts have recently been thrown upon its existence in the air, as a normal constituent. How far it will retain the place of honour it has so long held, or be forced to give place to peroxide of hydrogen, as a normal constituent of the atmosphere, we must leave for future investigation to decide.

The production of ozone on the larger scale has had much attention bestowed upon it of recent years, and it would seem as if an important new chemical industry were thus being established.

A search for other constituents of the normal air was made by various methods. It was recognised that rain, in falling through the atmosphere, must collect not only normal gases, but many of the impurities that were known to necessarily exist there. Extended investigations, involving analyses of the rain from many different localities by many different workers, demonstrated the presence of those substances we should just expect to find, chiefly common salt in the air over the sea, the sulphates and ammoniacal salts increasing as towns are approached.

Successful attempts were made by Angus Smith and others to imitate the action of the rain by washing the air and analysing the air-washings. In this way soluble substances were collected and crystallised out, solid substances measured and counted, and determinations made of the organic matter.

Living organisms, both nocuous and innocuous, were found to exist, and their collection and examination constitute a special study by itself—the bacteriology of the air. Fortunately, however, these micro-organisms seem to be present only in the lowest strata of the atmosphere, whither they are raised by air-currents. They are incapable of rising into the air without such assistance. They increase with the dust and diminish with elevation and stillness. At the same time, we cannot forget that it is in the lower strata of the atmosphere that we are compelled to live.

The New Gases.

We must now return for a moment or two to Cavendish. Cavendish began his "Experiments on Air" in 1777, and published six or seven years later. He established endiometry as an exact method, absorbed the oxygen with nitric oxide and water, and demonstrated by analysis the apparent uniformity in composition of atmospheric air. He found air freed from carbon dioxide to consist of 79·16 of nitrogen (phlogisticated air) and 20·84 of oxygen (dephlogisticated air), results that surprise us by their close approximation to the results of the most accurate modern analyses.

Priestley had found that the volume of air was diminished by the passage of electric sparks. Cavendish repeated these experiments, and reasoned out carefully that the nitrous acid produced was the result of the combination of the two airs, oxygen and nitrogen; then he proceeds to raise the doubt . . . . "whether there are not in reality many different substances confounded together by us under the name of dephlogisticated air (oxygen)." "I therefore made an experiment," he continues, "to determine whether the whole of a given portion of the phlogisticated air (nitrogen) of the atmosphere could be reduced to nitrous acid, or whether there was not a part of a different nature from the rest which would refuse to undergo that change." He kept adding oxygen and sparking to reduce it down, neutralising with caustic potash, and finally absorbing the excess of oxygen added, and found still a little bubble left, the volume of which was estimated. He draws this remarkable conclusion—remarkable and most interesting when viewed in the light of recent discovery—"So that, if there is any part of the phlogisticated air (nitrogen) of our atmosphere which differs from the rest, and cannot be reduced to nitrous acid, we may safely conclude that it is not more than 1-120th part of the whole." By burning a large quantity of common air with hydrogen, he found that the dew so often noticed in the tube was really water, and "that almost all the inflammable, and about one-fifth of the common air, are turned into pure water."

Lord Rayleigh found that nitrogen, separated from atmospheric air, was about 1-200th heavier than the purest nitrogen obtained from other sources by chemical means. As this difference could not be accounted for by errors of experiment, the suspicion was at once aroused that "atmospheric nitrogen" contained some other constituent than nitrogen, possibly a smaller portion of a heavier gas.

With the assistance of Professor Ramsay as chemist, a vigorous campaign by physicist and chemist was entered upon to clear up the discrepancy. The able investigation that ensued, laborious, painstaking, and skilfully carried out, is fresh in the memories of all. The long-neglected endiometric analyses of Cavendish were unearthed, and repeated with all modern refinements, and the existence of that remanent bubble "not more than 1-120th" of the original volume was verified. Other methods were devised and adopted in further refinement and confirmation, ending (1894) in the isolation of a new gaseous element of such phenomenal chemical indifference as to earn the name of *argon*. Conservative members opposed its acceptance, but all opposition was overcome, and its existence in the air to the extent of about *one* per cent. is now an accepted truth. It is interesting to remind ourselves that Cavendish had this very gas isolated and under his observation more than 100 years before (1785).

It was natural to search for any further habitats of this "new stranger, who has been with us so long *incognito*." It was soon found that gases from mineral waters and springs contained it, a meteorite, and certain minerals; but it was not found as constituting a portion of either vegetable or animal tissue.

The next new element discovered in the atmosphere was *helium*, which has a story of fascinating interest. An unknown orange line first observed in the spectrum of the sun's corona in 1868, and afterwards in stars and nebulæ, was attributed by Lockyer and Frankland to an unknown element, which they named *helium*.

Ramsay, in 1895, when looking for argon in the nitrogen gas (which Dr. Hildebrand had obtained from a crystal of uraninite in 1888), detected not simply the spectrum of argon, but the orange line that had given the spectroscopists so much trouble during the previous 26 years. Once helium had been isolated, Lockyer soon found that it accounted for many of the unidentified spectral lines of sun and star and nebula.

And just here important assistance comes from a rather unexpected source. The liquefaction of gases, beginning with Faraday's, at first, simple experiments, had developed through the assistance of Pictet, Cailletet, and others, until, in the hands of Dewar and Hampson and Triplet, it has reached such a state of perfection that the liquefaction of air itself has become as simple an operation as was ice-making but a few years ago.

Liquid air seems destined in the early future to play a most important part in the industrial world. As a possibly convenient motive-power in certain cases, as an explosive agent, as a ventilating agent, as a fuel, are some of the many directions in which it is confidently hoped by many that liquid air will find useful and extensive application.

The price of production, which must so largely govern its uses, has been reduced from many pounds an ounce (£600) to a matter of pence a gallon; and Pictet appears to have some further surprises in store for us, so that it would be rash at this stage to put limits to its possible industrial applications. But what is of greater interest at present to the scientist is its power of producing intense cold, which has constituted it a new instrument of research, already attended with remarkable success. Through its assistance the valuable physical and chemical researches of Dewar have been made possible, and it is interesting to observe that it has facilitated to an astonishing degree the study of the composition of atmospheric air itself, these new constituents being most readily separated from air in the liquid condition.

Very great interest attaches to the researches of Dewar in his struggle to reach the nadir of temperature; he has cooled helium to 9° absolute, without liquefying it, so that its critical temperature must be below that point, its probable boiling-point being 5° absolute. Professor Dewar is now desirous of getting another gas as much more volatile than helium as helium is than hydrogen, to enable him to reach a temperature of 1° absolute. May he succeed! His experiments are being watched by the scientific world with the keenest interest, and by some, if not with full confidence, at least with a large hope that he will be able to throw new light upon the nature of the molecule. We all want to know what will happen when the absolute zero is actually reached. If it is ever reached, will the throbbing of the solid or liquid atom or molecule be simply stilled for the time, or will the vortex-ring or liquid atom vanish into thin ether—gravitational matter into non-gravitational matter—and a portion of the visible universe be unbuilt? and since matter seems to get simpler and simpler as the temperature rises, if the zenith of temperature (if such there be) could be reached, would something similar happen? So that there would be upper and lower limits of temperature within which alone the visible universe can exist. What will really happen we shall find out if we ever get there. It may be something very surprising; it will no doubt be something very simple and natural, such as we all might have predicted had we only thought of it. Just as we shall doubtless find when we reach the poles of our earth.

Looking at the question, however, from the standpoint of a chemist—my only standpoint—I cannot but think that it shows a want of confidence in the power of human ingenuity to piece out the imperfections and limitations of our senses by the skilful adaptation of means that nature has placed within our reach, to believe that the molecule and the atom are beyond our powers to approach, and, if they are visible, that we may not yet see them by first or second hand sight.

Time will not permit me to follow Lord Rayleigh and Professor Ramsay and their collaborateurs throughout their memorable searchings for still other constituents of the atmosphere by analyses that were made possible, or at least greatly simplified, by operating upon liquid air.

Each new product had to be submitted to a laborious series of examinations, involving the employment of fractional diffusion, fractional distillation, and other methods of the most rigid physical and chemical scrutiny, aided and controlled in part by the use of the spectroscope. Throughout this quest, indeed, the spectroscope has proved itself quite invaluable as a royal road to identification, and in determining whether or not a simple substance has been reached.

The result of this classical and ever-memorable suite of investigations has been the isolation and identification of the five new substances—Argon, Helium, Krypton, Neon, and Xenon—their addition to the list of chemical elements and to the list of the constituents of normal atmospheric air.

One of the most notable characteristics of these new gases is their disinclination to combination of any kind; but the chemist will scarcely rest content until he has tortured them into union with something. We know how comparatively inert nitrogen is, and yet, like all known elements other than these, it is known to have its own province of affinity; and we find it entering into combinations of great importance, highly organised, but leaning to instability. So we may yet find it to be with these late additions to the list of chemical elements, capable of producing compounds perhaps still more complicated in constitution, still more highly organised, still more unstable. They may need higher or lower temperatures, higher or lower pressures, or some altogether new conditions, for their proper affinities to come into play.

Other Recent Analyses—Combustible Gases.

The researches by M. Armand Gautier on the combustible gases of the atmosphere are of great interest. His memoir also contains some notable modifications of the usual analytical methods. He absorbs carbon dioxide by barium hydrate, preferably to caustic potash; the moisture by phosphoric oxide, instead of oil vitriol; and the carbon monoxide by iodine pentoxide; the hydrogen, marsh-gas, or other hydro-carbons, he burns by aspirating through a long tube of oxide of copper, heated in a specially-constructed furnace, absorbing and weighing the resulting water and carbon dioxide.

He employed a train of 28 pieces, and tested all his methods on artificial mixtures, factors being found necessary for the hydrogen and marsh-gas.

He finds approximately two parts of free hydrogen per 10,000 by volume, at sea, in the mountains, and in the air of Paris. This is equal to ⅔ of the normal amount of carbon dioxide in fresh air. The marsh-gas is insignificant in amount at sea, about 2-10ths of a volume (2·19 per 100,000) per 10,000 in the mountains, and about 1·2 per 10,000 in the air of Paris.

The carbon monoxide he finds to be nearly insignificant in the normal Paris air, but of Benzene vapour and analogous compounds he registers ·17 parts per 10,000.

It has long been known that these substances exist in the air. Marsh-gas, often accompanied by hydrogen, comes from decomposing vegetable matters; some fermentations yield a large proportion of hydrogen; fire-damp, petroleum gases and volcanoes are all well-known sources of hydrogen.

M. Gautier suggests additional sources of hydrogen, and gives an interesting and suggestive analysis of the gases obtained from a granite.

C.c. per Kilogramme of Granite.

(CO_2) Carbon dioxide, 272·6.
(H_2S) Hydrogen sulphide, 1·2.
(C_2H_2) Acetylene, 12·3.
(CH_4) Marsh-gas, trace.
(N) Nitrogen rich in argon, 230·5.
Hydrogen, 53.

Liveing and Dewar, in their investigation "*on the spectrum of the more volatile gases of atmospheric air which are not condensed at the temperature of liquid hydrogen,*" demonstrated the presence of free hydrogen in the air over the Royal Institution. I cannot, of course, follow the authors throughout their beautiful research on an occasion such as this, and shall content myself with a very brief reference. After having removed the known gases from the fractionally-distilled liquid air, they made a laborious attempt to identify the spectral lines which the residue exhibited on sparking. One direction of their inquiry will be gathered from their own words—" As our mixture of gases probably include some of all such gases as pervade interplanetary and interstellar space, we early looked in their spectra for the prominent nebular, coronal, and auroral rays."

It is a source of satisfaction to have the presence of free hydrogen in the air demonstrated at the same time by two such different processes; and, now that its presence in the atmosphere is assured, another old and interesting question has been reopened, as to the relative proportions of the mixed constituent gases of the atmosphere as higher and higher elevations are reached, and as to whether hydrogen can escape from the influence of the earth's attraction. Dr. Johnstone Stoney considers it impossible that the earth can retain by gravitational attraction either the hydrogen or the helium of the atmosphere, in which case the earth would be undergoing a steady loss of these gases. On the other hand, Liveing and Dewar argue that "if the earth cannot retain hydrogen, or originate it, then there must be a continued accession of hydrogen to the atmosphere (from interplanetary space), and we can hardly resist the conclusion that a similar transfer of other gases must also take place."

The settlement of this question by an appeal to experiment must necessarily be difficult; some might be ready to say impossible. The theoretical conclusions depend upon considerations purely physical, and the chemist might yet be able to point out a natural process at work sufficient to meet the whole difficulty, and by which these gases are combined—the combustible gases at least—oxidised, and retained for the earth. We have abundance of oxygen; we have a powerful oxidising atmospheric ingredient; and we have atmospheric electricity, together with solution during precipitation.

According to Hinrichs, if we assume each constituent gas to form an independent atmosphere (Dalton), and that there is no reciprocal action, then, by calculation (La Place's formula), at 6·2 miles high the hydrogen will have increased from 0·02 to 0·06 per cent.; at 18·6 miles, the carbon dioxide will have disappeared, the hydrogen increased to 0·64 per cent., and the oxygen lowered to 13·9 per cent.; at 37·2 miles, argon will have reached its limit, the hydrogen constitutes 16·94 per cent., and the oxygen have fallen to 7·52 per cent.; at 62 miles high, the hydrogen equals 95 per cent., the oxygen falls to 0·3, and the rest is nitrogen—all being per cent. by volume.

If the percentage of hydrogen in air is, under ordinary conditions, anywhere between 5 per cent. and 72 per cent., the mixture explodes when fired with a light. We might expect explosive mixtures in the higher regions of the atmosphere, and agencies exist there to determine their combinations; but we have disturbing influences operating which are not taken into account in these calculations.

We have seen what broad and enlightened views respecting the complicated character of atmospheric air have been held by some of the ablest thinkers of remote and recent centuries, and we have considered how far modern scientific research has been confirming and expanding these views by rigid demonstration; but, far as the modern scientists have led us, they have only opened up fresh avenues of investigation.

Air Traffic.

Experiment has abundantly demonstrated that the proportions of the chief ingredients of the air remain wonderfully constant all over the world; experiment has also confirmed, what observation and reasoning have for so long suggested, that the composition of the atmosphere in every place is undergoing ceaseless change. There is a stupendous and constant traffic in air and its constituents. Just as all waters tend to flow into the sea, so gases, unless imprisoned, flow into the air. The atmosphere is their natural reservoir. We know that gases of many kinds are produced all over the earth. We have carbon dioxide from some fermentations and decompositions; we have hydrogen and marsh-gas and similar substances from others; sulphuretted hydrogen, phosphuretted hydrogen, &c., as results of decay; gases from volcanoes; gases imprisoned in stones; gases in the waters of springs, lakes, rivers, of the sea; gases in the arable land, and in the porous strata. All these gases, when permitted, escape into the air. The vapours of most, if not all, liquids pass into the air, and the vapours of at least many solids; besides these, we have liquids and solids in various states of exceedingly fine division, finding their way into at least the lower portion of the atmosphere, and sometimes into the higher reaches.

But there is a return traffic. Rain, dew, snow, hail, and all such results of condensation and precipitation, dissolve up, or include or entangle the gases of the atmosphere in proportions depending upon temperature, pressure, and other varying conditions. We have only to follow a shower of rain. In condensing, and falling through the air, it has dissolved up some of the gases, and washed out certain vapours and many of the solid and liquid particles which the air has been holding in suspension.

Falling on the ground, part, as we all know, is absorbed through being soaked up by more or less porous soil or rock, part is evaporated back into the air, and part flows off the land into the rivers—into the sea. The portion that has fallen on the soil, and entered it, carries some of its gases with it; the oxygen oxidises, the carbon dioxide forms carbonates, and both may thus have become fixed for the time, constituting portions of solids. The part that has evaporated back into the air will carry, no doubt, some of its dissolved air-gases and some of the new gases that may have been produced in the meantime; the part finding its way to the sea may have passed over land such as limestone, which its gases have partially dissolved and carried into the sea; many other chemical changes may have been brought about by these air-gases on the way, resulting in the formation of other solid, liquid, or gaseous compounds. We know that such traffic is going on, and that, arrived at the sea, some of the products help to build up shells, and bones, and coral reefs, and new continents. Some of these air-gases may be returned to the air again shortly, or only after countless ages. The animal and plant life of the sea are just as dependent upon these gases as are the same lives upon the land, and for that reason nature has to provide by wind and wave an aerated ocean. But a rain-shower is not necessary to effect a great interchange of gases between air and sea and land.

A sheet of water, or a moist surface, has the power of dissolving gases, and air has the power of dissolving or absorbing water in the vapourous state. This interchange is constantly going on. The amount of air dissolved by water depends upon the composition, the temperature, and pressure. We have to remind ourselves that there is a larger proportion of oxygen and carbon dioxide in the air-gases dissolved in water than what exists in the air itself, thus increasing its chemical action upon rock and soil and inhabitant of the waters.

As the pressure and temperature are constantly changing, so the exchange of gases must be constantly going on, for this reason. Indeed, each puff of wind must have its effect. But, even if temperature and pressure were constant, there would still be a continued exchange.

Take arable land as an example of porous ground. The moist ground will, as we have seen, absorb and give out air-gases; but the porous ground will have a constant interchange of air in at least two ways. As the pressure of the air increases, more air will be pressed into the ground; as the air-pressure falls, gases will be withdrawn—a simple case of expansion and contraction of gas. For the most part, fresh air will be caused to enter, and more or less waste or soil gases will be expelled.

Now, if we watch a delicate barometer, such as a glycerine barometer, we can see that, in most places, the pressure is undergoing constant variation; and in certain parts of the world, where the daily maxima and minima are easily detected, there will be a great double breath a day—two inhalations and two exhalations—besides the short irregular breaths produced by gusts of wind, or other causes. The great world of mountain and plain is, therefore, constantly breathing. We can understand that it must be so, but, if anyone desires ocular demonstration, let him descend an alluvial mine, as at Allandale, Victoria, and, with lighted candle in hand, stand by the entrance to an abandoned drive that has been imperfectly closed. Let him hold the candle-flame opposite any of the cracks that are sure to remain, and he will find his candle-flame in a constant state of unrest, blowing in towards the drive or blowing out from it. He will then have seen the breathing of the earth. He may prefer to say it is the atmosphere breathing, and not the earth, but the result is the same. The earth pulls and the sun pulls and warms.

A breathing earth, with an earthquake shock every half-hour, and a trembling seismometer that feels its heart beat—what would Thales and his followers have given for such information, when arguing that the earth was a living being! or how much of it all had they devined?

If vegetation exists on this arable soil we are considering, then there is another obvious action at work. Vegetables exhale moisture—some in enormous quantities; the moisture is drawn up through their roots by capillarity, &c., and exhaled by the leaves. They are pump-wells; but, if the water is pumped away from the soil round the roots, air will be drawn in to take its place. or water carrying air.

This must follow the draining of the land, of country, of strata, or of a mine.

Besides the oxidising, carbonating, or other chemical action of the air upon soil and rocks, on the surface or at depths, and the rapid combustion or gradual decay of animal and vegetable matter, we have the interesting air-traffic traversing the two kingdoms of plant and animal. As all the world knows, the animal as a living heat-engine feeds the flame of life with the oxygen of the air, burning its substance, and producing as waste, amongst other substances, carbon dioxide and water. The plant, reversing the operation, decomposes the carbon dioxide, and builds the carbon with the elements of water into its substance, restoring to the atmosphere in a free condition the oxygen that the animal had combined. Truly a beautiful natural adaptation that calls for our admiration afresh whenever it is presented to us!

The organic matter in the soil and in the plant comes from the air, and the organic matter of the animal comes from the plant. So that, except the little inorganic matter they contain, the substance of the vegetable and animal worlds come out of the atmosphere. They are built out of air

We find, then, all this never-ending traffic in the constituents of the atmosphere, from the air to the waters on the earth's surface, and to the waters under the earth, carried through the strata and the solid rocks, and performing known and unknown chemical changes with often long and complicated geological careers, returning in part to the upper world again in the springs (argon and helium carbon dioxide and the rest), and by way of volcanoes of fire and mud; and, in the outward breath of the earth, into and out of the seas and lakes and streams, into and out of the bodies of plant and animal, in the land and in the waters, and throughout the atmosphere, with diffusive interchange, and by the mechanical movements of the winds. If we are to accept recently-revived suggested possibilities this traffic may not be confined to the liquid and solid earth and its gaseous envelope, but have to include an exchange of atmospheric gases with systems across interstellar spaces.

Work Awaiting Workers.

I have referred thus in bold, and necessarily imperfect outline to the traffic in air and its constituents, with the object of drawing attention to some of the questions that still await investigation; and I have referred to the determination of only a few of the substances that are usually found in normal air; but it would seem that, just as we may regard the sea as the world in solution, so may we, with perhaps equal truth, consider atmospheric air not simply as what has been left over from the making of the earth up to the present moment, but as the earth in a gaseous condition, with, especially in the lower regions, solids and liquids in molecular condition, or in fine suspension; and just as we almost seem to be able to find any element in the sea for which we seek diligently enough, so, possibly, for the atmosphere. We can see how much yet remains to be done. It is of great importance, in the first place, that old experiments should be repeated, old experimental ground traversed again, using the new tools and appliances with which modern science keeps supplying us; it may be instruments of greater precision; it may be a new method of research, such as spectral analysis, or photography, or the X-ray; it may be an improved or novel method of exact chemical analysis; or new devices for producing extremes of heat or cold; it may be liquid air and a helium thermometer; or the discovery of a new principle, or new substances; or something else that will exalt our powers of research. This applies, of course, to every department of science, but I am regarding it especially in connection with atmospheric air. There is great room for the repetition and extension of old experiments, and the devising of new ones. Is not the long neglect of Cavendish's "residue" still fresh in our minds?

Systematic and periodic analyses are needed all over the world in connection with the air and rain—chemical climatology. The analyses ought to be made with the utmost exactness by recognised standard methods, which ought always to be stated. The recent discoveries of Rayleigh and Ramsay have rendered it necessary for us to overhaul all our old results, and follow by rigid analyses the changes in the composition of the air throughout the air-traffic in rock and soil and river and sea referred to above.

The changes in the air brought about by the vegetable and animal worlds have only been very crudely stated.

The exhalations of the animal and the plant, their outward breaths, require to be submitted to the same rigid and exhaustive examination as that to which the atmosphere is now being subjected by the chemist and spectroscopist; and it may be that equally startling discoveries in both these directions are awaiting the patient investigator. Besides these, we have the great reservoir of the atmosphere itself to further explore throughout its depths.

Finally, the study of the chemistry of the atmosphere has led us to the study of other atmospheres than ours—a study that is teaching us much concerning the atmosphere of the earth. We read our own history in nebulæ, and stars, and sun, and planets. This has been made possible through the application of especially two most wonderful instruments of research—spectral analysis and photography. The examination, and ultimately the explanation, of the presence of certain dark lines in the solar spectrum brought us by one bound to a solar chemistry, and then, as a corollary, to a chemistry of the stars. We thereby recognised in the sun's atmosphere certain chemical elements known to exist on our earth, and we arrived at the further conclusion that certain elements existed in the sun's atmosphere and in the atmosphere of stars and in nebulæ, which had not been so far recognised on the earth. One of these, helium, as we have seen, has been recently discovered in our own atmosphere (discovered in the heavens first before it was discovered on the earth!), and others are now being persistently searched for. If they are with us, as we cannot but think they are, their discovery is only a question of time.

Photography has brought us aid of a different description, and of perhaps a still more amazing character. It draws these lines for us, and fixes the information in a picture. It fixes, not only the lines we can see, but those that are invisible to the human eye. It shows us the invisible by second-hand sight.

What is perhaps still more astonishing is that by its power of accumulating faint impressions the sensitive plate can build up a picture of stars and systems that are so faint and remote as to be the despair of the possible telescope. And yet, this faint light comes to us full of information about other atmospheres, only some of which messages we have learnt so far to read.

With what a wonderful conception of the universe does it leave us! The weary wastes of ether constitute a moving manuscript. From every point of space to every other point of space information of the most complete description is passing by wireless messages. The history of the universe is written in ether by the rippling pencils of light and other radiant energies. We pride ourselves on the discovery and the deciphering of ancient records from Nineveh, or from the land of Ur; but what are Nineveh bricks to the manuscript of light that we are receiving on the long-exposed sensitive plate, which brings records that may have been printed on the ether before man was born upon the earth, it may be—who knows?—before the foundations of the earth were laid, and which, if the universe is infinite in extent, may be still passing on to remoter space after the human race has disappeared.

However ancient these light manuscripts may be; however long they may have been on their journey, this we know—that they come to us laden with messages out of the darkness of space. But light is one form of energy, bringing one kind of information; how many other forms of radiant energy there may be, bringing how many other kinds of information, we can only guess. Already we are familiar with radiant heat, and with invisible rays above and below the visible spectrum; radiant electrical energy has long been a portion of our demonstrated knowledge, and ether waves from a few feet to thousands of miles in length are believed to have been recognised.

All this may well fill us with the belief, not only that Nature's fertility of resource is inexhaustible, but that Nature scarcely places limits to the possibilities of scientific discovery, or to the width and depth of human knowledge.

SUB-SECTION B.

BACTERIOLOGY AND FERMENTATION.

THE MICRO-ORGANISMS AND THEIR APPLICATIONS IN THE INDUSTRIES.

By R. GREIG SMITH, M.Sc., Macleay Bacteriologist to the Linnean Society of New South Wales.

INDUSTRIAL bacteriology or mycology treats chiefly of the changes that are effected in such carbohydrates as starch and sugar by various yeasts, moulds, and bacteria. In less degree, it deals with the fermentation of albuminoids, the growth of yeasts, moulds, and bacteria for the production of trade cultures, the preparation of toxines, and the manufacture of antitoxines and protective sera.

Ferments and Fermentation.

Before proceeding to consider in detail the various applications of bacteriology, it will be well to understand the meaning of fermentation. The old idea of formed and formless ferments has had its day, and the discovery of zymase, the alcoholic ferment, showed the folly of attributing fermentative action to protoplasm simply because we did not know how to separate its active products, the enzymes. Protoplasm produces the enzymes which do the work. As a rule, the fermentation of any simple or complex organic chemical substance is referred to the micro-organisms themselves, instead of to the enzymes which they secrete. This is done only for the sake of simplicity; and if we should so refer to the yeasts or bacteria, let us not forget that fermentation is a change brought about by the action of enzymes, and that the term "ferment" now applies to the enzyme, and not to the micro-organism. The organic ferments or enzymes are bodies of unknown more or less complicated constitution. Zymase, the alcoholic ferment, approaches nearer to protoplasm in its reactions than the older known enzymes, such as rennet, diastase, and pepsin. Indeed, at one time, after the discovery of zymase, there was much discussion as to whether alcoholic fermentation was the work of an enzyme or of diffused protoplasm; it is now accepted that it is really done by the former. The micro-organisms may secrete many ferments; for example, yeast has been shown to produce at least five. It can convert starch to maltose by means of a diastase; it can invert cane-sugar by its invertase; maltose is changed to glucose by glucase; glucose is fermented to alcohol by zymase; and, finally, albuminoids are digested by a proteolase.

Moulds in the Alcoholic Fermentation.

Undoubtedly the most important fermentation from an economic point of view is the alcoholic; and perhaps the oldest fermentation of all, the lactic, comes next. In the Western world, the yeast-plant as a producer of alcohol holds sway; but within the last few years moulds from the East have been gradually introduced, in some cases to aid the yeast, in others to displace it; and, in all cases, chiefly to dispense with the expensive malt.

It is a matter of common knowledge that the steps in the process of making alcohol are starch, maltose, glucose, alcohol, and sometimes saccharose, glucose, alcohol. The active "-ases" in effecting these changes are diastase, glucase, zymase, and invertase, pymase. Instead of using malt or a mixture of malt and grains, such as rye, for the production of fermentable sugar, a cheaper cereal, rice, is sometimes infected with the mycelia of *Aspergillus oryzae*, a mould that occurs along with a yeast in Japanese koji, the grains of which are used by the Japanese in making a strong rice-wine. *Aspergillus oryzae* has a strong diastatic action, and furnishes taka diastase, a trade product.

But another mould or group of moulds, the Mucors, have found more favour with European distillers. The most important species is *Mucor* (or *Amylomyces*) *Rouxii*, which produces practically a straight fermentation from starch to alcohol, the saccharification and fermentation proceeding simultaneously. The process was first used in Europe at Lille, in France, and the method consisted in sterilising a mash of brewer's settlings by heating under a pressure of two atmospheres. This was followed by cooling and infecting with the *Mucor*. After 20 hours, when the mycelia had penetrated uniformly throughout the mass, a few cubic centimetres of yeast were added, and the fermentation allowed to proceed. When the process was finished, 97·5 per cent. of the theoretical yield of alcohol was obtained. The method is now used in the Belgian distilleries; but, instead of *Rouxii*, a more energetic variety—*Mucor B*, or Belgian koji—is employed. One gramme (15 grains) of *Mucor* suffices for 25 tons of grain, thus replacing three tons of malt, and saving a loss of six cwts. of starch, which is equivalent to 44 gallons of pure alcohol.

The yeasts and moulds, however, are not the only micro-organisms that can saccharify and ferment. Some bacteria ferment starch to alcohol, and others ferment sugar. An example of the latter is *Bact. coli commune*, a common intestinal bacterium, which ferments one-sixth of the glucose in the medium to common alcohol.

Yeasts and Yeasts.

In the wine industry, moulds are also used, but this is done unwittingly, and much bad wine could be traced to their agency. Those fermented beverages which contain the original juice of the fruit, or extract of the grain. and in the fermentation of which it has been the custom to employ yeast, cannot have the yeast replaced either partly or entirely by moulds, because these produce substances which are disagreeable to the palate. I use the word yeast with all due caution, because there are yeasts and yeasts, some of which are as objectionable as moulds. It is a common idea that all yeasts ferment, and therefore any yeast is good enough to produce alcohol. That is quite right, and also quite wrong. There are species of yeasts—and of these species there are varieties, and of these there are races—and there is as much difference between the races of yeasts as between the races of mankind. If we take, for example, the cultivated yeast of the brewer (*Saccharomyces cerevisiae*), we find that it can be divided into top and bottom varieties, the former rising to the top of the wort during fermentation, and the latter remaining at the bottom of the fermenting vat. These, again, can be subdivided into races, each of which will have a different effect upon the finished beer. There are possibly as many races of *Sacch. cerevisiae* as there are breweries.

The Routine of Brewing.

The brewer is a happy mortal. He kills the bacteria in his mash by boiling, and adds hops, the essential oil and extractive matters of which hinder the subsequent growth of bacteria. He can, if he desire, add to his wort a pure culture of yeast, so that he has everything under control. He knows the composition of his wort, and can attemperate it to any degree. He is scientific in his methods, and can repeat the process day after day with the utmost regularity, and with the sense of security engendered by the knowledge that his beer a year hence will be the same as it is to-day.

Yeast and Wine.

The vigneron is by no means so happily placed. He does not crush his grapes every day, and he cannot boil his must. Many a vigneron does not know the benefit that can be derived from using pure cultures of yeast. A spontaneous fermentation is allowed to set in, with the result that yeasts and moulds of every creed and denomination strive for a mastery; so that a wine is produced whose future career is wrapped in doubt. There is only one partial safeguard the vigneron has, and that is the acidity of the must, which favours the wine-yeasts, and checks other yeasts and bacteria. A check, however, is not a prevention, and some Australian wines are prone to develop turbidity, and to undergo the mannitic fermentation, both of which diseases are caused by bacteria. But the acidity and the sugar are varying quantities, and it is easy to believe that the wine-maker must be an expert, since he has to contend with so many difficulties. These may be to some extent overcome by the use of pure cultures of selected yeasts. In the selection of a yeast, one microscopic cell is taken, and cultivated, and the action of the culture upon must has to be tested chemically, and with the trained palate. The temperature and the acidity best suited to its growth must also be ascertained. Perhaps the temperature is the most difficult condition the vigneron has to regulate; but it is quite possible that a native race of the wine-yeast, *Saccharomyces ellipsoideus*, might be found that would ferment out at an Australian summer temperature the sweet Australian musts.

Although a previous pasteurisation of the must is theoretically advantageous prior to the addition of a pure culture, yet, by using a large quantity of starter-yeast, the action of the natural yeasts and moulds can be kept under. This is the principle of mass effect when 25 to 100 yeast-cells are added for every yeast or mould that may be on the surface of the grapes. The added yeasts of the starter are more numerous and more vigorous, and, generally speaking, finish the fermentation before the others have had time to begin. The advantages of using pure cultures in the wine-fermentation may be summarised thus:—A quicker fermentation, a better clearing, a cleaner taste, and an improvement in flavour and bouquet. At present European yeasts are used in a few isolated cases, where the vigneron has realised the importance of leaving nothing to chance in this world of competition.

Distillery Yeasts.

Vignerons, however, are not the only men who are ignorant or apathetic regarding the properties of yeasts. I have heard of a distillery where they use a brewery yeast for pitching their wort. It is possible that this may be correct, but it is more than probable that it is not. Distillery yeasts and brewery yeasts are two different things—as different from one another as Gorgonzola is from Cheddar cheese. To the distiller, an incomplete fermentation is a loss, but to the brewer it may not be. The distiller requires a straight fermentation, while the top-fermentation brewer relies upon an after-fermentation in the barrels.

Malt Wine.

Wines are presumably derived from the grape; but within the last few years, wines have been made from malt. The sweet wort is infected with lactic bacteria, and after the requisite acidity has developed various wine-yeasts are added, according to the kind of malt-wine desired. The fermentation is accelerated by the addition of raw sugar. After the fermentation, the only thing that remains to be done, and that the most important, is to eliminate the malt flavour. This is accomplished by keeping the wine at a temperature of 50° C., and continually renewing the air in contact with the surface for some weeks. The malt odour entirely disappears, and a pleasant aroma takes its place. By using different yeasts, sherry, Madeira, and other malt wines can be made, which compare favourably with the average quality of wine usually sold.

The production of different malt wines from the same wort by specific yeasts infers that the yeast is entirely responsible for the flavour and bouquet. This is a matter that is open to doubt, and, although the different yeasts have some influence in producing distinctly flavouring substances, yet it can scarcely be denied that the grape is of the most importance. It is interesting to note in this relation that the sixth Austrian Wine Congress concluded that pure yeast must be carefully chosen; that the distinction caused by its use is most marked in young wines, and less in mature wine; and that the effect of the yeast on the bouquets of well-made wines is hardly noticeable.

Bread Yeasts.

The manufacture of pressed yeast must not be forgotten. In this industry the type of yeast is selected to give a maximum quantity of yeast from a minimum of material. As the fermentative power of a yeast-cell is inversely as its reproductive power, it follows that yeast grown specially for sale has comparatively a small specific fermenting power. Many pressed yeasts, however, are derived from breweries and distilleries in which more yeast is collected than the manufacturer requires.

Yeast is used for other purposes than the production of alcohol. The baker employs it to make his "sponge," which raises his dough. As a rule, he obtains it in the first instance from a brewer, when it is comparatively pure. But, after it has been used numerous times, it partakes more of the nature of a bacterial than a yeast culture. I have seen many specimens, and in these the yeasts were in the small minority. Doubtless the bacteria have some influence on the taste of the bread for good or evil, and they may also produce a quantity of sugar from the starch. There is a point, however, that strikes one as being bad, and that is the original source of the yeast. A beer yeast is adapted for beer, and not for bread. A bread yeast should produce a maximum amount of carbon dioxide from the sugar which is present. A beer yeast has not been primarily selected to produce gas. There is a need, therefore, for the selection of a yeast-type which will produce a maximum quantity of carbon dioxide gas under the conditions that obtain in bread-making.

Non-alcoholic Fermented Beverages.

Certain beverages which are supposed to be non-alcoholic derive their effervescing property from the carbon dioxide of the alcoholic fermentation. Mention may be made of the ginger-beer plant, which is a mixture of a peculiar bacterium and a yeast, the two together forming small solid lumps, which, when placed in a sugar solution, ferment the fluid. Quite recently a bacterium has been used to produce an absolutely non-alcoholic effervescing beverage. The bacterium is a slime-forming organism (*Leuconostoc dissiluens*), which is infected into a sterile solution of cane-sugar flavoured with fruit-juices and fermented in closed vessels.

The Manufacture of Lactic Acid.

There is a group of bacteria that produce lactic and practically no other acid. Lactic acid is formed by most acid-producing bacteria; in some cases from lactose, in others from glucose or saccharose. The butyric bacteria first produce lactic acid, which they convert to butyric. It is, therefore wrong to suppose that a bacterium which produces lactic acid should be called a lactic bacterium. The quantity of acid produced and its purity must be taken into account. In many of the industries in which the action of lactic acid is required it is preferable to use the acid itself, and not the bacteria, for by doing so the action is completely under control.

In the manufacture of the acid any raw material that will furnish a solution of glucose at the cheapest possible rate is used. After saccharification, the wort is brought to a certain gravity, just as in brewing, boiled and cooled down to 45° C., when it is infected with a starter prepared from a pure culture of a selected lactic bacterium. The fermentation is conducted at about 45°, and the liquor, which should have been slightly acid, is treated with chalk, or with milk of lime, from time to time, so that the acidity is maintained at from 0·2 to 0·5 per cent. At the close of the fermentation the liquor is heated to kill off the bacteria. After the dead bacteria are removed by filtration, the liquor is evaporated, and the calcium lactate allowed to crystallise. The crude lactate is decomposed with sulphuric acid, and the lactic acid evaporated down to market strength.

The skill of the technologist is employed in regulating the temperature to prevent the alcohol and the acidity to check butyric fermentation. For economic production, over 90 per cent. of the glucose must be fermented, and this is managed, *inter alia*, by the attenuation of the wort and care in the selection of the bacterium. A point of interest in the process is the temperature at which the fermentation is conducted. On the small scale, in the laboratory, a temperature of 37° is equivalent to 45° in a 5000-gallon vat. Something of a similar nature occurs in the fermentation of must, where the fermentation generally goes on at a temperature at which the yeasts would not grow in the laboratory.

Lactic acid is chiefly used in the dyeing of wool, and as a menstruum for obtaining a solution of aluminium, tin, and calcium, with one acid in mordanting cotton goods. It also promises to play an important part in the tanning of leather.

The Tanning of Leather.

In this industry the raw hide, which has been preserved from putrefaction by the use of disinfectants, is cleaned, and then either "sweated" or "limed," in order to take off the hair with the adjacent mucous layer, and leave the corium or true fibrous skin. One of these processes, the "sweating," consists in exposing the hide in pits saturated with moisture, when a rapid putrefaction fermentation sets in. In the other process, the hides are steeped successively in stronger and stronger solutions of milk of lime. After these treatments the hair and outer layers of skin are easily removed. The hide is next immersed in the "bates," which consist of fermentable solutions of dog or pigeon dung and of bran. The bates, by their fermentation, furnish lactic acid, which acts upon the dehaired hides in two ways. It eliminates the lime salts, and causes the hides to swell up and become porous or "plump," in which condition they are quickly and uniformly tanned. The remainder of the outer skin is removed by the tryptic ferments of the manure. The lactic acid is formed by lactic bacteria from the starch of the bran, which is saccarified by the bran diastase cerealin. Thus several processes go on in the "bates." There is also a production of fermentation gases which were supposed to be the chief agent in causing the plumping, by blowing up the substance of the hide. Lactic acid is being used in place of the bran-drench, and it is claimed for this improvement that the process is more under control; and it certainly seems more feasible to employ the product of the bacteria than the irresponsible organisms themselves. It has been suggested that pure cultures of bacteria could be used to replace the dung; but, as the latter contains something more than pure bacteria, the suggestion has apparently not been put into practice.

In the tan liquors, where the prepared hide is converted into leather, quite a number of fermentations go on. There is the alcoholic, the acetic, the lactic, and sometimes the viscous. These are to be traced to micro-organisms introduced in the hides, the water, the air, and the bark. In these fermentations the lactic is the chief, and by its plumping action the tanning material is assisted into the interior of the hide.

The lactic fermentation is found in the distillery, where it plays a not unimportant part in acidifying the wort, and thus preventing the growth of putrefactive bacteria, which prefer a neutral or slightly alkaline medium. It is also of enormous importance in all dairy fermentations, and of these I shall write subsequently.

The Fermentation of Silage.

Until quite recently it has been understood that the lactic bacteria played a most important part in the fermentation of silage. It was considered that the sour silage—in which the temperature never rises so high as in the sweet—was fermented by the lactic and butyric ferments, and the sweet silage by the lactic bacteria only. It has now been shown that the fermentation is not bacterial, but results from the physiological acivity of the plant-cells. Silage can be made under conditions that exclude bacterial action. The acidity is due to the intra-molecular respiration, and the quantity is roughly proportional to the length of time that the vegetable-cells respire. Thus the greener the plant and the lower the temperature of fermentation, the more acid is produced.

The Production of Butyric, Oxalic, and Citric Acids.

The butyric fermentation is a later stage of the lactic, as the butyric bacteria first form lactic, which they then convert into butyric acid. Butyric acid is accordingly never solely produced by bacteria from starch or sugar, but is always mixed with lactic. In fact, a pure bacterial acidification of any kind is seldom if ever obtained, *e.g.*, in the presence of air, lactic bacteria always produce some acetic acid.

Fermentation butyric acid is used chiefly in the preparation of alcoholic butyrates, which are flavouring essences. The writer recently separated a lactic-butyric bacillus from raw sugars, in which it is universally found, and it is possible that this organism was responsible for the original pine-apple odour of rum. I write "original," for in these days of enlightenment the flavour is most easily imparted by the addition of the pure ethyl butyrate. Oxalic acid is always produced by the acetic bacteria in the presence of carbohydrates, and the crystals of oxalate of lime in culture media are familiar to every microscopist who has grown the commonly-occurring hyphomycetes. *Aspergillus niger* has been suggested as a source of oxalic acid, but it does not appear to have advanced beyond the experimental stage.

The production of citric acid by certain citromycetes from glucose at one time promised to become of some importance. The yield was good, six parts of acid being obtained from eleven parts of sugar; but, owing to a fall in the price of the natural acid, the mycological industry failed.

The Vinegar Fermentation.

The vinegar manufacturer has much to contend against. Up to a certain point he is virtually a distiller; that is to say, he produces alcohol from the cheapest possible source, and uses up most of the fermentable carbohydrates. There is this difference, however, and here the vinegar manufacturer resembles the brewer—the fermenting mash cannot be acidified by lactic bacteria, nor treated with antiseptics, such as fluorides, since neither lactic acid nor fluorides must appear in the finished product. The grain which furnishes the starch is usually kiln-dried, and this practice, besides producing flavouring substances and assisting the gelatinisation of the starch, kills off most of the moulds and bacteria on the surface of the grain. After saccharification and attenuation of the wort, a good quantity of brewers' yeast is added. This is quite legitimate, for in a vinegar factory, where a mash is made intermittently, it is better to use brewers' yeast—generally a stable substance, owing to the regularity of the brewing process—than to keep over yeast from a previous fermentation. The addition of what may be called an excess of yeast gives a rapid start to the fermentation, thus reducing the possible secondary bacterial fermentations. The fermented wort, after aëration, is passed into the acetifier, which contains twigs infected with vinegar-slime. The acetifying wort is repeatedly passed by pumping and sparging over the portion of the acetifier which contains the slimy twigs.

It is perhaps in the preparation of these infected twigs that the manufacturer has the most need of selected and pure vinegar bacteria. Infecting the twigs from an old slime, which may be the home of many organisms besides the acetic bacteria, is neither scientifically nor economically correct, although, practically, it may be easy. The acetic bacteria are many, and, like other bacteria, they differ among themselves in their capacity for doing the work that is required of them. For example, it has been shown that some acetic bacteria produce three times as much acid as others, and that some can withstand twice the amount of alcohol that others can. In one respect bacteria are like human beings—they must be fed; and this is notably so in the acetification of the alcoholic fluid. If the food constituents, *i.e.*, the salts, carbohydrates, or nitrogenous matter, become exhausted, the bacteria refuse to work until properly fed. The vinegar manufacturer has frequently to feed his bacteria, especially when he uses sugar instead of grain for his wort.

Bacteria in the Dairy.

Perhaps it would now be advisable to consider the dairying industry in some of its bacteriological aspects. Milk, it need scarcely be said, is a complete food, and when neutral, or nearly so, is a fluid exceedingly well adapted to grow bacteria. It is a common fallacy that the curdling of milk is always due to souring. It is just as often—and this applies to the milks obtainable in the neighbourhood of Sydney—caused by rennet enzymes secreted by bacteria, especially the spore-forming kinds. Sydney milk is practically unsterilisable. It can be sterilised by repeated and intermittent boiling, but this process alters the fluid, and it has then as much right to be called milk as butter heated in the same way can be called butter. The so-called sterile milks are such in name only, and contain bacterial spores, which are prevented from germinating by the absence of air. But should the smallest quantity of air obtain access, or, what comes to the same thing, should all the air not have been expelled in the steaming, the latent spores germinate, and the milk rapidly curdles. It will be noticed that in such cases the milk rarely has a sour taste.

Pure "Starters" v. *Manure Bacteria.*

In the souring of milk, the primary process in the manufacture of butter and cheese, it is advisable to pasteurise the cream or milk by heating it for 15 to 20 minutes over 68° C. (= 154° F.)—the death-temperature of bacteria—and, after cooling, to infect with a "starter." Starters are made by infecting a small quantity of pasteurised cream or milk with a pure culture of what should be a selected lactic bacterium. The "starter" has the same significance to the butter and cheese maker that the "sponge" has to the baker. Without previous pasteurisation the souring process cannot be so effectively done, on account of the secondary fermentations that ensue. I need not remind the reader that the chief source of the bacteria in milk is the manure that adheres to the udder of the cow, and so obtains access to the milking-pail. A small particle of manure contains myriads of bacteria of a most objectionable nature, and one small particle from each cow very soon becomes aggressive in the milk from a herd. It has been calculated that the people of Berlin consume half a ton of manure in their milk per diem. This can easily be imagined when one remembers the rhyme of one's childhood—" A little drop of water, a little grain of sand, &c." It is, therefore, evident that pasteurisation of milk in the dairy, the factory, and the home is advisable on hygienic and practical grounds. But to return to the starter. This should be prepared originally from an indigenous species, which was done by the authors of a paper read before this Association two years ago. To show the necessity for selecting the races, it has been shown that from one sample of milk, races of the same bacterium have been separated, some of which produced twice the amount of acid that others did. The imported pure cultures of lactic bacteria are preserved in some such material as starch, which appears to be a source of impurity, because, when the bottles are opened in this country, they are found to contain cultures of the common moulds, and generally no lactic bacteria.

The Aroma of Butter.

Bacteria are also useful in imparting to butter an agreeable and pleasant aroma. Perhaps the best-known of the aroma bacteria is *Bacillus Connii* (or *Conn* 41), which undoubtedly improves the quality of butter prepared with its aid. I have tested this bacterium experimentally, and the difference between butters made from one lot of cream with and without it was very marked.

Commercial Pure Cultures.

Commercial pure cultures consist of some absorbent sterile powder, such as starch or sugar, impregnated with a pure culture of the bacterium. The pure culture is grown upon suitable solid media, and scraped off, distributed in water, and mixed with the absorbent powder, dried, and sealed up; or a fluid culture is scattered over the powder, which is subsequently dried at a low temperature. Theoretically, there is no difficulty in the process, but practically the utmost care is needed to conduct these simple operations in an aseptic manner, so that the finished dry powder contains the required living bacteria, and no other micro-organism.

The Ripening of Cheese.

In the making of cheese the lactic bacteria are all-important in acidifying the milk for the production of a good rennet curd. To convert the tasteless curd into a mellow cheese some agent is needed. We know that in some kinds of cheese moulds are essential, and they are purposely added by means of mouldy bread, mats, or wires. In such cases the moulds undoubtedly play a part in giving a flavour to the finished cheese. These, however, have little to do in the ripening of the curd, and they play no part in the maturing of an ordinary Cheddar. The cause of the ripening of firm cheese has for a long time been under discussion, but it is now understood that the gelatine-liquefying bacteria have no influence, and that lactic bacteria, if they play a part at all, only regulate the process, possibly by starving out objectionable micro-organisms. The active agents are two enzymes; one, galactase, occurs normally in milk; the other, pepsin, is added with the rennet. So far as we know at present, these are the only agents that cause the ripening of cheese.

The Rancidity of Butter.

The rancidity of butter has been ascribed to the action of bacteria, light, or air; and the most recent research, like all previous ones, does not furnish an answer to the question. The rancidity is not proportional to the free acid, but is proportional to the casein and milk-sugar, while light and air are without influence. The last finding is scarcely what one would have expected.*

An Effervescing Milk Beverage.

Kephir and koumiss are two effervescing milk beverages of Eastern Europe. Koumiss, originally made from mare's milk by the Tartars, is now made in Western Europe by adding a little sugar and common yeast to cow's milk. The casein becomes partly digested during the fermentation, and on this account the beverage has been recommended for invalids.

The Retting of Flax.

We now come to certain industries that utilise a mixed fermentation of albuminoids and carbohydrates for the purpose of separating non-fermentable fibres and starch from other fermentable vegetable substances.

The "retting" of flax (hemp, loofa, &c.) has until quite recently been left to chance. The stalks of the harvested

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* Still more recent are the investigations of O. Jensen, who found that, when exposed to light and air, in the absence of micro-organisms, butter acquires an unpleasant taste and odour, but does not become rancid. Rancidity is only produced in the presence of bacteria and moulds. These require air for their development, and thus the rancidity proceeds from the outside to within the mass of butter. [Added 7.11.92.]

plants were immersed in water, and allowed to rot spontaneously until the bast fibres only remained. It is now proposed to infect the water with pure cultures of particular bacteria, and, by adding nutritive salts to favour their growth, the retting is accomplished in a few days in any class of water. The latter point is important, because the water of certain rivers, as the Lys, was considered a necessity for the process. The improvement not only saves the cost of transport of the crop to the river, but the flax is better than when the natural process is employed. Furthermore, by performing the retting, and drying in one closed vessel, the fibre is not so much broken.

Starch, Indigo, and Tobacco.

The preparation of starch, by fermenting potatoes, &c., with certain bacteria, has been attempted, but the process is too lengthy to compete with the ordinary one.

The fermentation of indigo was considered to be bacteriological, but we know now that it results from the activity of certain plant enzymes. One of these, a diastase, converts the indican into indigo-white, glucose, &c. The indigo-white is oxidised by an oxidising enzyme or oxidase in alkaline solution into indigo-blue.

The curing of tobacco was also supposed to have been occasioned by the agency of bacteria, and even yet the subject is under discussion; but the evidence is in favour of the theory that it is brought about by the natural enzymes of the leaf.

Many other fermentations of vegetable substances which at one time were considered as bacteriological are being shown to be caused by the enzymes inherent in the cells of the plant.

The Farming Industry.

The changes that bacteria produce in nitrogenous material are of the greatest importance to the farming industry, for they include (1) the conversion of manure of various kinds into suitable plant-food, (2) the losses accompanying the change, and (3) the gain by the nitrogen-gatherers. In the first place, nitrogenous vegetable and animal matter of almost any description supply the nourishment necessary for the growth of most bacteria, so that in the presence of moisture a putrefactive fermentation quickly sets in. In the rotting of manure the straw, &c., rapidly loses its shape; the structure of the substances that went to make it, becomes altered and unrecognisable; and, at the same time, much mineral and nitrogenous material that was previously insoluble, or difficultly soluble, owing to it being in organic combination with the tissues, becomes easily soluble in the soil water. A great number of organisms take part in the rotting, and during the process there is much diminution of the organic matter, with an evolution of quantities of carbon dioxide. There is also a loss of nitrogen, which goes off partly as free gaseous nitrogen and partly as ammonium carbonate, which is volatilised by the heat evolved in the fermentation. The former loss is caused by the denitrifying bacteria, which find part of their food in xylan or wood gum—a substance that is found in straw. When the manure is ripe and ready for working into the ground, the xylan has been destroyed, and the denitrifying bacteria, being no longer able to find a suitable food, do not denitrify the valuable soil nitrate. It is partly on this account that well-rotted farmyard manure is so highly esteemed. In the decomposition of manure, the albuminoid matter is converted into substances of the nature of urea, and finally into ammonium salts. The process from albuminoids to ammonia is known as ammonisation, and can be done by many bacteria; but one of the most active in this work is *Bac. mycoides*. This is also one of the most active of the bacteria capable of decomposing bone.

Once a salt of ammonia is formed a special class of bacteria take up the running, and change the ammonia into nitrite and then nitrate. This is known as nitrification, and although it has been said that nitrification is necessary before the plant can absorb combined nitrogen, this is not the case. The plant exercises its selective action only after the manurial constituents have passed by osmosis from the soil into the tissues. What is required is used, and what is not wanted remains dissolved in the fluids, and no more of that constituent passes into the plant. Since any soluble nitrogenous constituent will pass into the plant, the ultimate nitrification is unnecessary, if the constituents are not fixed by the silicates and humates of the soil. Ammonia salts are fixed, and must be nitrified into the diffusible nitrate.

It is not so very long ago that nitrate of potash was made by fermenting a mixture of soil, wood ashes, and liquid manure in the nitre beds. Now Chili saltpetre—the product of the action of bacteria upon masses of seaweed in the past ages—is the source of most of our nitrate. Nitrate of potash is still obtained by leaching the surface soil of the nitre fields, which are the sites of old encampments and villages, where wood was burned and manure thrown down.

We have seen that nitrate, by the action of the denitrifying bacteria, is reduced to free nitrogen gas. In the course of ages there must necessarily have been a depletion of the world's combined nitrogen were there not a compensating action at work in the fixation of nitrogen by certain algae and higher plants. There is thus a cycle in the alteration of albumen, viz., albumen-ammonia-nitrate-nitrogen-albumen.

The Fixation of Nitrogen.

The interest in the fixation of the nitrogen question is centred around the *Leguminosæ*, whose roots are studded with nodules, within which are bacteria of a particular kind. By some means, at present unknown, these cause the plant to absorb and elaborate gaseous nitrogen. Two of the most recent suggestions are that the bacteria secrete an enzyme, which causes fixation in the leaves, and that the plant absorbs nitrogen to form a compound which is elaborated by the bacteria and returned to the plant. The fixative power is not restricted to the *Leguminosæ*, but is found in other plants. Likewise, bacteria have been isolated that fix nitrogen directly—a thing that has not been proved for the nodule bacteria. It has, however, been placed beyond doubt that in poor soils the genera of the *Leguminosæ* will not grow unless the bacteria peculiar to themselves are present. There are races of the nodule-former for each plant genus; for example, the bacterium in the nodule of the vetch is different from that in the bean, and the lupin bacterium differs from both.

Nitragin and Alinit.

Pure cultures of individual nodule bacteria are sold under the name of "nitragin," for the purpose of scattering over the ground before sowing, say, a crop of peas, or for infecting the seeds previous to sowing. Nitragin is a culture of the bacteria in gelatine which has been liquefied and then solidified, so that the bacteria are diffused throughout the solid gelatine. Experiments with these pure cultures have been contradictory, and it is apparent that they are only useful when a plant is introduced into a field for the first time. In such a case, a bag of soil from an old field, where the plants have been growing, would probably serve equally well.

Under the name of "Alinit," a bacterium has been placed upon the market for the purpose of increasing the cereal crop. Just as in the case of nitragin, field-experiments with this bacterium have been inconclusive and contradictory.

Sewage Filtration.

Very closely allied to the decomposition of manurial organic matter in the heap, or in the soil, is the fermentation of sewage matter by the bacterial processes. The only difference is that the hygienist endeavours to regulate the fermentation, while the farmer leaves it very much to chance. Of the many systems, or devices, for oxidising sewage matter, there does not appear to be one universally applicable, for every sewage requires its own particular treatment. In the sewage-meadow the soil is irrigated with sewage for a certain time, after which it is turned off, and the soil allowed to become aërated. This is generally done by dividing the bed into four parts, and running the sewage into each part for six hours. Thus each quarter gets a rest for 18 hours per diem. In the sewage contact filter the sewage is allowed to flow into the bed containing coarse material until it is full, and, after standing for two hours, the liquid is run off into another bed containing finer material. Here it remains for a similar period, after which it is generally clear enough to be discharged into a river. The operation is repeated every eight hours, there being three fillings in the day of 24 hours. It is but a step to arrange a filter of some coarse loose material coated with bacterial slime, so that aëration and filtration can go on simultaneously. This is the principle of the continuous bacterial filter. But before a filter, either contact or continuous, is "ripe," *i.e.*, before the fragments of clinkers, coal, gravel, &c., become coated with bacterial slime, and the filter becomes capable of doing a maximum amount of work, a time varying from six weeks must elapse. This is a waste; and I see no reason why the "ripening" should not be started and accelerated by means of artificial infection, combined with feeding the bacteria with appropriate salts.

The aërobic filter is sometimes preceded by the anaërobic chamber, in which quantities of the sewage are kept for about 24 hours. The chamber may be air-tight, but this does not appear to be a necessity, for the fermentation is so vigorous that the superincumbent air has little opportunity to get into the mass of the sewage. In these chambers the disintegration of the raw material, and reduction to simpler chemical substances, is very rapid, and (with some kinds of sewage) this preliminary treatment is of the greatest help to the aërobic filters, which rapidly oxidise the reduced (anaërobic) products. The function of the anaërobic treatment is to ammonise, and of the aërobic filter to nitrify;

but, practically, the anaërobic fermentation is only partial, and the aërobic is a very mixed fermentation.

The bacteria of the sewage are by the aërobic treatment not reduced in numbers; they are rather increased, and no diminution of the pathogenic and intestinal bacteria seems to occur. What does happen is that the crude sewage, when properly treated, becomes sufficiently purified to withstand a further putrefactive fermentation; and it can, therefore, be discharged into a large volume of river-water without discomfort to the inhabitants of the neighbourhood.

It must not be forgotten that the anaërobic treatment may be unnecessary, if the sewage is contained for any length of time in the sewers, where it rapidly undergoes a fermentation practically similar to that which goes on in the anaërobic chambers.

The Chemical Laboratory.

Although the chemical laboratory is one of the last places where one would expect to find micro-organisms, yet even there many can be found. Every chemist has probably noticed how soon an aqueous solution of litmus becomes decolourised. This is due to the reducing action of bacteria, especially the gelatine-liquefying kinds. Solutions of organic acids and salts need to be continually filtered from the growth of moulds within the bottles. One of the earliest researches in mycology was that of Pasteur's upon the selective action of an unknown mould upon one of the constituents of ammonium racemate, the dextro-tartrate being utilised, and the laevo-isomer ignored. To obviate the continual filtration of the solutions, the addition of an inert antiseptic, such as chloroform or thymol, is recommended.

The selective action of bacteria, yeasts, &c., can be advantageously employed by the chemist. For example, mannite can be separated from the common sugars by fermenting out the latter with yeast. Certain yeasts can ferment certain synthetic sugars, but are unable to attack the stereochemical isomers of the same. Again, bacteria, *e.g.*, *Bact. Hartlebii*, can be employed to separate the aldoses from the ketoses, while others prefer levulose to dextrose.

The brilliant red colour of *Bact. prodigiosum* is only produced in the presence of traces of magnesium sulphate. One of the most delicate tests for arsenic is made by placing a drop of the suspected fluid, or portion of solid, on a potato culture of *Penicillium brevicaule*, and incubating the culture for 24 hours at 37°, when a marked odour of arseniuretted hydrogen is evolved. Such minute traces (0·00001-

0·00005 grm.) can be detected as give a scarcely-perceptible deposit in Marsh's test.

These are but a few examples of how the action of micro-organisms come within the province of the chemist in the laboratory.

The Products of Pathogenic Bacteria.

Certain pathogenic bacteria modify the albuminoid media in which they are cultivated into substances of a poisonous nature. These are known as toxines, and as each bacterium produces a specific poison, the toxine generally bears a name derived from the bacterium, or of the induced disease, as, for example, mallein (from *Bact. mallei*, the glanders bacterium), diphtheria toxine, &c. Tuberculin is perhaps the toxine most extensively manufactured, and the method employed is generally applicable for the preparation of other toxines.

Tuberculin—Old and New.

Tuberculin is neither more nor less than a concentrated and sterile glycerine-broth culture of the tuberculosis bacterium. The broth generally consists of meat extract, peptone, and common salt, with the addition of 7 per cent. glycerine. On such a sterile broth fragments of an old and pure culture of the bacterium are floated, and the vessels are incubated at 37° C. for several weeks, until a maximum toxine formation is obtained. The culture is then boiled, filtered, and evaporated down to one-fifth. It is thus a solution of the toxine in 35 per cent. glycerine, which acts as a preservative.

This process of manufacture is rather costly, and a step in a forward direction was made about two years ago, when it was announced that the toxine of the tuberculosis bacterium was simply a dilute solution of an alkaline succinate. If such is the case, the toxine which formerly cost pounds could be obtained for as many pence. But nothing more has apparently been done with the discovery, and it therefore lacks confirmation.

There is another and newer form of the toxine on the market, with the designation *Tuberculin, T.R.* While the old tuberculin consists of the excreted products of the bacteria soluble in glycerine, the new contains only the substances within the bacteria. The method employed in extracting the endocellular toxines from the tubercle bacterium may be taken as a general process, and is approximately as follows:—A well-dried culture is broken in a mortar, and placed upon one of two very closely set steel rollers, which are made to revolve. The bacteria adhere to the rollers, and are thus subjected to a crushing process for some time. The powder, consisting of crushed and entire cells, is brushed or scraped off the rollers, and kept until a sufficient quantity has been obtained. The crushing is done inside a closely fitting glass case, in the sides of which are fixed rubber sleeves and gloves for the manipulator, who by their aid is enabled to remove the powder, and attach a culture, without opening the case, excepting at the beginning and end of the process. When enough has been prepared, the powder is mixed with water, and centrifuged until there is obtained a clear supernatant liquid above a slimy deposit. This liquid is akin to the old tuberculin. The slimy deposit is dried, ground as before, and centrifuged. The clear supernatant liquid of this centrifuging is the first portion of *Tuberculin T.R.*, and contains only the endocellular products. The process is repeated with the deposit, and the clear fluid is added to the first portion of *T.R.* When the deposit contains nothing but a *débris* of cotton-wool, &c., the operation is finished, and all the centrifuged fluids are mixed together, and, with the addition of 20 per cent. glycerine, form the pure toxine. An immunising property has been claimed for this preparation, but it does not appear to have been corroborated, and it has been denied.

Vaccines, Prophylactics, and Protective Sera.

Anthrax vaccine is simply a culture of anthrax bacteria. Two vaccines are generally employed, the first consisting of a culture of bacteria which have been weakened in their virulence by heat, the second containing virulent bacteria. The weakened culture is first inoculated, and, when the animal has become partly immune, the virulent culture is injected, to complete the immunising process. Instead of using two vaccines, it seems reasonable to suppose that a single vaccine, which is just on the safe side of virulence, might be employed. A single anthrax vaccine (a secret preparation) is used in Australia, and in the United States a single vaccine has been used for "black-leg" with success.

Plague prophylactic is a broth culture of *Bacterium pestis*, in which the bacteria have been killed by an exposure to 70° C. The prophylactic is preserved by the addition of a half per cent. of carbolic acid. It is, therefore, a suspension of dead bacteria in a solution of bacterial toxine, both of which constituents have immunising properties.

The various protective and antitoxic sera are obtained by injecting first weakened and then virulent bacteria, in gradually increasing doses, into large animals suitable for the purpose, *e.g.*, the horse. In course of time the blood serum of the animal becomes strongly bactericidal and antitoxic, and by frequent bleeding a continual supply of the serum can be obtained. Standardisation of the serum is effected by injecting various doses of the serum into test animals, and following this with a virulent culture of the bacterium, or a lethal dose of the toxine in question. By noting the effect upon the test animals, the amount of serum necessary to immunise against the bacteria or toxine for a certain body-weight is determined.

A Panacea for Bacterial Diseases.

As our knowledge increases the antitoxines and bactericidal sera will doubtless become simplified. Already Emmerich and Löw have prepared an enzyme from *Bact. pyocyaneum*, which destroys most of the species of pathogenic bacteria by dissolving their cell-walls or protecting capsules. By artificially forming a non-diffusible albuminoid compound with the enzyme, they claim to have been able to confer upon animals an immunity lasting several weeks, thus enabling them to withstand infection with different virulent bacteria. An antitoxic action is also claimed for this preparation.

Gamaleia had already shown that certain alkaloids, and especially the ammonia salts of glutamic acid, produce a destruction of the staining power of bacteria. If a solution in which this occurs is precipitated with acetic acid, the precipitate dissolved in ammonia, and added to cultures of pathogenic bacteria, there is obtained a bacteriolysin which dissolves bacteria. We thus see that a simplification of the bactericidal sera is claimed by these investigators, and it seems probable that we shall soon have a panacea for all the bacterial ills to which this flesh is heir.

ON THE DECOMPOSITION OF POTASSIUM CYANIDE SOLUTIONS BY MEANS OF PARTICLES OF GLASS.

By Sydney Radcliff.

In the following experiments, Potassium Cyanide, free from carbonate, and distilled water were used; the glass particles were also cleaned by treatment with acid, ammonia, distilled water. The method of experiment was as under:—

An ordinary gauge glass tube was closed at one end with a piece of calico to form a filter; glass particles were filled in to form a column in the tube exactly 12 inches in height. The volume of the tube having been determined by weighing the amount of mercury required to fill it to the given height, and the specific gravity of the glass used being known, the volume of the void-space in the column of particles was obtained.

Particles of four degrees of fineness were experimented on.

1. The particles passed through a 40 mesh sieve, remained on a 60
2. " " " 60 " " " 80
3. " " " 80 " " " 100
4. " " " 100 " " " 120

In each case 25cc. of solution, containing ·2075gm. KCN were allowed to percolate through the column; this was immediately followed by a water-wash of equal volume. The total volume of solution passing through was measured, and the amount of KCN and KCNO in it determined. The particles were then removed from the tube, digested with dilute HCl, washed, and the amount of K in the filtrate estimated with platinic chloride.

The cyanate formed was estimated by taking 10cc. of the solution, and adding $AgNO_3$, until all the AgCN and AgCNO was precipitated. The washed precipitate was treated with 5cc. normal HNO_3, and the acid remaining titrated with $\frac{N}{10}$ NaOH.

All experiments were made in duplicate. The results are given in the accompanying table:—

Size of particles. Sieve.	Total KCN originally present.	KCN after percolation.	KCN oxidised to KCNO.	KCN retained on particles.	KCN unaccounted for.	KCN to KCNO.	Retained on particles.
	grains.	grains.	grains.	grains.	grains.	per cnt.	per cent.
40-60	·2075	·1880	·0169	·0026	·0019	7·7	1·25
60-80	·2075	·1833	·0193	·0034	·0015	9·3	1·6
80-100	·2075	·1720	·0305	·0039	·0013	14·62	1·87
100-120	·2075	·1710	·0318	·0045	·0002	15·3	2·1

In the two first instances the solutions percolated in under 20 minutes; in the case of No. 4, the time taken was 2 hours; and this variation in the time of percolation would correspondingly affect the results, which are probably low as regards oxidation, in the case of No. 1 at any rate.

As an ordinary tailings heap contains a considerable percentage of particles which would pass through a 100-mesh sieve, and a small amount of very much finer material, the above results afford a partial explanation of the exceedingly rapid consumption which takes place when KCN solutions are run on to a dry ore.

As the cyanate formed during percolation must obtain the necessary O from the air in the void-spaces between the particles, the amount of O present is readily determined; and, assuming the O and N are in the ordinary proportions in the tube, the following results are obtained:—

Wt. of O corresponding to Cyanate formed.	Vol. of O in cc. at NTP.	Vol of total gases in tube.	Vol. of total void in tube.	Degree of Compression
grains.	cc.	cc.	cc.	Atmosphere.
·0039	2·72	9·06	9·97	1·00
·0054	3·76	12·53	9·97	1·25
·0075	5·22	17·36	9·99	1·73
·0078	5·44	18·13	9·99	1·81

THE CHEMISTRY OF THE EUROPEAN, ASIAN, AND NEW ZEALAND SPECIES OF CORIARIA.

By Prof. Easterfield, M.A., Ph.D., and B. C. Aston.

[*Abstract.*]

1. *Coriaria myrtifolia* (Southern Europe) has been shown to contain ellagic, gallic, and tannic acids, a yellow glucoside, together with a highly toxic glucoside coriamyrtin (Reban, 1866).

2. The three New Zealand species of coriaria are considered the most poisonous plants in that Colony. They contain the same acids as the European species, and the same colouring matter, but the toxic principle is a new glucoside tutin, perfectly similar in pharmacological action, but slower in producing the physiological effects.

3. Only one species is recorded from Asia (*C. nepalensis*). This is not known to be poisonous, and the authors have not succeeded in isolating a toxic substance from it.

4. The examination is being extended to the Mexican species, with the object of furnishing material from the chemical standpoint for those engaged in the study of variation.

THE POISON OF THE KARAKA BERRY.

By Prof. Easterfield, M.A., Ph.D., and B. C. Aston.

[*Abstract.*]

The karaka tree (*Corynocarpus lævigata*) is endemic to New Zealand and the surrounding islands; the kernel of the berry is a staple article of Maori food in the North Island. The berry is intensely poisonous in its raw state, but is rendered innocuous by cooking and subsequent soaking in water.

Chemical examination has shown—

1. That the air-dried powdered kernels contain 14 per cent. of a non-poisonous, easily saponifiable oil, together with mannite, mannose, and dextrose.

2. An aqueous extract of the kernel yields prussic acid on distillation, and at the same time loses its bitter taste.

3. After the bitter taste has disappeared, the solution contains a non-nitrogenous, non-toxic compound, easily soluble in ether, and which is not present in the freshly-prepared solution.

4. The freshly-prepared solution contains a nitrogenous, bitter glucoside ($C_{15} H_{24} N_3 O_{15}$ M.P.$\cdot_{122}$), and sparingly soluble in cold water, alcohol, ether, &c., easily soluble in acetone and acetic ether. This glucoside is probably identical with that described by Skey under the name karakin, but as Skey's description appears to have been based upon an examination of impure material, the properties of the two substances do not agree closely.

A second glucoside corynocarpin has been isolated; it is probably a product of the limited hydrolysis of karakin.

NOTE ON EMPLOYMENT OF RAOULT'S METHOD FOR MOLECULAR WEIGHT DETERMINATION IN ELEMENTARY SCIENCE CLASSES.

By Prof. EASTERFIELD, M.A., Ph.D., and JAMES BEE, M.A.

[*Abstract.*]

THE cryoscopic method is one of the most rapid of the many methods for the approximate determination of molecular weight. The necessity for employing delicate thermometers has, however, been generally held as deterrent to the employment of the method amongst elementary students.

It is, however, evident that if, in applying the well-known formula,—

$$D = K \frac{w \times 100}{S \times M}$$

(in which D = observed depression; M = mol. weight sought; W = weight of dissolved solid; S = weight of solvent; K = a constant for the particular solvent), the depression might be measured on a common thermometer if a solvent were taken with a high depression constant and the dissolved substance were of sufficiently low molecular weight. Thus, the molecular weight of water is 18, the constant for phenol 72°, so that 1 per cent. of water depresses the m.p. of phenol nearly 4°, and since degrees on a common thermometer can easily be assessed to fifths, good values can be obtained with the simplest apparatus, viz., common thermometer, brass-wire stirrer, and test tube. It is important in the case of water in phenol that the concentration shall not exceed 1·5 per cent, since at higher concentration molecular association takes place with extraordinary rapidity.

PRESERVATIVES IN FOODS.

By W. Doherty, F.I.C.

Mr. W. Doherty, F.I.C., of the Government Laboratory, Sydney, forwarded a paper strongly adverse to the use of preservatives, which was well summarised in the concluding paragraph:—

"So general has the use of antiseptics become, that we encounter them in almost every article of food. Thus, at breakfast, we may have borax in our coffee, boracic acid in our milk, in our butter, in fish (fresh and otherwise), in sausages, and salicylic acid in jams and preserves. Later on in the day we meet them again in wine, in ale, in aërated waters, in cheese, in pickles, &c., in quantities more or less in accordance with the personal equation of the purveyor. Our supper may consist of salicylated stout, and oysters soaked in a solution of boracic acid. Formaldehyde sulphites, fluorides, &c., may add their quota to the day's menu. The cumulative effect of all this dosing, hour by hour, day by day, continued throughout the year, is quite a different matter from a grain or two of a drug in a bottle of ginger-beer. We may not fear a single ant, but we carefully avoid sleeping on an ant-bed. That's the point."

A discussion followed.

Mr. Blackett, Government Analyst, Victoria, spoke against the use of preservatives,, and more especially of salicylic acid in wine or beer.

Mr. W. F. Ward, the Tasmanian Government Analyst, said that, in his opinion, it might be laid down as a general rule that any chemical which retarded decomposition also retarded digestion, and was, consequently, harmful. The onus of proof that it was not so should be upon those who desired to use such chemical. He especially wished to emphasise one point, which concerned future generations. In the first place, it was a matter of special, if not of general, knowledge, that the women of Australia were, to a large and increasing extent, shirking the duties of maternity, as the birth-rates showed. This being so, and until they could be brought to a more patriotic and less morbidly selfish frame of mind, we must do our best to preserve as many as possible of the lessened number of infants. Far too many of them are fed on condensed milk, to much of which preservatives are added, and while the milk has only been condensed to one-third of its bulk, with the addition of some cane sugar, most extravagant quantities of water are directed to be used, so that for a certain quantity of milk solids the unfortunate infant, bottle-fed (often only owing to the selfishness of the mother), may have to drink seven times more water than in its proper natural food. But this is not the worst. In a book specially devoted to Australian infants, it is directed to dilute condensed milk with no less than 48 times its bulk of water, whereas cows' milk is only to have an equal bulk of water added to it. This seemed a distinctly dangerous piece of advice, which required immediate correction, when it was borne in mind that the milk is condensed to one-third only. The mothers, in these respects, he strongly condemned. Much of it he attributed to laziness. They wilfully lowered the birth-rate, or injured their infants with foods containing unwholesome preservatives, and did their best to ruin their country and their race.

Two members spoke more or less in support of the use of preservatives, but the Section generally agreed with Dr. Greig Smith, who claimed that no one should be dosed against his knowledge and will.

Attention was called later to the "humanised condensed milks" now being made, and to the report of the English committee on the subject, one of the recommendations of which is, "(*e*) that in the case of all dietetic preparations intended for the use of infants or invalids, chemical preservatives of all kinds be prohibited."

NOTES ON THE COMPOSITION OF METEORIC IRON FROM BENDOCK, VICTORIA.

By John C. H. Mingaye, F.I.C., F.C.S., Analyst to the Department of Mines, New South Wales.

In 1899 a small sample, consisting largely of metallic iron much oxidised, also a number of brittle stones, were submitted to a qualitative analysis, and reported to be of meteoric origin.

A letter from Mr. J. A. Skinsleigh, dated 27.12.'00, to the Department, states as follows:—"Found, about seven miles from here (*i.e.*, Bendock, Victoria), in a sluicing claim in heavy boulder-wash." It is said to have weighed about 60 lbs. when first discovered. Various inquiries have been made, with a view of obtaining the balance of the meteorite, but no answer has been obtained; hence it is assumed that the sender has left the district.

The meteorite comes under the class of mixed meteorites, or siderolites, which contain metallic iron, and various silicates, in their composition. The non-metallic portion was separated from the metallic portion, a separate analysis being made of each.

Metallic portion.—This consisted mainly of metallic iron, iron oxide, and nickel. The mass had undergone considerable oxidation, and is thickly coated with rust, portions of the material being readily broken on slight pressure being applied.

Chemical Composition.

Silica, and insoluble matter ...	1·540
Iron	78·288
Nickel	7·814
Cobalt	·526
Copper	Minute trace
Magnesia (MgO)	1·874
Sulphur	·461
Phosphorus...	·184
Oxygen, &c.	9·313
	100·000
Specific Gravity	5·839

Non-Metallic portion.—On treatment with hydrochloric acid, the powder gave off a copious evolution of sulphuretted hydrogen. Decomposed by acids, with separation of gelatinous silica. 96·4 per cent. of the material was found to be soluble in hydrochloric acid. On treating some of the fine powder with distilled water, and filtering, the clear solution gave a reaction for chlorine, iron, lime, and magnesia. Under a 1-inch objective, small grains of a yellowish mineral, inclined to green, and resembling olivine, were observed; also grains of a mineral clear-white in colour, enclosing material of a reddish tinge. Several pieces of mineral of a dark colour, and somewhat resembling troilite, are noticeable.

Chemical Composition.

Moisture at 100° C.	·840
Water over 100° C.	5·350
Silica	29·350
Alumina	2·208
Iron Sulphide	5·816
Iron	17·170
Copper Oxide	·012
Chromium Sesquioxide	Trace
Manganese Monoxide	Trace
Nickel Protoxide	·960
Cobalt Protoxide	Minute trace
Lime	Trace
Magnesia	32·806
Potash	·277
Soda	Trace
Phosphoric Acid	·095
Carbon Dioxide	·080
*Chlorine	·227
Oxygen	4·901
	100·092
Specific Gravity (mean of three determinations)	3·466

* Less Oxygen equivalent to Chlorine 0 :047.

From the above analysis, it will be seen that the non-metallic portion is essentially a silicate of magnesia and iron, with iron sulphide. Some of the olivine has undergone alteration, and is changed into hydrous magensium silicate, as shown by the material containing 6·19 per. cent. of water.

THE OXIDATION OF CHARCOAL TO MELITTIC ACID.

By Professor Easterfield.

SECTION C.

GEOLOGY AND MINERALOGY.

PRESIDENTIAL ADDRESS.

By T. S. HALL, M.A., University, Melbourne.

THE POSSIBILITY OF DETAILED CORRELATION OF AUSTRALIAN FORMATIONS WITH THOSE OF THE NORTHERN HEMISPHERE.

"It is the aim of the Stratigraphical Geologist," says a well-known author (Marr, 1898, p. 1), "to record the events which have occurred during the existence of the earth in the order in which they have taken place." In the case of formations which come into contact, the order of succession can be settled by the Law of Superposition—the underlying strata are the older. But the law is not always applicable, and the identification of strata by their fossil contents becomes necessary, and thus their relationship to other sets of strata is made possible. As a matter of fact, no two series of beds, separated from one another by any reasonable distance, ever do contain exactly identical faunas, but differences, more or less marked, are discernible on careful examination. These differences may be due to several causes, such as slight differences in age, geographical remoteness, or different conditions of deposition as regards depth of the water, the rate of sedimentation, and the numerous other factors which cause differences in the fauna at various places near our shores to-day.

In recent times geographical remoteness is an important factor in bringing about differences in the facies of faunas. As distances increase, specific and generic agreements decrease, and, speaking generally, the wider spread is any form the older is it geologically. The converse, however, is not always true, for many genera or species now restricted to small and isolated areas have a considerable geological antiquity. Highly specialised types, as opposed to highly organised ones, are prone to have but a short geological range, and yet these forms, as, for instance, those terminal twigs of a genealogical tree, which bud forth into spines and bizarre ornament, are just those which are easy to recognise when found as fossils. Limited in geographical distribution and in geological range, they are of considerable value to the geologist in the study of limited areas; but it is the less specialised forms to which we must turn in attempting to correlate strata widely separated in space. It is just here, however, among these generalised forms, that difficulties of determination occur, and these are perhaps greater than at first sight appears, for it by no means follows that, because we are unable to differentiate, for instance, an Australian Tertiary *Limopsis* from *L. aurita* of Europe, or a *Saxicava* from *S. arctica*, that, if we found them recent, and had the whole animal to deal with, we should regard them as identical, or even as so closely allied that they are only separated by trivialities, and are directly sprung from the self-same stock. Yet it is on such superficial likenesses that broad generalisations are apt to be built, on the occurrence in widely-separated localities of forms such as these that doubtful correlations are sometimes vehemently asserted. Doubtless they are, at times, all we have to go upon, but in such a case a suspension of judgment is oftener the wiser course.

The long-continued isolation of Australia has preserved archaic types among its terrestrial inhabitants, and there is no need to specially draw attention to them. Similarly, among the marine forms a few stragglers from ancient times persist, like *Trigonia* among molluscs and *Cestracion* among fishes. Thus there sprang into existence that strange theory that in Australia we were, so to speak, still living in the Jurassic period—a theory which increase in our knowledge has banished from all but a few belated popular works. As a matter of fact, our seas are no richer in "living fossils" than those of other parts of the world. Our *Cestracion* is surpassed by *Chlamydoselache* and *Heptanchus*, and *Trigonia* is matched by *Pholadomya* and *Nautilus*. Our marine fauna is as highly specialised, and, so to speak, as recent, as that of any other region; and had it and our fossils been investigated before those of the Northern Hemisphere, as much attention would have been drawn to northern abnormalities as has been directed to southern ones. "Orthodoxy is my 'doxy,' heterodoxy is the other man's doxy."

UNIVERSAL FLORAS AND FAUNAS.

The theory of universal floras and faunas at various periods in the past has been supported by many, and arrived at on several grounds. Possibly in past times conditions of temperature may have been more uniform over the surface of the globe, and there may have been a closer approach to uniformity in the plants and animals of widely separated localities, but it may be safely said that identity never existed. Here in Australia we are at the Antipodes of all the well-worked formations of the world, and more and more clearly, as detailed work is pushed on, do the differences appear. At first it was customary to ascribe almost all our fossils, from Palæozoic to Tertiary, to European forms; but, with the growth of collections, the distinctions between allied forms are being elucidated.

M'Coy, in 1861 (M'Coy, '61, p. 162), says—"Confining ourselves to the details, now first made known, of the contents of the graptolite beds, we have the astonishing fact of the *specific identity* of the *marine fauna over the whole* world during the most ancient palæozoic period." And, further on, "We can point now for the first time to the marvellous fact of the specific identity of the inhabitants of the seas of the most widely distant points of the northern and southern hemispheres during this second great geological epoch of the zoological history of the earth" [*i.e.*, the Upper Silurian of the Victorian Survey.] In the same essay, in a less sweeping way, he extends this view so as to comprise the more recent periods. In this connection it must be remembered that M'Coy arrived at this conclusion when he was fresh from the study of the Palæozoic fossils of Britain, and possibly, had he waited till more perfect material was obtained, he would not have put forward this idea, which, however, he never relinquished.

De Koninck (de Koninck, '98, p. 2) says M'Coy "has not hesitated to admit *the general specific identity of the marine fauna of the two hemispheres in the early times of the Palæozoic Era.* My own observations enable me to confirm" this. "I may add, as well, that I arrive at the same conclusions, as far as the Devonian and Carboniferous systems are concerned." However, it cannot be said that subsequent work has confirmed this; and Etheridge points out (Etheridge, '91, p. 125)—"No service can be rendered to Australian stratigraphical geology by the definite reference of any of its fossils to European species, unless on the clearest possible evidence." The Clarke collection, on which de Koninck founded his generalisation, was destroyed by fire, so that we have no means of checking his records in detail; but Etheridge has suggested, in the descriptions of many new species, gathered from the same localities as Clarke's fossils, that the supposed identities were frequently mere resemblances, while in the case of the corals the resemblances were quite superficial, and the Australian species were generically, or even ordinarily, distinct. (Etheridge in de Koninck, '98.) Specific identities do undoubtedly occur, especially among the fossils of the older formations, but they are not in overwhelming numbers.

A. C. Seward (Seward, '00, p. 303) says—"The comparison of the English plants with the Upper Gondwana flora of India, and with Australian floras of corresponding geological position, has confirmed me in the opinion that the differences between the Mesozoic vegetation of the Northern and Southern Hemispheres have been greatly exaggerated. Geographical separation of fossil species frequently leads to an unnecessary amount of specific distinction in the naming and determination of plants . . . In Jurassic times there was, no doubt, a much greater uniformity in the vegetation of the world than exists at the present day. A closer analysis of the Gondwana floras and a more detailed comparison with those of the Northern Hemisphere may enable us to recognise well-defined distinguishing features suggestive of botanical provinces, such as existed in the Lower Gondwana period; but this is a matter for subsequent treatment."

The belief of Baron von Ettingshausen in a universal Tertiary flora is well known (von Ettingshausen, '83), and he derived much support of his view from his investigations of the Tertiary fossil plants of Australia. It must, however, now be generally conceded that Mr. Henry Deane (Deane, '96, '97, '00, '01) has shown that the whole idea is a mistaken one, and rests on the comparison of our fossils with European recent forms, instead of with those now actually growing in Australia. Our Tertiary flora, in fact, proves to have been as typically Australian as anything we have at the present day.

There remains yet another asserted case of a cosmopolitan fauna which we may consider, and this is the one suggested by Murray and advocated by Pfeffer, in order to explain Bipolarity in the Distribution of Animals.

The Bipolar Theory.

It is stated that there are large numbers of animals of various groups present in the seas of high northern and southern latitudes which are absent in the intervening tropical regions, and this is explained by the supposition of a universal early Tertiary fauna. But opinions differ both as to the existence of the similarity and as to its explanation. In a recent summary of the evidence in favour of the theory, Miss E. M. Pratt (Pratt, '01) says that Pfeffer, Murray, Selenka, De Guerne, Fischer, Shipley, Théel, Ehlers, I. C. Thompson, and herself, who have all worked on material from the far South, are believers in the resemblances. On the other side, we have D'Arcy Thompson, Herdman, Ludwig, Chun, and Ortmann, who also speak from personal knowledge, and are just as strong in their disbelief of the similarity of the two faunas.

The evidence marshalled by the supporters of the idea as to the present distribution of the fauna is explicit, and must be weighed and valued by experts in the various groups; but there seems to be no doubt that there are certain animals—either species or genera, or even higher groups—which are present in both Arctic and Antarctic seas, and appear to be absent from the intervening ones. Even if there be no specific agreement in the case, still the resemblances in some cases are undoubted. But even if we take the statements as to the great similarity of the two polar faunas as correct, we have yet to consider the theory which would explain the asserted facts.

Sir John Murray (Murray, '95) gives a laborious summary of the question. Taking the Kerguelen region as typical, he finds about 530 animals are known. Of these 45 occur in the North Atlantic, 11 in the North Pacific, but only 18 in the tropical Atlantic, and 22 in the tropical Pacific. He concludes that it may "be assumed that the identical species now found living towards both poles, or their immediate ancestors, had a world-wide distribution, which involves a nearly uniform temperature throughout the whole body of ocean waters."

Perhaps the most trenchant article against the theory is that of D'Arcy Thompson (Thompson, '00), in which he discusses Murray's list in detail, and sums up by saying (*l.c.*, p. 313)—"Many, if not most [of these] , are dubious, even in the eyes of their first recorders—many others have too few characters for precise recognition." He also insists, with justice, as we shall see in the sequel, that we must "discriminate between those whose affinities appertain to the fauna of the North Pacific and of the North Atlantic respectively. For the fauna of the North Pacific presents many unknown problems for us; but this we do know, that it contains in part a northern circumpolar fauna, and in part a fauna very distinct from that of the North Atlantic, and peculiarly linked to the fauna of the Southern Ocean."

Some of the forms he instances, "from a circumpolar habitat in the Antarctic, seem to creep up to varying distances along the Western American coasts to the Galapagos, to California, and even to the northern islands of Japan." Thompson would then have us believe, with Ortman ([1]) (Ortmann, '01. I am unable to refer to this paper, and quote from Miss Pratt's rendering of it) that what agreement there is is, in the main, due to migration along the western shores of America, from south to north, where cold currents lower the temperature of the tropical seas. The explanation which at present concerns us is that given by Murray, and stated more strongly by (Pfeffer, '01, p. 311), and that is the theory of a uniform early Tertiary fauna. "We must," says Pfeffer, "accordingly expect to find in the oldest and earlier middle Tertiary a large number of species identically occurring in the Northern and Southern Hemispheres, for instance, in our own region, and in South [*sic*] Australia. If we simply compare the lists which have been drawn up, this certainly does not seem to have been the case; but if we take account also of the remarks made by the authors, we find that there is a large number of species closely allied to, and difficult to distinguish from those in the Antipodes of a similar age. When, further, we recall that the palæontologists of different countries have very often named their species with little or no reference to the works of their colleagues, we have to admit that circumpolarity of the earlier Tertiary faunas was so marked that it extended not only to the greater majority of genera, but in a great many cases (whose number future studies will probably increase), even to species. And thus it is certain that the early Tertiary fauna had an approximately similar uniform expression or representation throughout the whole region of its development." Further on he says—"The faunas of higher latitudes represent coeval relics of the almost uniformly developed and almost uniformly distributed early Tertiary faunas, as they have been evolved under the influence of the cooling of the climate by a process of separating out and selecting. The similarity of the operating causes secured that the same components of the old fauna remained behind in both north and south, and thus has arisen the great and well-marked similarity of the two faunas."

This is an extremely clever case of special pleading, and is, in my opinion, absolutely without justification. The fauna of our older Tertiaries has been investigated chiefly by men familiar with that of Europe, and in some cases, anxious, apparently, to identify it with that of European horizons. How, then, does it come about that to this day we are unable to state absolutely the age of our beds in European terms? The answer is plain. There was no uniform Tertiary fauna. There are resemblances in our recent fauna to that of the Northern Hemisphere, but there was no greater approach to uniformity in the early Tertiary times than exists at present. Then, as now, it was essentially Australian in facies, and it is to Australian seas that we must look for affinities more than to the Tertiaries of the Northern Hemisphere. In saying this I would not blink the fact that there are genera, now extinct, which are represented in the Tertiaries of both hemispheres, but the general facies of our early fauna is Australian, and in no way supports the idea of a uniform Tertiary fauna, or anything approaching it, and the exponents of the Bipolar theory must look elsewhere for an explanation.

In considering the probability of the existence of universal floras and faunas, it is necessary to define exactly what is meant by the terms. A few cosmopolitan genera, and even species, exist at the present day, but no one on the strength of, say, the distribution of the genus *Natica*, or of *Lasæa rubra*, in recent seas, would for a moment think of suggesting a uniform recent fauna; and so it would appear to have been in the past. A few genera and species, with a long range in time, or with special means of dispersal, or want of plasticity, are widely spread, but side by side with these are many peculiar forms, characteristic of the region, and which do not pass beyond it.

Naturally, the first forms to be examined and recorded in a new country are the familiar ones, and the lists prepared in this way are apt to be misleading; the resemblances are accentuated; the differences are barely noticed. In dealing with a collection of not too well preserved fossils, how easy it is to succumb to temptation, and identify, more or less definitely, some forms on their resemblances to already described fossils, and to lump all the rest as unrecognisable. Let the palæontologist who is without sin among you cast the first stone.

Correlation of Periods.

Huxley, in his presentation of the doctrine of homotaxis, suggested the possibility that a Silurian fauna in North America might be contemporaneous with a Devonian one in Britain; but probably he did not seriously believe in the possibility himself, and only suggested it in order to make the idea the more striking.

The general question of homotaxis was dealt with at our last meeting by the late Professor Tate in his President's address; and the trend of modern thought is in the direction in which his conclusions led him. Geological periods are so vast that dispersal, at any rate in the case of marine forms, has time to act, and keep the broad facies uniform throughout the world (see Marr, '98, p. 49), and marine genera characteristic of one period in the Northern Hemisphere, if occurring in the Southern, may be, as a rule, taken as characteristic of the same period.

Dr. R. L. Jack (Jack and Etheridge, '92, p. 2) says—"In dealing with the animal remains . . . . we trace a parallelism between the formations of Australia and Europe . . . . the *order* of succession of the Queensland formations bears a general and striking resemblance to that of the European."

Mr. R. Etheridge, jun. (Etheridge, '91, p. 134), in speaking of the strong presumptive evidence for considering *Lepidodendron australe* to be of Carboniferous age, is careful to use the words "supposing, that is, we are to adopt, or to endeavour to adopt, a European classification for our Upper Palæozoic rocks." Elsewhere (Etheridge, '91, p. 4) he says—"At the same time, great caution must be exercised in assimilating our geological subdivisions strictly with those of the Old World."

There is, however, no need to multiply quotations on this head. As far as our present knowledge goes, the general aspect of the faunas of the formations, to which we in Australia are accustomed to attach such names as Silurian or Cretaceous, is that of their European prototypes.

When, however, we come to deal with fossil plants we are at once confronted with the difficulties presented by the *Glossopteris* flora; though *Glossopteris* itself appears to be unknown in Europe,* yet many of its Australian associates are found there, and occur in Mesozoic strata. In Australia this flora is Palæozoic, and is associated with a marine fauna which has partly a Carboniferous aspect and partly a Permian one. (Jack and Etheridge, '92, p. 70.) The refusal of some of our Australian geologists to bow to the plain stratigraphical facts, and the influence that this refusal had on geologists elsewhere, had a disastrous retarding effect on the progress of geology in Australia. It is all ancient history now, and the truth has in the end prevailed, as it ever will.

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* It has recently been recorded from Russia.

It is beside our present purpose to deal at length with this well-worn theme, and the result may be well expressed in the words of Seward (Seward, '97, p. 194)—" From some cause, then, it would appear that the Palæozoic vegetation, which in Lower Carboniferous times had a more or less world-wide distribution, was replaced in the south by a new set of plants, while in the Northern Hemisphere the older forms continued to flourish till the end of the Permian epoch, and were then superseded by a flora of a newer facies."

One effect of the *Glossopteris* controversy has been to shake, perhaps unduly, our confidence in the evidence of plants, and of terrestrial forms generally, as indices of age; and we are told that the marine fauna is the only reliable test that we have, that the terrestrial fauna and flora which originated in Gondwana Land could not migrate north on account of a marine barrier, and when this marine barrier was bridged then an incursion northwards took place. Is there no possibility, it may be asked, of a land barrier delaying the spread of marine forms in a similar way?

It has long been customary to refer to our Australian formations by the names used by European geologists, and, broadly speaking, we are, no doubt, justified in such a course; and yet difficulties at times arise from the apparent mingling of the faunas of two distinct periods. The usual solution of the difficulty is to accept the idea that some of our beds are consequently intermediate in age; that they represent the lapse of time indicated by the unconformities which so definitely delimit the periods in the Northern Hemisphere; and thus have arisen the terms Cretaceo-Eocene, Permo-Carboniferous, Siluro-Devonian, and Cambro-Silurian. These terms are used to designate strata that, like Janus, are two-faced. The fact that they are intermediate by no means follows from the premises, for we must bear in mind the possibility of a somewhat different range in the Antipodes of certain forms of life. This transgression of genera has been proved in the case of some of the Lower Ordovician graptolites of Victoria, where those of Lancefield show a mingling of Cambrian and Ordovician forms.

In his presidential address to this Association, in 1893, Professor Tate said, in speaking of Australia (Tate, '94, p. 34)—" The limits of the Silurian and Devonian, and of the Devonian and Carboniferous, seem so ill-defined that it is questionable if the middle term exists, as viewed from a European or North American standpoint. Then we have the palæontological overlap of the Palæozoic and Mesozoic in the Newcastle coal series, and probably something analogous between Mesozoic and Cainozoic."

It would be easy to quote other authors to show that it is possible to bring our larger groups of strata approximately into line with those of Europe, while at the same time inconsistencies occur which are apt to cause perplexity.

The Correlation of Minor Subdivisions.

When we come to the consideration of the possibility of comparing the minor subdivisions of the great periods, these difficulties increase in direct ratio as our classification becomes more detailed.

M'Coy, true to his belief in universal faunas in the older epochs, recognised in Victoria representatives of the British Llandeilo, Bala, Wenlock, May Hill, Upper Ludlow, Keuper and Bunter, as well as others. But it must be borne in mind that the correlation was founded, in some instances at least, on the occurrence of a single imperfect plant, the very nature of which has subsequently been called into question, and in other cases on some two or three marine fossils.

Other authors, with larger collections at their disposal, have been more cautious, as, for instance, Mr. R. Etheridge, jun., who is content to refer the Bowning beds doubtfully to Wenlock age.

The inadvisability of using European names for our geological formations has been treated at some length by Mr. Pritchard (Pritchard, '00), and with his conclusions I am in complete accord.

The difficulty of correlation, as we have seen, is caused chiefly by the want of concordance in range of certain fossils, or, to use a term, without any intention of implying moral obliquity—the Transgression of Fossils.

Transgression of Fossils.

Difficulties of classification of strata due to this cause are by no means confined to Australia, and a few instances may be noticed.

Oldham (Oldham, '93, p. 191) says—"The obvious method of determining the age of the rock-groups of Gondwana by direct comparison of the fossils they contain with those of Europe leads to very unsatisfactory and inconclusive results." On the following page he gives, on Feistmantel's authority, the alliances shown by the plants. In the Rajmahál series, for instance, the European representatives range from Permian to Oolitic, while the series is regarded as Liassic. The other series show the same inconsistencies in the flora, which is, however, as we know, not a very safe guide. The fauna is but little more satisfactory. The Damuda series (Permian and Permo-Carboniferous) contains reptiles with Permian and Jurassic affinities, while the fauna of the Khota Maléri (Lower Oolitic) has alliances with European Upper Trias, Lias, and Jura. Further on (*id.*, p. 284) he says—"The great distinction between Palæozoic and Mesozoic rocks of Europe does not hold good in India . . . . the interval between Mesozoic and Cainozoic is similarly bridged." He further insists (*id.*, p. 300) that caution is necessary in applying palæontological results derived from a single order of animals, and prefers to follow views based on stratigraphy and general palæontology.

One very abnormal range is noted, and that is the occurrence of the genus Bellerophon in the Ceratite beds (Trias) of the Salt Range (*id.*, p. 129).

Noetling (Noetling, '99) shows a considerable agreement between the Miocene of Burma and the Eocene of Europe, which he explains by the theory of migration from west to east, which commenced in Eocene times, and probably continued up till the recent period.

Professor J. W. Gregory (Gregory, '00, p. 3), in speaking of the Jurassic corals of Cutch, says that the 66 species from the Putcham beds have English representatives in beds ranging from Upper Cretaceous to the Trias, and remarks—"This apparent 'confusion of species,' belonging to different horizons, is usually observed when distant coral faunas are compared. D'Achiardi, for example, has noticed the similarly inconsistent evidence of the corals of Mentone and of other localities in South-eastern and Central France. D'Achiardi found occurring together on the same horizon at Mentone corals which in adjoining provinces are regarded as characteristic of Bathonian and Corallian age. It is therefore not surprising that the specific comparison of distant faunas yields unsatisfactory results. The faunas as a whole serve as more reliable grounds for comparison. But even then the evidence of the coral fauna in the present case is not very definite. The corals . . . . were deposited in different zoological provinces, and corals then lived in Indian seas which were not found in Europe till later; similarly, some European families . . . . appear to have entered the Indian region . . . . during the subsequent period."

The Brachiopoda of Cutch tell a similar tale, according to the reviewer in *Nature* of Mr. P. L. Kitchin's work

(Kitchin, '00). The reviewer says—"A superficial glance at the plates would lead one to suppose that many British species of the Inferior Oolite and Great Oolite Brachiopoda were represented . . . . but, although there are forms which appear to show affinity with British species belonging to different Jurassic divisions, yet such forms occur together in Cutch strata, and correlation becomes impossible when forms of one horizon suggest Bajocian, Bathonian, and Callovian ages."

There do not appear to be many instances of definite statements of the same character by Australian Palæontologists, and I must confine myself to the few records I have been able to find.

Dr. R. L. Jack (Jack and Etheridge, '92, p. 406) speaks with no uncertain voice. He says—"It is remarkable that almost every Palæontologist who has worked hitherto on Queensland material has come to the conclusion that fossils from different horizons have been mixed up, and this explanation has appeared specially necessary in the case of the fossils from the Rolling Downs [Lower Cretaceous]. On the other hand, my own explorations have satisfied me that Queensland fossils are not more liable to this kind of accident than those of other countries; that the mixing-up, which has caused so much annoyance to Palæontologists, has been perpetrated by Nature herself . . . . the Rolling Downs formation contains a marine (and occasionally freshwater) fauna, representing the migration of many species which in Europe date from the Rhætic to Cretaceous."

In the New South Wales Permo-Carboniferous de Koninck recorded a species of *Palæaster* (*P. clarkei*), a Silurian and Carboniferous genus. But Etheridge (Etheridge, '92, p. 70) instituted a new sub-genus, *Monaster*, for its reception; and Gregory (Gregory, '99, p. 345) raised it to generic rank, and elsewhere (Gregory, '00, p. 250) referred the genus only doubtfully to the Palæsterinæ, which range from Cambrian to Devonian *Poteriocrinus* also occurs in the same beds, being elsewhere not more recent than Carboniferous, and Phialocrinus has a similar range.

Evidence of transgression in the case of graptolites is somewhat stronger, and is more clearly seen, as the collecting in a part of our Lower Ordovician has been done zonally. I have elsewhere shown (Hall, '99, i., p. 175) that on the same slabs of rock at Lancefield we find *Bryograptus* and *Clonograptus tenellus*, which in Europe are exclusively Cambrian, associated with *Didymograptus*, *Tetragraptus*, *Clonograptus flexilis*, *C. rigidus*, *Phyllograptus*, and two species of *Dictyonema* which are just as typically Lower Ordovician in Europe. In America *Clonograptus flexilis* is associated with such forms as occur at Bendigo, the next horizon above the Lancefield beds, which do not contain them, while *C. rigidus* is found with *Loganograptus logani*. Now, in Australia the last-named does not put in an appearance till the rich fauna of Bendigo and a great part of that of the Castlemaine series, which is younger than the Bendigo series, has disappeared entirely. Another example may be quoted. The group characterised by *Didymograptus bifidus*, the "tuning-fork graptolites," as they are sometimes called, is in Europe and America characteristic of Upper Arenig, when the complexly branched forms, and the peculiar *Phyllograptus*, have already died out. With us their horizon is lower and their range very short. *Phyllograptus*, *Clonograptus*, and *Dichograptus* long survive them, while *Loganograptus logani* only put in an appearance when they, in their turn, have almost passed away. Graptolites are not always easy of recognition, but these forms all belong to readily-recognisable groups; the specific determinations, it is possible, may be incorrect, but the generic cannot be confounded.

The Basis of the Classification of the Australian Tertiaries.

When we come to the Tertiaries, the evidences of transgression are very well marked, and, owing mainly to this, the determination of their age is a task of great difficulty. It is generally admitted that, measured in years, the Tertiary periods are much shorter than those of the Palæozoic and Mesozoic eras; thus, it follows that the attempt to correlate them with those at the Antipodes is more on a level with an attempt to correlate, say, Wenlock or Bajocian throughout the world. It is easy enough to recognize Tertiary strata anywhere, and to correlate them with others as Tertiary, but we do not yet know whether we can assert the presence of Eocene, Miocene, or Pliocene here in Australia. It is not enough to say that certain beds are Eocene here because their fauna has reached what may be termed the same stage of development that the Eocene fauna of Europe has done. Our aim must be more definite than this, though perhaps, we shall never reach the mark. Homotaxy is not the end; contemporaneity is. The solution of many questions of phylogeny, the place of origin of certain types, and consequently the place where we must look for their ancestors, are problems the answers to which will depend, in many cases, on the accuracy with which we can assert that certain beds are, not merely homotaxially, but actually older than certain others separated from them, it may be by half the circumference of the globe.

We are yet far from this ultimate goal, and even the homotaxy of our beds cannot be said to be settled beyond dispute.

Many attempts have been made to fit the Tertiaries of Southern Australia into the British Procrustean subdivisions, and I do not know that the results are any more satisfactory to the strata than they were to the guests of Procrustes himself.

Two distinct methods of arriving at a result have been employed, though one of them is somewhat disguised by modifications. The one is by direct comparison with European strata, and the other is by the application of Lyell's method—the determination of the percentage of recent mollusca in the series.

M'Coy (M'Coy, '61, p. 168) decided by the presence of a few species in our lowest Tertiaries, which had close allies in European strata, that the Victorian beds were partly Miocene and partly Oligocene.

Harris (Harris, '97, p. VIII.) would use phylogeny, "which, rightly understood, . . . is a broader and surer basis for classification of the various horizons, and might be made to run *pari passu* with the Lyellian method." This plan is, of course, merely the comparative method in a somewhat sublimated form.

Some authors advocate the employment of the comparative method as applied to mollusca alone, or in great part; others would attach more importance to such wide-ranging forms as sharks and whales; while others, again, have regard to the fauna as a whole. Some would fix their attention on the striking transgressing forms, and so plead for a younger or an older age, as the case might be, than the fauna, as a whole, would indicate; while others, finally, would ransack the Tertiary fauna of the Northern Hemisphere for close resemblances, and then correlate our beds with those which show the greatest number.

It will, I think, be readily admitted that the method of comparison in all its forms has dangers of its own, and these, grave ones. Do we know, for instance, in which direction migration took place—was it in any particular instance from north to south, or *vice versâ?* Do close resemblances necessarily imply very close phylogenetic relationship, and if they do, were the kindred even approximately coeval? In the case of genera with varying and almost characterless species, such as *natica* and *turritella*, how much reliance can be placed on the supposed identity of their fossil remains from widely separated localities? In considering the supposed widely-ranging forms, such as sharks and whales, can we attach much weight to identifications based on isolated teeth? Or, again, is the geological column so perfect in Europe that our strata must of necessity fit into it somewhere? If we regard most or all of these questions as settled, and it is doubtful if any of them are, then the conclusions based upon them do not always point in the same direction when we come to apply them to the determination of the age of the Australian Tertiaries.

The Lyellian method of determining the age of Tertiary strata may be simply stated. Find the percentage of recent mollusca in the beds. The application of this principle to Australian strata in anything like an exhaustive manner is due to Professor Ralph Tate. To a certain extent he used the comparative method as well, and, in fact, in his later writings this tendency, especially under the influence of Cossmann, became somewhat more pronounced. Still, it it was to the Lyellian principle that he always attached most weight. Since it is to Tate, above all others, that we owe our knowledge of the fauna of the marine Tertiaries of Southern Australia, it is but natural that his opinion should have been generally accepted by recent workers in the field, and his influence in this respect was more potent, since the question most in evidence was not the comparison of our beds with those elsewhere, but their connection one with another. Recently, Mr. Pritchard and myself have tried to divorce the wider question from the local one by the employment of local names for the formations (Hall and Pritchard, '02.). Against the Lyellian method, the most constantly urged objection is that the personal equation enters so largely into the question of the determination of species that the results deduced are quite unreliable. Undoubtedly there is a great deal of truth in this, and short as is the history of our detailed work among these beds, it is not without instances of very plainly-put differences of opinion on certain specific identities. But are we then of necessity to adopt the comparative method? There is certainly something very soothing about the term "comparative method," but in the present case is it really more scientific than the Lyellian, and may not the self-same charge—neglect to estimate the personal equation—be as justly levelled against the one as the other? Is the Lyellian not comparative, and is it not as easy, or as difficult, to decide what forms in the Northern Hemisphere show the closest affinity with ours, as it is to decide whether the latter are living species or not?

It is not easy to decide what is the most satisfactory basis to adopt for the determination of the age of our Tertiary strata, for the faults of what appear to be the only two available ones "must give us pause."

The Fauna of the Oldest Australian Tertiary.

Some of the difficulties may be indicated by a hasty glance at the fauna, which is extremely rich, but as yet very far from being completely worked out. About fourteen years ago Professor Tate summarised his knowledge of the constituents of the Older Tertiary Fauna of Australia (Tate, '88). Under the name "Older Tertiary" it may be mentioned that he included those beds which he called Eocene and Miocene. Altogether 1519 species of all classes are noted, 941 being mollusca. His comparisons are made with the Older Tertiary, as he consistently called it, as a whole, and reference may be made to his masterly paper for his results, which, it must be remembered, are founded on his own knowledge of the fauna in a practically undescribed condition.

At present our so-called "Eocene" has yielded about 1500 described species, some 600 of them being mollusca, and a slightly smaller number being polyzoa. The corals, echinoids, and brachiopods comprise about 52, 35, and 40 species respectively. So that, to have any weight, comparisons must be very numerous indeed.

The only two authors who have made any large number of comparisons of our earliest Tertiary fossils with forms occurring elsewhere are M'Coy and Tate, and I think it is probable that in making the comparisons, they did not wish to be understood as affirming that these were always made with forms showing the closest resemblances. Small reference collections, comparatively poor libraries, and distance from fellow-workers are reasonable excuses for any imperfections in this respect in work which it is far better should be done on the spot, and which all agree has been well done by these two pioneers in Australian palæontology.

M'Coy (M'Coy, '74, *et seq.*) figured and described 53 species from the oldest series and compared 21 mollusca with species occurring elsewhere, with the following results:—

10	showed	affinities	with	Recent	species.
2	,,	,,	,,	Pliocene	,,
5	,,	,,	,,	Miocene	,,
1	,,	,,	,,	Oligocene	,,
3	,,	,,	,,	Eocene	,,

He made four comparisons in the case of other classes, two sharks, a whale, and an echinoid. The three first resembled Miocene species, and the last a Recent one. This is practically all the evidence M'Coy published in support of his opinion that the beds were in part Miocene and in part Oligocene.

Tate, in his long series of papers, makes his comparisons of mollusca with species ranging from Lias to Recent, and by far the greater number are with either Recent or with Eocene species, and it is certainly startling to find that his comparisons with Recent forms are twice as numerous as those with Eocene ones.

Transgressions of our Oldest Tertiary Fossils.

Before it can be stated what forms are to be regarded as transgressing, some decision must be come to as regards the age of the beds containing them, and as in most of the recent work the age of our Oldest Marine Tertiary beds has been spoken of as Eocene, we shall take that as our standard of comparison, and note some divergences from that standard.

Porifera.—The occurrence of *Plectroninia* is an extension back into the Eocene of the Lithonine sponges, hitherto uniquely represented by the recent Japanese *Petrostroma* (Hinde, '00). Possibly some of the associated forms, Dr. Hinde thinks, may be really Pharetrones, and if so, we have an extension forward of a group hitherto generally regarded as Mesozoic, though Professor Dendy has described what he regards as a recent member in the existing Victorian fauna (Dendy, '94).

Hydrocorallinæ.—*Deontopora* is only doubtfully separable from *Stylaster*, a recent genus elsewhere. *Deontopora* is widely spread in our "Eocene" and "Miocene" deposits.

Zoantharia.—Mr. Dennant tells me that, as far as his observations go, it is to Miocene rather than to older species that he has to look for affinities with our Eocene corals. There appear to be no striking anomalies of range.

Echinoidea.—Tate tabulated the range of 28 genera of urchins occurring in our Eocene, and 5 other genera have been recorded since. Two genera, only, show evidence of transgression, namely, *Holaster* and *Cardiaster*. Gregory (Gregory, '90, p. 491) in speaking of the collection examined by him says that *Cassidulus*, *Cardiaster*, *Holaster*, and *Micraster* are characteristically Cretaceous, while *Coelopleurus* and *Echinolampus* are as strikingly Eocene, and further, the absence of typical Upper Eocene genera is very noticeable. "The real correlation of the beds will depend more on the Mollusca than on the Echinoidea; the latter are so anomalous a collection that little faith can be attached to their evidence on the subject . . . [The fauna] seems to be composed of two constituents; about a third are species of the ordinary Palaearctic Upper Cretaceous genera; these seem to have migrated southwards, and become mingled on their journey with a fauna that agrees most closely with that of the Eocenes of India and Malaysia." The conclusion is arrived at that the beds are Eocene, and, perhaps Oligocene. However, it may be remarked that the so-called *Holaster* is not a *Holaster* at all, as it has a very distinct subanal fasciole, and has, on other grounds, been made the type of a new genus (*Duncaniaster*) by Lambert (Lambert, '96, p. 317, footnote). Its evidence of Cretaceous affinities is then valueless. In other beds which the molluscan evidence shows to differ but little in age from the those yielding the fauna examined by Gregory, we have *Clypeaster* and *Monostychia*, which are usually regarded as showing Post-eocene affinities.

Remains of Asteroidea, Ophiuroidea, Holothuroidea, and Crinoidea occur, but their fragmentary nature does not allow any conclusions of value to be drawn. The same may be said of Crustacea, a few plates of Cirrepedia, and some Decapod chelæ are known.

Polyzoa.—The polyzoa are an anomalous collection, but though many have been described and recorded, the details of distribution are very incomplete. There is a large number of recent species, and at the same time survivals occur. The typically southern family, Catenicellidæ, is well represented, perhaps as well as in recent seas. With these we find the Cretaceous *Tecticavea*, apparently the European *T. boletiformis*, which is widely distributed in the limestones. Other genera not less Mesozoic in aspect are also found, but the difficult group to which they belong—the Cyclostomata—has not yet been satisfactorily dealt with.

Brachiopoda.—Tate (Tate, '80, p. 143) says "the facies of our Tertiary Palliobranch fauna is, so far as regards genera, most decidedly modern, but the specific points of contact are few . . . [Six species are quoted as near allies to living species, though none are living]. A general resemblance seems to subsist between our Tertiary species and those of the European Miocene. . . . . the resemblance is mimetic rather than actual . . . . if we select *Terebratula subcarnea* and the *Terebratulinas* (excepting *T. scoulari*) we might equally well claim for our Australian Tertiary Palliobranch fauna a Cretaceous facies." However, the revision of the genera and great groups of the Brachiopoda by Hall and Clark has led to such radical changes in our conceptions that, till our fossils have been re-examined in the light of their researches, any detailed discussion of the range of our Older Tertiary genera elsewhere would be of but little real value.

Mollusca.—Pilsbry clearly points out the position when he says (Pilsbry, '00, p. 499) in speaking of fossil Gastropoda:—"The Eocene faunas of Europe, North America, Asia, and Northern Africa share a great many species in common, and have numerous others which are vicarious. A very different aspect is presented by the Eocene fauna of Australia, New Zealand, and South America, where we find the evident forerunners of forms now inhabiting the southern portion of the Atlantic and Pacific Oceans."

Tate (Tate, '88, p. 243) says—"Viewed as a whole, the Old Tertiary [*i.e.*, 'Eocene' and 'Miocene'] fauna is closely related generically to that existing in the same area." Some typical genera are absent, while others are as well represented in the fossil as in the recent condition. Some again have a more tropical aspect. In some cases the genera, though living elsewhere, appear to be extinct in the Australian region. Of the extinct forms, some, as might be expected, show relations to the fauna of the Northern Hemisphere, while others are peculiar to the Southern." Genera illustrative of these points are given by Tate, and there is no necessity to quote them. Hedley records the following as common to the Eocene and Recent, *Arcoperna*, *Sarepta*, *Kuphus*, and *Chileutomia*, and Tate has made a few additions to his early list, such as *Philobrya* and others. These forms emphasise the Australian facies in early Tertiary times.

Amongst Vertebrata the identifications rest mainly on the recognition of detached teeth, but there is one marked exception—*Wynyardia bassiana*, Spencer, from the marine beds of Table Cape. These beds were latterly held by Tate to be Oligocene, whereas Mr. Pritchard and myself believe them to be older than the Lower Muddy Creek series, which Tate considered Eocene. *Wynyardia* is a marsupial of generalised form, neither distinctly polyprotodont nor diprotodont. Muddy Creek has yielded a ramus of the lower jaw of a toothless whale. This was obtained by Mr. G. Sweet from the polyzoal rock which forms the base of the lower series usually spoken of as Eocene. The Mystacocete whales are not definitely known in the Northern Hemisphere till Pliocene times. But Lydekker (Lydekker, '93) records a European genus, *Cetotherium*, one of the Balaenidae, from the Chubut deposits of Patagonia, and speaks of the beds as not later than Miocene, while they may possibly be Upper Eocene. This would appear to point to a southern origin for at anyrate some of the Cetacea. In the same paper Lydekker propounds a new genus, *Prosqualodon*, having teeth like *Squalodon*, but differing in number, and showing other peculiar characters in the skull. There is no reason why *Squalodon wilkinsoni*, M'Coy, from our "Eocene" should not be referred to this southern and older genus, for only a couple of detached teeth seem to be known. The other whale records are more satisfactory.

A few generic and even specific identifications of sharks have been made, notably *Carcharodon angustidens* and *C. megalodon*, which occur, though rarely, in the Eocene of the Northern Hemisphere, but are characteristically Miocene.

The above hasty survey of our Lowest Tertiary fauna shows, as many authors have pointed out, some strange abnomalities. Some forms have a distinctly Mesozoic aspect, it may be Cretaceous, or even Jurassic, others are distinctly Eocene, others again point to a Miocene or Pliocene age, while running through all is a strong dash of southern blood.

Southern Origin of certain Forms.

It has already been pointed out that the survivals in our Recent fauna exercised a powerful influence on the opinions of the older zoologists, and it became almost an article of faith that everything here had a false appearance of antiquity. Gradually however it has been shown that many forms of life, both of plants and animals, had a southern origin, and consequently we arrive at the possibility that certain forms which in the north are late Tertiary really had a higher antiquity at the Southern Antipodes. For instance, Osborne (Osborne, '00) is of opinion that the Hyracoidea, Edentates, and perhaps Proboscidea, originated in Neogaea and passed over to Africa, and so to Europe; while Notogaea was the chief point of radiation of the marsupials which passed thence to Neogaea.

Smith Woodward (Woodward, '98, p. 417) takes even a wider view, and ascribes the origin of the Mammalia to a southern land. He says—"No undoubted trace of the Jurassic land fauna has hitherto been discovered in the Southern Hemisphere . . . but it is extremely probable that on some continent in that part of the globe the Anomodontia were gradually being transformed into Mammalia. At least, in Jurassic formations both of Europe and North America there are occasional remains of small mammals as large as rats; and the most plausible explanation of these is that they were accidental escapes from some other region with a more advanced fauna, just as the rats and mice of the present day in the comparatively antique realm of Australia.

W. L. Sclater (Sclater, '99, p. 197) says—"Aquatic mammalia which pass their lives entirely, or for the greater part, in water, are, of course, subject to very different laws of distribution from the terrestrial forms." Speaking of the present distribution of *Otaria*, he says—"I think, therefore, we may assume that *Otaria* was originally an Antarctic form, but has travelled northwards along the West American coast, and is now firmly established in the North Pacific. In a parallel way in the class of Birds, the Albatrosses (*Diomedea*), which is essentially a group of the Antarctic seas, are represented by three distinct species in the North Pacific." Further on (*l.c.*, p. 216) he says—"It is evident that the Pacific has much more in common with the Notopelagian region than the Atlantic. *Otaria* and *Macrorhinus*, quite unknown in the Atlantic, extend themselves to the northern extremity of the Pacific, the former pervading that ocean up to Behring's Strait, and the latter reaching to the Californian coast. It follows that in former ages there must have been some barrier in the Atlantic which did not exist in the Pacific, to stop their progress northwards. The only barrier one can imagine that would have effected this must have been a land uniting South America and Africa, across which they could not travel." Sclater further points out that the occurrence of the Manatee on both sides of the Atlantic, and also of the Monk-seal (*Monachus*), with one species in the Mediterranean and on the African coast and another in the West Indies, point to the same conclusion.

The Union of Africa with South America.

The former presence of a land connection between Africa and South America would lead not only to peculiarities in the distribution of marine mammals to which it was a barrier, but would in like manner hinder the migration of fish, and of the marine invertebrates generally. If this barrier was effectual and long-continued, the difficulties of correlating the marine Tertiaries in the two hemispheres would be materially increased, but the reason for the difficulties would become more plain.

Belief in the existence of this land connection has been arrived at on two lines of argument. In the first place the present and past distribution of the terrestrial fauna and flora seems to point to it, and in the second place that of the marine fauna seems to lead in the same direction.

Suess is of opinion that the Atlantic is of comparatively recent origin, and arose as a north and south extension from a westward enlargement of the Mediterranean.

The close agreement of the recent fauna of the West Indies with that of the Mediterranean Miocene has been frequently drawn attention to. (Gregory, '95, p. 306.) The agreement runs through corals, echinoids, and molluscs, and as the Tertiary Mediterranean fauna is not found in Northern Europe and America, it must, as Gregory points out, have crept along the southern shore of this ancient sea. Osborne, as previously remarked, requires the land connection in early Tertiary times to explain the distribution of the Sirenia and Edentates. The latter, he holds, originated in South America, crossed to Africa, and reached Europe in early Oligocene times.

Blanford (Blanford, '90, p. 106) suggests a further extension of this land to the eastward in Mesozoic times. He says—"There may even, in the Mesozoic era . . . have been a girdle of land, chiefly in low latitudes, round nearly three-quarters of the earth's circumference, from Peru to New Zealand and the Fiji Islands." This land he believes broke up in early Tertiary times.

Lydekker accepts this ancient land. He says (Lydekker, '96, p. 23)—"Various lines of evidence indicate that during the Jurassic and Cretaceous epochs there was a continuous land connection between Africa (by way of Madagascar and the Seychelles) and India; while at some time in the Secondary era, in the opinion of Drs. Neumayer and Blanford, South America and South Africa were in communication across the South Atlantic."

The existence of a South Pacific continent has a strong advocate in our President, Captain Hutton (Hutton, '96), and his work will be fresh in the minds of most.

The most recent advocate of the idea appears to be Pilsbry. (Pilsbry, '01, p. 576.) Basing his ideas on an examination of the terrestrial mollusca of the Pacific Islands, he says—"The remarkable homogeneity of faunas scattered over so wide an area of Polynesia indicates either a former great extension, and therefore approximation of the Archipelagos, or they actually formed parts of a single land-mass." He believes, however, that this mid-Pacific continent never joined America, and became separated from other lands in mid-Mesozoic.

Hedley (Hedley, '99 and '92 and '98) practically proves a former land connection between Fiji and New Guinea, through the Solomons. This would appear to have been a more modern extension than that advocated by Pilsbry, and far less extensive.

There is no need to further multiply quotations in favour of an almost continuous land-belt from South America through Africa, India, and away into the Pacific, in Mesozoic times, and blocking entrance into the Atlantic well down into the Tertiary. This land is usually regarded as a means for the spread of the terrestrial fauna and flora, though its effect as a barrier to marine forms is an article of faith with many Indian geologists, and indeed it is from their studies that its existence was first surmised. While it existed, in whole or in part, it must have exerted a retarding influence on the commingling of the northern and southern marine faunas; and as it appears to have persisted into Tertiary times, across the Southern Atlantic, its effect in keeping apart the faunas of this age in the two hemispheres must greatly lessen the value of all attempts to correlate Australian and European Tertiary strata by direct comparison. Had the recent marine West Indian fauna been a fossil one, a strong case could have been made out in favour of its Miocene age. Similarly, our geographical remoteness from Europe, and the former seclusion of its Tertiary seas, must cause us to hesitate before correlating our strata with theirs on what appears to be misleading evidence.

Conclusion.

It is possible in most cases to refer our Australian strata definitely to one or other of the great European periods; but it is not always so. Terms such as Permo-Carboniferous and Trias-jura express a mingling of faunas representing two distinct northern systems, and are not cloaks to hide our ignorance. This mingling is not necessarily due to the Australian systems being intermediate in age, and being the representatives of the great unconformities of the Northern

Hemisphere, but probably in great part follows from differential rates of migration, and points to a northern or a southern place of origin of the transgressing forms. In comparing the systems of the two hemispheres, the divergencies are not usually serious; but when we come to consider the divisions of the systems, the effects of the discordances become more marked, and the more detailed the subdivisions the greater are the difficulties of correlation, so that its definite attainment seems to be beyond us. The assertions that have been made of the existence of universal floras and faunas in the past, the occurrence of which would so greatly aid our attempts at mere homotaxial correlation, do not derive any support from the analytical examination of any particular case, but spring from imperfect knowledge and hasty generalisation. And yet "to record the events which have occurred during the existence of the earth in the order in which they have taken place" demands, not the assertion of mere homotaxis, but the reference of strata to a definite place in an absolute time-scale.

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REPORT OF THE GLACIAL COMMITTEE.

[Captain F. W. Hutton, F.R.S.; R. M. Johnston, F.S.S.; W. Howchin, F.G.S.; E. F. Pittman, Assoc. R.S.M.; A. Gibb Maitland, F.G.S.; W. H. Rands, F.G.S.; G. Sweet, F.G.S.; E. G. Hogg, M.A.; and Professor David, F.R.S., Secretary.]

The discoveries in Australasian glacial geology made since the last report of this Committee are not only the most important that have hitherto been recorded by us, but may fairly rank among the most important contributions ever made to our knowledge of the glacial geology of the world. The discovery by Mr. Walter Howchin, F.G.S. (the Lecturer in Geology and Palæontology at Adelaide University), of glacial beds of vast extent and thickness in the Lower Palæozoic rocks of South Australia is unique in the history of glacial geology in the Southern Hemisphere, and in the clearness of the evidence surpasses similar discoveries made in the Northern Hemisphere.

I.—Report by the Secretary of the Tasmanian Section, W. H. Twelvetrees, F.G.S., the Government Geologist.

Observations relating to glacial evidences in Tasmania have resulted in important discoveries lately.

Among earlier records of glacial action in Tasmania are those of Mr. C. Gould, formerly Government Geologist of Tasmania; Mr. C. P. Sprent, formerly Surveyor-General; and Mr. R. M. Johnston, the present Government Statistician.

Mr. R. M. Johnston, F.S.S., has given an able summary of our knowledge of glacial evidences in Tasmania in a paper read before the Royal Society of Tasmania.* He refers the evidences to two distinct geological horizons—(A) Late Cainozoic (late Tertiary or Post-Tertiary), and (B) Permo-Carboniferous.

Messrs. T. B. Moore, E. J. Dunn, F.G.S., A. Montgomery, M.A., Graham Officer, B.Sc., Lewis Balfour, B.A., and Acting-Professor E. G. Hogg, M.A., have all recorded distinct evidences of glacial action in Tasmania. These authors recognise the two distinct glacial horizons above-mentioned, but there is still some difference of opinion among them (i) (a) as to how much of the glacial deposits is Cainozoic, and (b) how much of them is Permo-Carboniferous material redistributed by fresh-water action in Cainozoic time, and (ii) as to how far down towards sea-level the glaciation has extended. Since this report was read, Mr. Howchin believes that he has identified glacial beds in the Lower Palæozoic rocks of the West Coast of Tasmania, on a horizon that is perhaps of Cambrian age.

Observations on the glacial geology of Tasmania may, therefore, be conveniently grouped under the headings of—(A) Cainozoic, (B) Permo-Carboniferous, and (C) Lower Palæozoic.

(A). *Cainozoic.*—Mr. T. B. Moore holds that the Tasmanian glaciers during the later part of this era came down to within 150 feet of sea-level, or even (on the West Coast of Tasmania) to sea-level itself.†

Mr. A. Montgomery is of opinion that, at the head of the Pieman River, the glaciers came down possibly to within 500 to 600 feet of the present sea-level.‡

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* The Glacier Epoch of Australasia. Papers and Proc. Roy. Soc. Tasmania, 1893, pp. 73-134.

† Papers and Proc. Roy. Soc. Tasmania, 1893, pp. 147-149, and *ibid*, 1894-95, Augt., 1896, pp. 73-77.

‡ Papers and Proc. Roy. Soc. Tasmania, 1893 [issued 1894], p. 164.

There can be no doubt, in my opinion, that glaciers existed on the Western Highlands of Tasmania, descending to within a few hundred feet of sea-level, if not to sea-level itself.

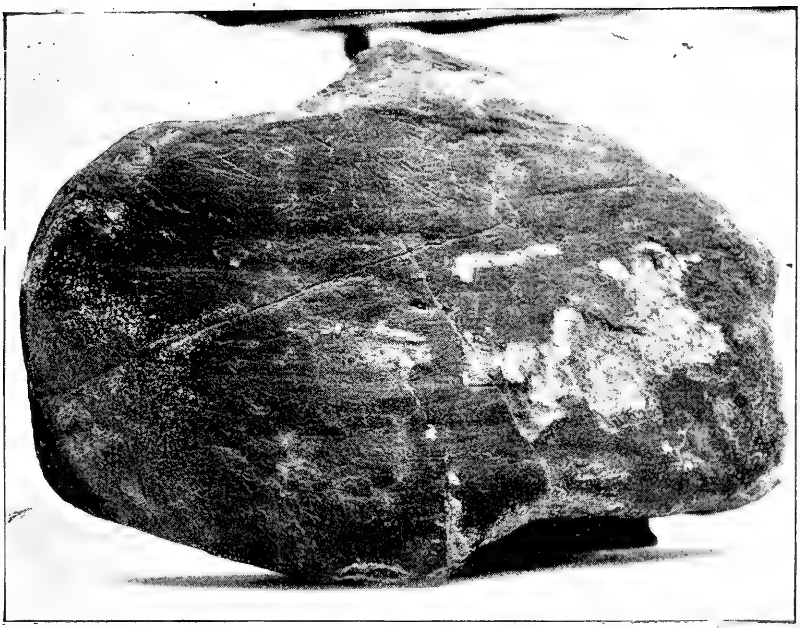
The greatest accumulation of moraine matter is at 2000 feet above the sea on that coast, but last year I remarked numerous large hog-backed moraine heaps at an elevation of 500 feet above the sea in the plains at the foot of the eastern slope of Mt. Darwin. These heaps are accumulations of stones derived from the Silurian schists and quartzites of the West Coast range. I saw no ice-scratched stones in the heaps themselves, but noticed a few among the ballast of the North Lyell railway line. This ballast had evidently been procured from the moraine heaps.

The moraines occupy a large valley, part of the existing drainage system, and hence it may reasonably be concluded that the Tertiary glacier conditions continued to the close of the Tertiary era, or were even prolonged into Post-Tertiary time.

(B). *Permo-Carboniferous.*—One of the most important recent discoveries in this branch of glacial geology in Tasmania has been made by Acting-Professor E. G. Hogg, M.A.* This author describes (*op. cit.*) the occurrence of ice-striated boulders at Oyster Cove and Little Peppermint Bay, 27 miles southerly from Hobart, on the west side of the estuary of the Derwent. These boulders are imbedded in a hard Permo-Carboniferous mudstone, which dips at 30° in a S.E. direction. The boulders do not exceed a foot in diameter. He suggests that this glacial horizon may be correlated with that of Branxton, in New South Wales, in the Upper Marine Permo-Carboniferous series, above the Greta coal-measures; while the glacial beds at Maria Island, off the South-East Coast of Tasmania, are considered by him to be probably homotaxial with the Lochinvar glacial horizon of the Lower Marine series of the Permo-Carboniferous system in New South Wales.†

* The Glacial Beds of Little Peppermint Bay, Tasmania. Annual Report of Secretary of Mines for Tasmania, 1900-1901.
† Trans. Roy. Soc. N.S. Wales, 1899, Vol. xxxiii., pp. 154-159, Pl. iv.

Under the guidance of Professor Hogg, a large number of the members of the Geology Section had the advantage of examining the Little Peppermint Bay Section at the conclusion of the Hobart Session of the Austr. Ass. Adv. Sci., when numbers of ice-scratched boulders were found *in situ*, thus entirely confirming Professor Hogg's views.



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Postscript I.—A discovery of considerable importance was made (during the meeting of the Association in Tasmania) by Mr. A. E. Kitson, of the Geological Survey of Victoria. Mr. Kitson, while on the excursion, observed ice-scratched boulders in coarse conglomerates along the beach between Burnie and Table Cape, on the North-West Coast of Tasmania; and the members of the Geological Section, under the leadership of the Assistant Government Geologist, Mr. G. A. Waller, were afforded an opportunity of inspecting this highly interesting glacial deposit. It is extensively developed along the shore at intervals between Burnie and Table Cape, one of the best sections being at a point about three miles distant from Wynyard, on the north side of the road from Burnie to Table Cape. The boulders are mostly from half a foot to one foot in diameter, much rounded, beautifully and intensely glaciated, the finest striæ being exquisitely preserved, as well as the deep and coarse grooves. The matrix in which these are imbedded is a very hard mudstone, so compact that great force is needed in order to dislodge the boulders from the matrix. The glacial beds have a low angle of dip, and rest with strong unconformity upon the nearly vertical edges of the older Palæozoic rocks.

At Table Cape the glacial beds are capped by over a hundred feet of marine Eocene beds, covered in turn by Tertiary nepheline-basanites. The section exactly recalls that of Hallett's Cove, near Adelaide, in South Australia, and Point Turton, in Yorke's Peninsula, also in South Australia. (See Mr. Howchin's description, given later in this report.)

There can be little doubt that the Table Cape Permo-Carboniferous glacial beds lie at the very base of the Permo-Carboniferous system, and are homotaxial with the glacial beds at the base of the Permo-Carboniferous system at Lochinvar, in New South Wales, described by Professor David.* It is equally probable that they are to be correlated with the Hallett's Cove and Turton Point glacial beds of South Australia.

The Table Cape glacial beds are clearly stratigraphically below the Mersey and Arthur River and Inglis River coal-measures, the relations being probably somewhat as shown on the sketch-section reproduced in part from the report on the coal near Arthur River by Mr. G. A. Waller,

* Trans. Roy. Soc. N.S. Wales, 1899, Vol. xxxiii., pp. 154-159, Pl. iv.

Assistant Government Geologist.* If, therefore, the Table Cape Permo-Carboniferous glacial beds underlie the Mersey coal-measures (Greta (?) coal-measures of New South Wales) conformably, they are of Lower Marine Permo-Carboniferous age; and if they are to be correlated, as seems probable, with the glacial beds of South Australia (such as those of Hallett's Cove), and with those of Victoria (such as the Bacchus Marsh beds), then these South Australian and Victorian beds will (in part at all events) be also of Lower Marine Permo-Carboniferous age. This discovery may have an important economic bearing. It would seem to show that in Victoria and South Australia, and in West Australia also (in view of Mr. Maitland's recent important glacial discoveries), the horizon for the *Greta Coal* (if it be developed at all) will be *above* the main mass of the glacial beds.

Postscript II.—When accompanying the geological excursion conducted by Mr. G. A. Waller, after the conclusion of the Hobart Session, Mr. Walter Howchin considered that some Older Palæozoic conglomeratic beds shown him by Mr. Waller, on the West Coast of Tasmania, were almost certainly the equivalents of the glacial beds recently discovered by Mr. Howchin in South Australia, and considered by him probably to belong to some part of the Cambrian system. These glacial (?) conglomeratic beds were observed at

II.—Report of South Australian Glacial Investigation Committee.

BY WALTER HOWCHIN, F.G.S.,

Lecturer in Geology and Palæontology, University of Adelaide.

We have to report an extended knowledge of the glacial features of South Australia, including several discoveries of more than ordinary interest. The new data modify previous ideas as to the geographical extent, as well as geological age, of the great extinct icefield which has been the subject of previous reports; and also add the discovery of a new glacial period for Australia, which must be referred to a stratigraphical position very low down in the Palæozoic group.

* Report on a recent discovery of Cannel Coal in the Parish of Preolenna, and upon the New Victory Copper Mine, near Arthur River. Government Printer, Tasmania, 1901.

With respect to the newer of these glacial formations—probably of Permo-Carboniferous age—its extent has already been indicated as occupying a great part of Cape Jervis Peninsula, south of the Sellicks Hill and Hindmarsh Ranges, the northern portion of Kangaroo Island, and the southern portions of Gulf St. Vincent, as far north as Hallett's Cove. We have now to report that these glacial deposits cover almost the whole of southern Yorke Peninsula, with an unknown extension in a northerly direction. No Cainozoic (A) has been recorded from South Australia. The Permo-Carboniferous (B) glaciation is well represented, and also the Cambrian (?) (C).

(B.) *Permo-Carboniferous, Southern Yorke Peninsula.** The geology of southern Yorke Peninsula includes some very singular features. The country is gently undulating, reaching its maximum elevation in the Warooka ridge, which may be about 200 feet above sea-level. The *recent* deposits consist of blown sand, travertine limestone (as a superficial crust), re-arranged clays probably of newer Tertiary age, and deposits of gypsum and salt in areas of depression.

Scattered over the district, in widely separated localities, numerous outliers of Eocene limestone occur. At Corney Point, forming the north-west angle of the coast-line, a very small patch of this limestone rests directly on the older (metamorphic) rocks, but as a rule the Eocene beds are superimposed on the denuded surface of a tenacious clay (glacial), which forms the principal geological formation of the district.

The older rocks, consisting of highly crystalline schists, gneiss, pegmatite, and occasional granite veins, form the leading headlands of the west and south-west coasts, but in each case the outcrop is of limited extent, and does not rise more than 15 or 20 feet above sea-level.

The chief feature of the physiography of the country is the great number of approximately circular lagoons, or salt-pans, 200 of them being indicated on the official survey-maps of one inch to the mile. These lagoons are sunken areas, from about 10 to 40 feet below the normal level; and as there is no drainage from the land to the sea within this area of about 800 square miles, all the rain that falls gravitates towards these saucer-shaped depressions, in consequence of which they have become intensely salt by a process of evaporation and precipitation.

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* *Ref.* Trans. Royal Society, S.A., 1900, Vol. xxiv., p. 71.

The clay which forms the retentive floor of these lagoons is the glacial clay, already referred to, and can be studied in many of the cliff sections, surrounding the lakes, and the large erratics which may be frequently seen in the bed of the lakes or exposed in their banks.

Perhaps the most interesting locality for these features is on the north side of Lake Fowler, the largest of these saline lagoons, with a circumference of more than ten miles. In the sloping banks of this lake, near the salt-stacks, a group of pink-coloured granites (probably fragments of a single block) can be seen, measuring six feet by ten feet. A little to the westward of these, two huge granite blocks are visible in the mud of the lake, not far from the shore, six feet high and eight feet wide. A little further west, two enormous boulders of a dark-coloured quartzite lie at the base of the cliff; one, slightly larger than the other, measured thirteen feet six inches long and five feet six inches wide. The cliffs at this point show irregular alternating exposures of clay and sand, with contortion lines.

Other inland localities where large erratics were noted were as follows:—Munkowurlie Lagoon, Moorowie Head Station, Pentonville Head Station Lagoon, a very conspicuous boulder near the public road, seven miles from Corney Point, with an exposure above ground of seven feet by five feet. Warooka Hill, one of the highest points of the district, is a ridge of glacial clay, eroded on three sides, with large boulders weathered out on the sides of the hill. In many other localities smaller erratics were recognised scattered over the cultivated fields, and similar evidence of glacial action was afforded in the material brought up from wells sunk in the district.

The exposures of glacial clay in the sea-cliffs, both on the south and north coasts, proved to be of a very instructive character. At Troubridge Hill and at Port Moorowie, both situated on the south coast, the sea-cliffs show sections of the glacial clay, with large erratics on the beach, between tide-marks. At the first-named locality the first definite evidence of the glacial beds *being inferior in position to the Eocene limestones* was met with. The excavations carried out at Hallett's Cove in 1894, under instructions from the Council of this Association, demonstrated the pre-Miocene age of the glacial deposits at that locality, but no evidence was available to indicate the time limit of the ice-age antecedent to the Miocene. In the section at Troubridge Hill, however, a bed of limestone, three feet in thickness, crowded with the characteristic Eocene echinus, *Fibularia gregata*, is seen to rest on the eroded surface of the glacial clay. This important section established beyond doubt, not only the pre-Eocene age of the glacial deposits, but, by inference, based on the stratigraphical unconformity of the two formations, a glacial age that must be antecedent to the Tertiary. This brings the South Australian ice-deposits one step nearer in time to the late Palæozoic or early Mesozoic glacial beds of Bacchus Marsh, in Victoria.

Considering the important bearing of this evidence, it was gratifying to find it confirmed in a still more striking section, exposed in the cliffs of Point Turton, on the north coast. This section is remarkable as including four distinct formations, with three planes of unconformability, as follows:—

	Feet.
1. *Recent*: Travertine limestone of variable thickness, up to	20
2. *Newer Tertiary*: Clays preserved in eroded hollows of Eocene limestone; thickness, *nil.*, to	20
3. *Eocene*: Compact limestone (worked for flux), variable up to	35
4. *Glacial* (pre-Tertiary): Till with included glaciated erratics, passes under sea-level; exposed in face of cliff	15
The stones of the beach are almost entirely the product of waste of boulder clay.	

The observations, briefly described in this report, have greatly extended the known occurrence of the pre-Tertiary glaciation of South Australia, and determine the valley of the Gulf of St. Vincent as one of the main channels of the glacial drift in a northerly direction. In those days, when the valley of the gulf was choked with ice, it was a much more important depression than it is to-day, for it has subsequently become choked with sediment at least 2000 feet in thickness. A bore put down at Croydon, about two miles west of Adelaide, penetrated this thickness of Recent and Tertiary beds before reaching the older rocks. It is significant that the lower 500 feet of this section consists of unfossiliferous sands and clays, inferior to the Eocene beds. It is probable that they represent the glacial beds, which occupy the same stratigraphical relationship to the Eocene, at the southern end of the gulf, and which can be seen passing below sea-level at Hallett's Cove, fifteen miles to the south of Adelaide.

The thickness which the glacial beds may attain in southern Yorke Peninsula is an interesting point, but has not been definitely settled. At Tocchi Lagoon, situated one mile east of Yorketown, the Government put down a bore, which went through clay and sandstone to a thickness of 305 feet. The last eleven inches was recorded as in "very hard blue rock," which was assumed to be bedrock, and the bore was stopped. It may easily be that this hard rock was an included boulder of quartzite in the clay, and did not prove that the glacial beds had been actually penetrated to their full depth.

Work still remains to be done in this district in tracing the limits of the glacial beds in their northward extension in the Peninsula, and also in determining whether the glacial clay, which passes under the sea at Point Turton, on the eastern shores of Gulf Spencer, outcrops on the western shores of that gulf.

(c.) *Glacial Beds of Assumed Cambrian Age.**

An entirely new feature in Australian Geology has been supplied by the discovery of an undoubted glacial Till in rocks of a very remote age. The beds in question consist of unstratified clays and sands, carrying grit, rounded and angular stones, and large blocks up to nine feet in length—all irregularly distributed through the unstratified matrix. The formation, when exposed to atmospheric conditions, splits into rough slabs along incipient or imperfect cleavage planes. The dip is uncertain, except when laminated shales or impure limestones are interbedded in the Till, which occasionally occurs. The included stones are, in many cases, foreign to the district, and frequently carry on their surfaces the evidences of ice-action in polished facets and striæ.

The Till was observed, in the first instance, in the valley of the Sturt River, about seven miles south of Adelaide, where the nearly vertical cleavage has led to the formation by river erosion of mural cliffs of great size. The beds, after passing out of sight under newer deposits towards the south, reappear in the valley of the Onkaparinga, about seven miles up from the mouth. At a distance of about 160 miles north of Adelaide, the Till beds outcrop in several parallel belts, running in a north and south direction. Five of such parallel outcrops are known to occur in an east and west direction, extending over 100 miles of country at right

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* *Ref.* Trans. Royal Society, S.A., 1901, Vol. xxv., p. 10.

angles to the strike. It will probably be found that the beds repeat themselves in successive folds in the district referred to. These outcrops have an indefinite extension northwards, and it is probable, as Dr. Chewing considers, that they extend in this direction as far as the Flinders Ranges on the west side of Lake Frome. This would give a line of outcrop (perhaps not continuous) of not less than 350 miles.

The glacial beds are assumed to be of Cambrian age, although this point can scarcely be regarded as definitely settled. The Till is interbedded in the series of the Mount Lofty Ranges, which the late Professor Ralph Tate regarded as of Archæan age; and not only so, but the beds in question occupy a position in the series which the late Professor considered the lowest horizon in sight. Rocks of Lower Cambrian age, determined on palæontological evidence (presence of *Archæocyathinæ*, &c.), occur a few miles to the south-east of the most southerly exposure of the Till, and it will probably not be difficult to trace the stratigraphical relationship which the Till bears to this Cambrian horizon.

The remoteness in time of these geological phenomena, the enormous extent of the beds in their lineal outcrop, the relation of the geological facts to cognate questions, and the practical value which this very characteristic formation possesses in establishing a datum-line in a very difficult geological country, invests this discovery with more than ordinary interest.

One of the glacially-grooved pebbles from these Cambrian (?) beds at Petersburg, in South Australia, is shown. This block was found firmly embedded *in situ* in the matrix of the boulder-beds on the occasion of my revisiting these beds last September, in company with Mr. E. F. Pittman and Professor David.

Note by T. W. Edgeworth David.

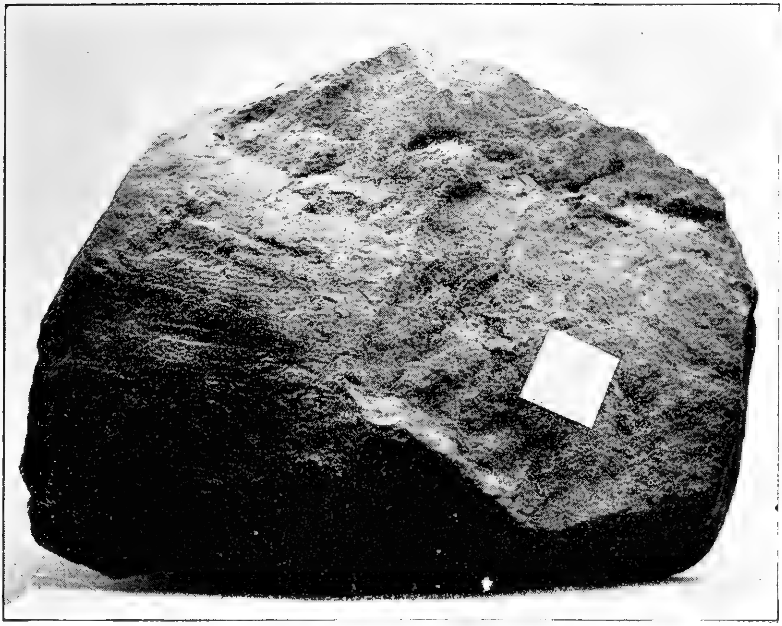
The discovery just described by Mr. Walter Howchin is of immense scientific interest to geologists and palæontologists, and presents, too, a most fascinating problem to the meteorologist, astronomer, and physicist. It is only within the last few years that evidences of glaciation in early Palæozoic time, probably Cambrian, have been discovered in the Northern Hemisphere; and so far all these previous discoveries have been made close to the Arctic Circle. The most classical locality is that of the Varanger Fiord, on the boundary between Scandinavia and Russia, where Reusch has described boulder-beds (the Gaisha-beds) of probable Cambrian age, containing glacially-striated pebbles resting upon a glaciated surface, or pavement, of quartzite. The exact age of these glacial beds at the Varanger Fiord is somewhat doubtful, and they may range from as low as

Cambrian to as high as Permian. Professor J. W. Gregory has described beds of possible glacial origin, in pre-Carboniferous rocks in Spitzbergen. These supposed glacial beds contain blocks more or less subangular, many feet in diameter, imbedded in a fine base. No glacial grooves nor striæ were observed on these blocks. Rocks of somewhat similar character occur on the Lena River, in Siberia, on a pre-Carboniferous horizon, and on the Mackenzie River, in North America, on a horizon that is perhaps Cambrian. With the exception, however, of the Varanger Fiord beds, no glacial markings have been observed on the included blocks of any of these ancient beds, supposed to be Cambrian in age, and to be of glacial origin. Even in the case of the Varanger Fiord, the geological age, though probably Cambrian, is still in doubt. What makes Mr. Howchin's discovery of such value is that (1) the evidence of the glacial character of the deposit is indisputable, great numbers of the included boulders, especially in the Petersburg (S. Australia) district, showing well-preserved glacial striæ, as clear and sharp in some cases as those of well-glaciated pebbles from Pleistocene or Recent boulder clays; and (2) the age of the glacial beds is capable of being definitely ascertained. They cannot, I think, be newer than Ordovician, and may be as old as Algonkian. Mr. Howchin is of opinion that they will probably be found to underlie the *Archæocyathinæ* limestones, and, therefore, to belong to a horizon low down in the Lower Cambrian; but further studies in the field are necessary before the exact stratigraphical relations of the beds can be determined. The intercalation of limestones with the glacial beds at the Sturt River is a novel and interesting feature. The Tapley's Hill laminated calcareous shales, which immediately overlie the glacial series, are perhaps marine, as they contain very numerous casts of what are probably radiolarian shells. If this surmise is correct, the ice in Cambrian (?) time came down to sea-level, in some portion of the Southern Hemisphere, perhaps even in South Australia itself. As regards the direction in which the ice moved, although no striated pavement has as yet been found, yet from the discovery by Mr. Howchin of boulders of a beautiful graphic granite at Petersburg (S.A.) which occurs *in situ* at Winulta (?) Creek, about 16 miles north of Ardrossan, in Yorke's Peninsula, over 120 miles to the south, it is probable that in Cambrian, as in Permo-Carboniferous time, the ice in South Australia moved from south to north. It is, however, as yet premature to generalise. This important discovery by Mr. Howchin was not fortuitous, but was the result of years of patient toil under trying conditions, and, therefore, all the more credit is due to the discoverer.

III.—West Australia.

(b.) *Permo-Carboniferous.*

The next discovery is that by Mr. A. Gibb Maitland, F.G.S., Government Geologist of West Australia, of extensive boulder-beds in the Marine Permo-Carboniferous rocks of West Australia. The illustrations Mr. Maitland has already published of striated boulders from these beds prove their glacial origin most conclusively. The following provisional description of these



× ⅓rd.

From a photograph by E. F. Pittman, Assoc. R.S.M.]

glacial beds has been published by Mr. Maitland.*—"During the course of the examination of the country between the heads of the Wooramel and the Minilya Rivers, one of the most important contributions of this State to pure science was obtained. There has been discovered, associated with the Carboniferous rocks, an extensive deposit of glacial origin. This deposit has already been proved to exist for a distance considerably over 60 miles. Although this seems to be one of those things which interest the scientist only, it affords, from a practical point of view, a most important stratigraphical horizon, which can be readily recognised and traced across country for a considerable distance, and which will prove of material assistance in any boring which may be undertaken in the future. With this deposit, the character of which is shown on Plate III., are ice-scratched boulders, photographs of which are attached, Plate IV." A feature of special interest connected with this discovery is the fact that these glacial beds extend into the tropics. The only other locality in Australia where Permo-Carboniferous (?) glacial beds have as yet been identified in the tropics is that discovered by Professor Baldwin Spencer and Mr. Gillen at Yellow Cliff, Crown Point, in the valley of the Finke River, Central Australia.

With regard, however, to Permo-Carboniferous glaciation in tropical Australia, the fact should be mentioned that Mr. R. L. Jack, the late Government Geologist of Queensland, has recorded the occurrence of small erratics, which he considers to be ice-borne, in the Middle Bowen series of the Permo-Carboniferous system of Queensland. No undoubted traces of the (A) (= Cainozoic) or (C) (= Cambrian) glacia-
glacial markings have as yet been noticed upon them. No
tion have as yet been observed in West Australia. There is, however, in my possession a photograph taken by the late Mr. Beecher, of the Geological Survey of West Australia, of a remarkable conglomerate at Nullagine, Pilbarra, W.A., which so closely resembles in general appearance the Cambrian glacial beds of South Australia as at once to suggest a possible glacial origin for the West Australian beds. They also are associated with a very finely-laminated shaly altered rock, not unlike the Tapley's Hill shales, which overlie the Cambrian (?) glacial beds of South Australia. These Nullagine beds are probably of Older Palæozoic age (possibly pre-Cambrian), and should well repay further investigation.

* Annual Prog. Rep. Geol. Survey, West Australia, for the year 1900, p. 28.

IV.—Queensland.

Mr. B. Dunstan, Government Assistant Geologist, has recently described some conglomerates containing large angular to subangular blocks of rock foreign to the neighbourhood, and which he considers to be perhaps of glacial origin, at Windah, on the Mackenzie River, near Rockhampton, Queensland.* Some of these blocks are several tons in weight. Mr. Dunstan considers that this horizon belongs to the Gympie Formation (Carboniferous). If this deposit is of true glacial origin, and the horizon is as old as Gympie, this will prove to be the first record of ice-action in Carboniferous as distinct from Permo-Carboniferous time, if we except the reference by Mr. W. H. Rands, then Assistant Government Geologist, to the occurrence of boulders of possible glacial origin in the Gympie goldfield of Queensland.† This Gympie (Carboniferous ?) horizon is to be distinguished carefully from the Permo-Carboniferous ‡

Mr. R. L. Jack has already recorded boulders considered to be ice-borne from the Middle Bowen series of Queensland, of Permo-Carboniferous age in the sense just defined.§

V.—New South Wales.

(A). *Cainozoic.*

Evidence of Glaciation in late Cainozoic time at Kosciusko.—At the beginning of last year Mr. Richard Helms, Mr. E. F. Pittman, and your Secretary visited Kosciusko, with a view to seeking for more definite evidence on the subject of ice-action there. Evidence of a doubtful kind, but favouring a past glaciation, had been re-

* Report on Geology of the Dawson and Mackenzie Rivers, with special reference to the occurrence of Anthracitic Coal. *Queensland Parl. Papers*, C.A. 9, 1901, p. 10. (Folio., Brisbane, 1901. By Authority.)

† Notes on Certain Boulders met with in the Beds and Reefs of the Gympie Goldfield, Queensland. Aust. Ass. Adv. Sci., Vol. i., 1887, pp. 297-299.

‡ This term is here used in the sense in which it is employed by N.S. Wales Geologists, as indicating a period when a *Glossopteris-Gangancopteris* Flora flourished in Australia, contemporaneously with a marine fauna of Permo-Carboniferous affinities.

§ Report on the Bowen River Coalfield by R. L. Jack, p. 7, paragraph 39. By Authority, Brisbane, 1879.

corded by Lendenfeld.* Definite evidence, in the shape of striated boulders, was first obtained by Mr. Richard Helms, during 1889 and 1893.† In 1897 Messrs. A. E. Kitson, F.G.S., and W. Thorn, concluded that there were evidences of glacial markings at Mount Etteridge, not far from the summit of Kosciusko.‡ Our visit last year, in company with Mr. F. B. Guthrie, F.G.S., has enabled us to collect further evidence so clear as to put beyond dispute proofs of past glacial action at Kosciusko. This fresh evidence entirely confirms the views previously expressed by Mr. Richard Helms.§

Briefly, the evidences observed were—(1) Extensive areas of grooved and striated rock-surfaces and *roches moutonnées* in the neighbourhood of Lake Merewether (Blue Lake) and Evidence Valley, as well as in Lake Albina Valley. The finest striated pavements were observed by us in the latter valley.

(2) Terminal, lateral, and median moraines. The largest of these morainic deposits is the large mass which Mr. Pittman and I have named the Helms Moraine, in honour of its discoverer. This moraine is like a huge railway embankment, 29 chains in length, and rising 400 feet above the level of Lake Merewether. Probably at least 270 feet of this bank measured vertically from the surface downwards is moraine. A remarkable feature about it is the very large proportion of grooved and striated blocks occurring in it.

In modern glacial moraines, like those of New Zealand, it is the exception rather than the rule to find striated stones; in the Helms moraine, however, more than half the stones are more or less strongly striated.

Mr. Helms suggests that this feature may be due to the material of the moraine having been derived from an old

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* Report on the results of recent examination of the central part of the Australian Alps, pp. 1-16, Pls. i.-iv. Government Printer, Sydney, Jan. 21st, 1885. Also, The Glacial Period in Australia. Proc. Linn. Soc. N.S. Wales, Vol. x., Pt. 1, pp. 44-53, Pls. vii., viii., Jan., 1885 [June].

† Proc. Linn. Soc. N.S. Wales, (2) viii., Pt. 2, p. 328, Sept., 1893 [March, 1894]. Also, *op. cit.*, (2) viii., Pt. 3, pp. 349-364, Pl. xviii., October, 1893 [April, 1894].

‡ Contributions to the Geology of Mt. Kosciusko and the Indi-Monaro track. Report, Austr. Assoc. Adv. Sc., vii., Sydney, 1898 [1899], pp. 367-370.

§ For details, see Proc. Linn. Soc. N.S.W., 1901, Pt. 1, pp. 26-74, Pls. iii.-x. Geological Notes on Kosciusko, with special reference to Evidences of Glacial Action, by Prof. David, Richard Helms, and E. F. Pittman, Assoc. R.S.M.

ground moraine, formed when the Kosciusko Plateau may have been covered by a *mer de glace*, which later, as the snowfall diminished, broke up into a group of small glaciers.

(3). *Glacial Lakes.*—Lakes Merewether, Harnet, Albina, and May are certainly of glacial origin, the ponding back of the water in them being due to the deposit of terminal moraine at their lower ends.

(4). Numerous large erratics and perched blocks, up to about 12 feet in diameter.

As regards the conclusions which may be provisionally deduced, Mr. R. Helms is of opinion that there is evidence of an older and far more extensive glaciation of the Kosciusko Plateau and surrounding region than the later one, of which latter such clear traces have been preserved. This may eventually be proved to have been the case; but, apart from this hypothesis, there is the positive evidence that the Kosciusko Plateau in late Cainozoic time harboured glaciers, which descended the valleys on either side of the Main Dividing Range, to the Snowy River on the east and the Murray River on the west. The glacier-ice descended from levels of over 7000 feet (Kosciusko itself is 7328 feet) to at least as low as 5800 feet, probably 5500 feet, above the sea. The glacier-ice was certainly (in places) from 200 to 400 feet thick, and the longest glacier, that of the Snowy, about three miles in length. There were two epochs of glaciation, or two marked pauses in the glaciation, which we term the "Hedley Tarn Epoch" and the "Lake Merewether Epoch." As regards the age of these glaciations, estimated (1) by the amount of erosion subsequent to the glaciation, and (2) by the freshness of the grooved rock-surfaces in positions where they never could have been covered by morainic material, the date cannot have been removed by more than a few thousand years from the present.

In creeks with a rapid fall, having only soft phyllites to erode, a depth of only from six to ten feet of the phyllites have been worn away since the last of the glaciers disappeared, while the almost vertical grooved cliff-faces of the Lake Albina valley preserve glacial striæ and grooves in almost their original freshness.

It is thought that the latest glaciation of Kosciusko cannot have been removed by more than about 10,000 years from the present day.*

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* *Op. cit.* David, Helms and Pittman, pp. 38-39, and 63-64.

SOME MODERN THEORIES CONCERNING ORE DEPOSITS.

By G. A. Waller, *Assistant Government Geologist, Tasmania.*

There is perhaps no branch of geological science upon which more difference of opinion exists, than upon the origin of ore deposits and the various phenomena connected therewith. Nevertheless, our knowledge has advanced very rapidly during the last ten years, probably more so than during any like period of the past. Many new and brilliant theories have been evolved, and older maxims have had to adjust themselves to our extended knowledge. In the present paper I propose to discuss some of the modern theories of the origin of ore deposits, and in doing so will base my arguments as much as possible on the occurrences of ore deposits in Tasmania, than which, I venture to say, there exists no more fertile field for the investigations of the mining geologist.

The condition of the science of the origin of ore deposits at the present day may be fitly compared to a region undergoing intense metamorphism; new facts are being added to our store of knowledge, and old ones are acquiring a new and more significant aspect. Matter which for years has lain in a clastic condition is gradually undergoing reconstruction, and crystallising into definite forms.

The most prominent feature in the progress of the science during the past decade is the advance made by the new school of geologists who, following de Launay and Vogt, attribute a plutonic origin to the majority of ore deposits. During the heated discussions which took place in the previous decade, when Sandberger championed the cause of lateral secretion, and Stelzner and Posepny so vigorously defended the old ascension theory, it would have been difficult to realise the complete change of position which the two schools were to occupy at the present day. The lateral secretionists abandoned the main positions occupied by Sand berger, and eventually evolved a theory which differs not very greatly from the old ascension theory. We may describe this school as the "meteoric school," since it attributes the concentration of ores to the action of circulating meteoric waters. Many, perhaps the majority, of the old ascensionists joined the ranks of the meteoric school, but not all—the remnant adopted a new line of enquiry. Basing their investigations upon the almost universal association of ore deposits with eruptive rocks, and aided by the rapid advance made in the science of petrology, they have evolved an ultra-ascension theory, which ascribes the majority of ore deposits either to direct differentiation from eruptive magmas, or to "after actions" connected with them during the process of consolidation. We may call this the "plutonic school."

It is, of course, not to be supposed that the members of the opposing schools advocate their own theory to the entire exclusion of the other. The members of the meteoric school will admit the applicability of the plutonic theory to some deposits, and *vice versâ*; but among the extreme members of each school there is always a tendency to minimise the applicability of the opposing theory almost to the point of extinction.

The Meteoric Theory.

In the meteoric theory of the origin of ore deposits it is supposed that ores are concentrated into veins or other forms of ore deposits from the minute metallic ingredients of either sedimentary or eruptive rocks by the action of circulating meteoric waters. The metallic ingredients may come from the rock immediately adjoining the deposit, or from rocks at great distances from them, the distinguishing feature, from the point of view taken up in this paper, being not so much the source of the metal, but the method by which it is supposed to have been concentrated, for it is in this respect that the two theories chiefly differ.

Of the rain which falls upon the surface of the earth, a portion sinks down through the pores, cracks, and fissures of the rocks into the crust of the earth, to issue again after a longer or shorter journey as a spring. This underground water is of two kinds. Firstly, that which circulates near the surface, flowing from higher and very numerous points of ingress to lower and fewer points of egress after a comparatively short journey. Such surface waters are usually oxidising in their action, and though they exert a most important influence over the upper portions of ore deposits which are already in existence, and produce local concentrations in them, they are not believed to be capable of producing any considerable primary concentration from the minute metallic constituents of the rocks. Secondly, that which takes part in the deep underground circulation. The motive force producing this circulation is no doubt in part the same as that producing circulation in the upper zone, namely, differences in the levels of ingress and egress, but it is probably chiefly due to differences in temperature between the ascending and descending columns. The deep underground waters have usually lost their free oxygen, and have taken up substances such as hydric and alkaline sulphides into solution, rendering them reducing in their action. It is to the action of these deep underground circulating waters leaching out the minute metallic contents of the rocks and depositing them in fissures and cavities, or in the spaces vacated by more or less soluble rocks, that the meteoric school attribute the origin of the majority of ore deposits.

That the common eruptive and many of the sedimentary rocks forming the crust of the earth are competent to supply the material for ore deposits, provided the means for concentration exist, is now admitted by the majority of geologists. The facts have been fully demonstrated by exhaustive analyses carried out by such investigators as Sandberger, Stelzner, Robertson, Don, and many others. The content is usually exceedingly small, going down as low as hundredths or thousandths of 1 per cent., or even lower than this, but still it exists. It has been further demonstrated that the metallic contents of igneous rocks are much greater than those of sedimentary rocks. Speaking very generally, it may be said that the metallic contents of igneous rocks are greater by about one decimal place than the contents of sedimentary rocks; by that amount, then, are igneous rocks the more favourable sources of the metallic contents of ore deposits.

Given, therefore, an agent capable of effecting the concentration of these minute metallic constituents distributed through the rocks, and we have evidently the materials for a working theory of the origin of ore deposits.

We have now, therefore, to enquire into the competence of this deep undergound water circulation to bring about such a concentration. The subject is a very large one, and cannot be fully discussed in the present paper.

The points which most need elucidation are the following:—

1. The porosity of rocks.
2. The motive forces producing circulation.
3. The nature and direction of the underground flowage.

The Porosity of Rocks.

I am not aware that any investigations have been undertaken with the object of definitely ascertaining the size and distribution of the openings in various rocks. Such an investigation would no doubt be extremely laborious, and it is doubtful if results could be obtained which would have much scientific value. Without any definite data, it is necessary to fall back on such conclusions as can be drawn from theoretical considerations and general observations.

It is well known that no rocks are absolutely impervious to water, while many kinds are, comparatively speaking, porous. Uncemented conglomerates, sandstones, tuffs, and other fragmentary rocks are the most porous, and these rocks permit of a most thorough leaching action by waters passing through them. Many rocks are traversed by joint planes, planes of fissility and sedimentation, which afford openings through which water may travel. The massive eruptive rocks contain cracks and joints caused by shrinkage during cooling, while all rocks are traversed by the larger fault fissures. It should be noted that the massive eruptive rocks which are believed to be the richest in their metallic contents, and those from which we would naturally suppose the great majority of ore deposits to be derived, are the least adapted to the leaching process. It is true they frequently contain joints and cracks, but these comparatively larger visible cracks expose only a very small proportion of the whole rock to the action of circulating waters. If the minute metallic contents of these massive rocks are leached out by circulating waters to any appreciable extent, almost the whole work of leaching must take place in the extremely small invisible openings, such as cleavage cracks, &c. We can hardly form any conception of the rate of flowage through such minute openings. The ordinary laws of Hydrostatics cease to operate for flowage through capillary openings. Van Hise,* in his valuable treatise entitled "Some Principals controlling the Deposition of Ores," shows that flowage in capillary openings is directly proportional to the pressure and to the 4th power of the radius (the square of the sectional area) of the opening. While in openings of larger than capillary size the flowage is proportional to the square root of the pressure, and as the square of the radius (or as the sectional area). This proves that in the small capillary openings flowage decreases very much more rapidly with decrease in pressure or sectional area than in openings of larger than capillary size. For example, in the case of super-capillary openings the flowage through a crack 1mm. wide will be one-tenth of that through a crack 10 mm. wide, and one-hundredth of that through a crack 100 mm. wide. But in the case of capillary openings the flowage through a crack ·001 mm. wide will be one-hundredth of that through a crack ·01 mm. wide, and one-ten thousandth of that through a crack ·1 mm. wide.

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* Trans. Am. Inst. M. Eng., 1890.

The flowage of water through capillary openings is, however, influenced to a very considerable extent by temperature, for it has been shown to be inversely proportional to the viscosity of the liquid. Now, the viscosity of water at 90° C. is one-fifth of what it is at 0° C., consequently five times as much water will flow through a capillary opening of given size at 90° temperature than will flow through the same opening under otherwise similar conditions at 0° C. This fact must be of very great importance in promoting the circulation of water in depth and in the vicinity of hot eruptive masses.

When the cracks become so small that the molecular attractions of the solids extend across the opening, we have what Van Hise calls sub-capillary openings; for sheet openings, such as cleavage spaces, this class includes all openings under ·0001 mm. wide. Concerning the flowage of water through these openings, Van Hise says—"The water is held as a film glued to the wall by the adhesion between the water and the rock. There is no free water in such openings as these. The flowage must be exceedingly slow or nil."

These facts seem to point to the conclusion that an effective circulation through a dense rock such as granite or gabbro must require an enormous motive force for its production, but it is hardly possible to draw any definite conclusions as to the amount of force required, or as to the rate at which the circulation will take place, or, indeed, whether it can become an effective circulation at all. Assuming that all rocks are to some extent porous (a fact that has been definitely ascertained by experiment), and that some force or forces exist urging the water to pass through them, then it follows, that no matter how small the force may be, circulation will take place. It is then a question of time only for the leaching process to become complete.

The Motive Forces producing Circulation.

The motive force which produces underground circulation may be conceived as arising from several causes, or from a combination of these causes. In the first place, the surface of the deep underground water is not horizontal, but forms an undulating plane, rising with the hills and falling with the valleys. From this fact it follows that there will be a tendency for the water to flow from the elevated regions to the depressed regions. In doing so, according to well-known laws of hydro-dynamics, it must utilise the whole of the available cross-section of the openings connecting the two regions. These openings are not confined to the space directly between the two regions, but are distributed more or less throughout the whole of the space between, surrounding, and below the two regions. Van Hise illustrates this law by supposing water to be poured into a well *A* and to flow to a well *B*, and quoting Professor Schlichter's theoretical investigations of the motion of underground waters, shows that the flowage is not by a direct path between *A* and *B*, but by a large number of diverging paths from *A* during the first part of the journey, and by a large number of converging paths to *B* during the latter part of the journey. Thus, it would appear that, given an undulating surface of the ground water level, the whole of the water below that level forming a part of the sea of deep underground water must be in motion. Secondly, circulation may be produced or promoted by differences in temperature between the ascending and descending columns. The expansion of water with increase of temperature amounts to over 4 per cent. between 0° and 100° C. at ordinary pressures. Assuming this difference to be the same at higher pressures, then, if the difference between the ascending and descending columns were 100° C., 4 feet of head in favour of the descending column would be produced for each 100 feet of depth. The natural increase of temperature in the earth's crust as depth is gained is one of the causes of the difference in temperature between the ascending and descending columns. For the ascending column flowing from a hotter to a colder region is always hotter than the rocks which surround it, while the descending column flowing from a colder to a hotter region is always colder than the rock which surrounds it. At any given depth, therefore, the ascending column must be higher in temperature than the descending column. The difference in temperature is, of course, largely dependent upon the rate of flow of the water; a rapid rate of flow would produce great differences in temperature, while a slow rate of flow would produce slight differences, since it would enable the water to assume the temperature of the surrounding rock.

As will be shown hereafter, there is a tendency for the descending water to flow comparatively slowly through a large number of small openings, and for the ascending water to flow comparatively rapidly through a small number of large openings. It follows from this that the temperature of the ascending water will differ more greatly from the temperature of the surrounding rock than that of the descending water. It is impossible to form any estimate of the difference in temperature which may be produced by this means, but it is none the less certain that some difference must exist. The heat engendered by orogenic movements in the earth's crust or by intrusive masses of eruptive rock must be the means of causing great differences in temperature between the ascending and descending columns. In such cases as these, the force producing circulation may be very great indeed.

The Nature and Direction of Underground Flowage.

The exhaustive treatment of this portion of the subject is beyond the scope of this paper. We are promised a full consideration of the phenomena in a treatise by Van Hise, to be published as a monograph in connection with the U.S. Geological Survey. Meantime, Professor Van Hise has given us a short explanation of his views in the paper already cited. I must confess, however, that I am unable fully to follow the distinguished geologist's reasoning in his abridged account, and must therefore await the appearance of the complete treatise. In the following short explanation I have presented the matter in a slightly different light, and attempted to show, briefly, what I believe to be the main causes which must control underground flowage. The results of my reasoning are identical with those of Van Hise.

For the purpose of understanding the nature of underground flowage, we may imagine the whole crust of the earth to be divided and sub-divided into an infinite number of blocks by the openings in the rocks. Thus, openings of the first order, such as the great fault fissures, would cut up the crust into a number of large blocks of the first order; openings of the second order, such as the smaller fissures, joint planes, &c., would sub-divide the blocks of the first order into a great number of blocks of the second order; and further, openings of the third and higher orders, such as bedding planes, cleavage cracks, and the spaces between the grains, would split up the blocks of the second order into an innumerable number of minute blocks of the third and higher orders. This picture will give a sufficiently accurate notion of the distribution of the openings in rocks for the purposes of the present brief theoretical inquiry into the general movements of underground water.

Now, let us imagine water to flow from one region to another. The great bulk of the flowage would no doubt take place through the large fault fissures, &c., but since the water must utilise the whole available sectional area of the openings connecting the two regions, flowage must also take place in the same general direction through all openings of the second and higher orders throughout the range of the travelling water. Though all available openings must be utilised, flowage through them will be inversely proportional to their resistance, and of course the amount passing through individual openings of the third and higher orders must be extremely minute, and the rate of flow must be small.

To form a conception of the amount of water likely to traverse the smaller openings in the denser rocks, let us picture a block of granite, say, 10 feet cube, surrounded by a water space varying from nothing to 1 mm. in width. A difference of hydrostatic head, between the water at each side of the block, that would be quite sufficient to determine a distinct and even rapid flow around the block, would evidently determine only the very smallest imaginable amount of flow through the minute openings of higher orders within the block; which openings we must, however, theoretically admit to bear some share in the transfer of water from one side of the block to the other.

It is further evident, from the above illustration, that there must be a constant interchange of waters between the openings of the various orders, and it is to this agency that we must attribute the leaching and cementing action of underground water. Unfortunately, we have not yet sufficient data at our command to form any approach to an accurate estimate of the amount of this circulation through the more minute openings, so that we have room for very decided differences of opinion as to its efficacy in producing the more marked phenomena, such as ore concentration.

To resume the larger question of the nature and causes of the general circulation—we have seen that difference in temperature between the ascending and descending columns is the main force producing circulation, and I propose here only to discuss the circulation which is produced by this means.

Imagine, then, all these openings in the system of blocks within blocks to be filled with water, and, further, suppose heat to be applied to the lower porton of this system of water channels. The heat causes expansion in the water, and, therefore, movement; then, as the resistance of the small openings is so much greater than that of the large openings, the greater part of the flowage would be induced in the main channels, *i.e.*, the heated water would rise to a higher level in the main channel than in the smaller openings. This excess of upward flowage in the main openings, which is the result of expansion alone, and may at first be very small, would constantly traverse rocks of lower temperature, so that the temperature of the water would always be slightly higher than that of the surrounding rock; that is, it would be higher than the temperature of any water, stationary, descending, or more slowly ascending in those surrounding rocks, and there would be induced a hydrostatic head due to difference of temperature in the waters contained in openings of the first order and those of higher orders. Thus, when the smallest difference of hydrostatic head was induced between the main channels and the smaller openings, there would be induced a constant flow of water from these smaller openings to the main channel, which would aid in causing the upward movement to cooler rocks and further accentuate the difference of temperature, and therefore of pressure. The whole cycle would be cumulative in its action, and given any movement whatever in the underground water system, an upward circulation in the direction indicated must ensue. Whether the main openings communicated directly or indirectly with the surface, the flowage in the ascending channels would find relief by a surface discharge, or, in some cases, possibly by a gradual distribution of the ascending water into openings of higher orders, the result of which would be to gradually cool down these waters, and return them to the descending channels.

Thus, we may see that the openings of the first order would be occupied with ascending currents under the influence of a difference of hydrostatic head induced by the application of heat to the water system. The channels of the higher orders would, however, be drawn upon to supply the flow induced in the larger channels, so that the whole body of underground water would be set in motion, the larger channels being occupied by ascending waters, and the smaller by descending waters.

It is further evident that the current ascending the few large openings of the system of flowage must be balanced in amount by the waters descending through the small openings. If the total areas of the respective systems were the same, the average velocity of flow would be the same also, but though it would be hard to give definite proof of the fact, it is apparent, almost to demonstration, that the sum total of the small openings must be immensely larger than the area of the comparatively few larger openings occupied by ascending currents. The flow through the smaller openings we know must be extremely slow, and we have the most ample ground for believing that on the whole the upward flow exceeds the downward very considerably in velocity.*

The above statement of the theory of underground flowage is necessarily condensed, and simply aims at a general statement of what seems to be the necessary conditions governing this circulation. I think, however, that the following conclusion has been fairly demonstrated:—*That, as a rule, the descending currents of the deep underground circulation pass through a large number of small openings, and the ascending currents pass at a relatively higher velocity through a small number of large openings.*

General Conclusions.

The circulation which is produced by the want of horizontality of the surface of the ground water level and by the natural increase of heat as depth is gained in the earth's crust, are general causes, comparatively feeble in their action, but which are everywhere and always present, and they must have the effect of producing a universal underground water circulation. Still, it seems highly probable that this universal underground circulation has had little to do with the leaching out of the materials for ore deposits. No doubt it must be the means of producing vast alterations in the composition and structure of rocks, and is largely responsible for the more general phenomena of induration and regional metamorphism; but its very universality is a strong argument against its being one of the prime causes of ore deposits, for ore deposits are far from being universal phenomena even among rocks which belong to the same geological horizon.

There are many reasons for believing that the main causes of effective leaching, if leaching is an important factor in the formation of deep-seated ore deposits, must be the heat produced by intrusive masses of igneous rock, for here we have a certain cause of vigorous circulation. Everyone can understand that the introduction of a mass of molten rock into a region saturated with stagnant or slowly-moving water must have the effect of producing violent circulation. It is a notorious fact that ore deposits are found in regions where vulcanism has been active; eruptive rocks are almost always found in the vicinity of ore deposits, and in the few well-established instances where eruptive rocks are apparently absent there is always the possibility that they are present below the surface, but have not yet been exposed by denudation. Moreover, the difficulty which we encounter when we try to explain the process of leaching by the circulation of water through extremely minute openings is lessened in proportion to the activity of the force which we may suppose has produced circulation. Speaking generally, it may be also said that the general facts of the occurrence of ore deposits point to a comparatively short period, or to a succession of comparatively short periods, of deposition rather than to a continuous process going on with equal vigour since the beginning of geological time. If, therefore, the materials for ore deposits have been concentrated by the leaching action of meteoric waters, then it is almost certain that the heat engendered by intrusive masses of eruptive rock is the principal force producing effective circulation.

The Plutonic Theory.

The plutonic school look upon the eruptive rocks as the main source of the metallic contents of ore deposits. In this they differ not very greatly from the meteoric school, for the latter also believe that the metallic contents of many deposits may be wholly derived from eruptive rocks. The distinguishing feature between the two theories is not so much the source of the metals, as the method by which they have been extracted. The meteoric school hold that this has been effected by the leaching action of the meteoric waters. The plutonic school, however, suggest two other methods of concentration, namely, "magmatic differentiation" and "magmatic extraction." Both of these methods have been thoroughly established in the case of certain classes of ore deposits, and with regard to these there is now very little difference of opinion. But there are other very large classes of ore deposits upon which definite proof either way has not yet been obtained, and in these classes there is a very wide difference of opinion.

Ore Deposits produced by Magmatic Differentiation.

It is now a thoroughly established fact that during the consolidation of certain eruptive rocks important concentrations of ores may take place through the process known as magmatic differentiation. The most important of these deposits consist of concentrations of titanic iron ores in gabbro, of chrome iron ores in peridotite, and of nickeliferous and cupriferous pyrrhotite in gabbro. The concentration of these ores is merely one phase of the general phenomenon of magmatic differentiation, or the process by which rocks of varying composition solidify from one and the same molten magma. As an example of the more general phenomenon, I may quote the mixed dykes of the Christiania district, Sweden, which have been fully described by W. C. Brögger (1) and J. H. L. Vogt. (2) The central portion of these dykes is composed of a normal mica-syenite porphyry, but towards the margin there is a gradual passing over into a rock (kersanite) of more basic character. Vogt shows that the percentages of the component minerals in the dykes in the centre and at the margin vary in the following manner:—

		Per cent.			Per cent.	
Pyrite	increases from	0·5		in centre to	2–3	at margin
Apatite	„	0·51		„	1·44	„
Magnetite	„	1–2		„	10–12	„
Mica	„	5·10		„	20–25	„
Plagioclase	„	40	(oligoclase)	„	60–70	(labrador and bytownite)
Orthoclase	decreases from	30		„	Nil.	
Quartz	„	10		„	Nil.	

This proves that the rock at the margin of the dyke is much richer in the minerals belonging to the first period of crystallisation (pyrite, apatite, and magnetite), and, to a lesser degree also, the ferro-magnesian silicates belonging to the second period of crystallisation (in this case mica), than the rock at the centre. Moreover, the acid plagioclase in the centre of the dyke is replaced by basic plagioclase at the margin, and orthoclase and quartz which are abundant in the centre of the dyke are absent at the margin. Series of analyses have been made right across these dykes, and have proved that the alteration in composition is quite gradual.

Similar occurrences have been recorded by a great number of investigators in various parts of the world, so that the example cannot be regarded as an isolated case, but as an instance of a universal phenomenon.

Although the concentration of the basic material at the margins of the eruptive mass appears to be the general rule, this is not always the case. Sometimes the basic material is concentrated in the centre, and sometimes the various rock types are irregularly distributed. Whatever the cause of magmatic differentiation may be, it is certain that the migration of the material has taken place before any of it has solidified. This has been proved in part by microscopic

(1) Die Mineralien der Syenitpegmatitgänge, &c. Z. f. Kryst, &c., 1890.
(2) Zeitschrift fur Practische Geologie, Jan., 1893.

examination, and in part by the nature of the occurrences themselves. Thus, although the majority of cases of magmatic differentiation show a gradual passing over from one type of rock into the other, sometimes this is not the case, and there is indisputable evidence that after the migration of the material, movements have taken place in the still molten rock, and irregular intrusions of one type into the other have been formed. In these cases the plane of division between the two types is often quite sharp. In other cases intrusions of the marginal type into the adjoining country rock occur.

Segregations of Titanic Iron Ores in Gabbro.

Although a large number of these deposits are known, comparatively few of them have been worked with success. This is due to their usually high percentage of titanic acid, which, besides being a drawback to their metallurgical treatment, also reduces the percentage of iron. The latter is often further reduced by a percentage of silicates, especially ferro-magnesian silicates, such as hypersthene, dialage, and olivine, so that they are generally somewhat poor, or only moderately rich in iron. In spite of such drawbacks these ores, on account of their dimensions and the consequent cheapness of production, have in several localities given occasion to some mining. As a typical deposit of this kind, the well-known deposit at Taberg, in Sweden, may be mentioned. The ore, which is known as "magnetite olivinite," consists mainly of titano-magnetite, with some olivine, and in parts a little biotite and strongly basic plagioclase. The latter are absent from the high-grade ore. Step by step the passing over from the normal olivine hyperite, which is comparatively poor in magnetite and olivine, to the plagioclase bearing magnetite-olivinite, and finally the pure magnetite-olivinite may be traced. Here, as in all other deposits of titanic iron ore, the concentrations have been made in the centre of the eruptive mass, not at the margins. A great number of similar deposits are known in Norway and Sweden, Finland, the United States, Brazil, New Zealand, &c. All of them present essentially the same features. They are invariably connected with basic eruptive rocks, with a maximum of 55 to 57 per cent. of silica. Usually the rock is of plutonic origin, seldom dyke-forming, and never effusive. They are always found in the central portions of the eruptive mass, and usually a gradual passing over from the normal rock to the normal ore may be observed.

Segregations of Chrome Iron Ore in Peridotite and Serpentine.

It is well known that the principal occurrences of chrome iron ore are connected with serpentine. Formerly all these deposits were believed to have been produced during the serpentinisation of the peridotite. It is probable that some of the chrome iron ore which is enclosed in serpentine has originated in this way, because we know that certain original constituents of the peridotites, especially chrome-diopsid and chrome-spinel (picotite), contain chromium in considerable quantities. Chromite may be formed by the decomposition of chrome-spinel and silicates containing chromium in the same way that magnetite is formed by the alteration of ferro-magnesian silicates into serpentine. Still, only a portion of the chromite can have been originated in this way, for comparatively recently considerable bodies of chromite have been found by Vogt in quite fresh peridotite, and he proves most convincingly that the greater part of the chromite has been formed as a segregation in the original magma.

Almost everything that has been said as to the mode of occurrence of the titanic iron ores in gabbro may also be said of the deposits of chromic iron ores in peridotites. Step by step the transition may be followed from the normal peridotite, containing about 1 per cent. of chromite, into chromite peridotites containing 5, 10, 25, and 50 per cent. chromite, and further, into purer chromite segregations containing 75, 90, 95, and even 99 to 100 per cent. chromite. Moreover, microscopic examination of the transitional types proves that the chromite is of earlier crystallisation than the accompanying magnesian silicates, olivine, and enstatite, which proves that the chromite was formed during the period of cooling of the peridotite magma.

A large deposit of chrome iron ore occurs in serpentine at Beaconsfield, Tasmania. It has not, however, been exhaustively examined from a genetic point of view.*

Segregations of Nickeliferous Pyrrhotite in Gabbro.

The presence of small sporadic particles of pyrites in volcanic and plutonic rocks is well known. Iron pyrites is one of the most widely-distributed accessory minerals of

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* Since the above was written these deposits have been examined by Mr. W. H. Twelvetrees, F.G.S., Government Geologist, and his report thereon will shortly be issued by the Mines Department of Tasmania.

eruptive rocks. It occurs in perfectly fresh undecomposed rocks under such microscopical relations with regard to the other component minerals that there can be no doubt as to its primary nature. Occasionally iron pyrites is replaced by copper pyrites. The minute particles of copper pyrites in the younger lavas of the Albano Mountains in Italy is a case in point. Pyrrhotite often occurs as an accessory mineral of many gabbros, and it has also been noted in basalts, for example, on the west coast of Greenland. In metallurgical processes, also, the formation of crystals of copper pyrites has been observed in silicious slags, which are very slowly cooled. Thus, the production of deposits of sulphide ores by the process of magmatic differentiation appears to be not only possible, but highly probable.

J. H. L. Vogt has given a very exhaustive demonstration of the eruptive origin of a very important class of nickel ore deposit, the nickeliferous pyrrhotite of Sudbury (Canada), of Ringericke, Bamble, &c., in Norway, of Klefua, in Sweden, the Gap Mine (Pennsylvania), &c. These well-known deposits, which have a world-wide distribution, contain the following characteristic minerals:—Nickeliferous pyrrhotite, with from 2 per cent. to 12 per cent. of nickel and cobalt; iron pyrites sometimes rich in cobalt; pentlandite (Fe,Ni)S., millerite, &c. Copper pyrites and titanic ore are always present, while other ores, such as galena, zinc-blende, compounds of arsenic and antimony, are either entirely absent, or are present only in minute traces. Both in composition and in the general nature of the occurrences these deposits exhibit essentially the same characters wherever they have been met with. The nickel content varies from 2 per cent. or 3 per cent. up to 12 per cent. The proportion of nickel to cobalt varies from 4 · 1 to as much as 15 · 1, and the proportion of nickel to copper from 2 · 1 to about 4 · 1. They are always intimately connected with a gabbro rock, and in the latter the sulphide ores are always to be found in greater or lesser quantities. Frequently the gradual passing over may be observed from the normal gabbro into pyrrhotite gabbro, with from 5 to 95 per cent. of ore, and finally into the pure pyrrhotite. Very frequently, however, the contact between the ore and the gabbro is quite sharp, and the former is often observed to form dykes or veins in the adjoining country-rock. Similar dykes are found composed of the intermediate product, the pyrrhotite gabbro, and the same class of phenomena are also frequently observed in the case of differentiated deposits of titanic iron ores and chromic iron ores. Such occurrences may be explained by supposing movements to have taken place in the magma after the process of differentiation had become wholly or partially complete. The gradual passing over of gabbro to pure pyrrhotite is not, however, so frequently observed as is the case with the oxide concentrations. This is probably due in part to the low fusibility of pyrrhotite. Microscopical research has proved that whereas the titanic iron ore and the chromite have solidified before the accompanying silicates, pyrrhotite has been the last to solidify. It is also highly probable that the fluid molecules of the sulphide ores, as soon as they are formed, have a tendency to run together and separate from the gabbro magma in the same way that matt separates itself from molten slag. Any movements in the magma, from whatever cause arising, before the differentiated products had solidified might produce intrusions of ore into the gabbro or into the adjoining country-rock. The nickel pyrrhotite deposits are essentially a marginal phenomenon. In the great majority of cases they are found directly at the contact of the gabbro mass. Sometimes, however, they occur within the gabbro, but usually, even then, they are nearer the periphery than the centre. The intrusions into the neighbouring country-rock are seldom found more than a few hundred feet from the contact. One or two deposits of nickeliferous pyrrhotite are known in Tasmania, but so far have not been worked extensively.

As further examples of metallic concentrations which are believed to be caused by magmatic differentiation, may be mentioned, the native iron in basalt on Disko Island on the west coast of Greenland; the nickel-iron alloy awaruite in pyroxenite at Awarua, New Zealand; the native platinum in olivine gabbro in the Ural Mountains. Gold has been recorded as an original constituent of granite from a great number of localities, as also native copper in basaltic rocks. In the two latter cases, however, the primary nature of the metal can hardly be regarded as absolutely certain.

The cause of magmatic differentiation is a subject of great complexity, and a very large number of theories have been put forward by eminent geologists. So far, however, these efforts have failed to supply an adequate explanation of the facts as recorded. Vogt discusses the various theories at length in a recent number of the *Zeitschrift fur practische Geologie*, and though he finds them all wanting, he comes to the conclusion that the chemical action of water in the magma must have been one of the principal factors in bringing about magmatic differentiation. This is a very interesting conclusion, for if this becomes established, there seems to be a reasonable hope that a comprehensive theory of magmatic differentiation will be evolved which will not only account for the concentration of ores in the magma, but will also account for the pneumatolitic extraction of the metals which are found in deposits formed by gaseous emanations from igneous magmas. It is to this class of ore deposit that we must now turn our attention.

Magmatic Extraction.

Eruptive magmas are known to contain magmatic water in varying amounts. This is proved directly by our experience of volcanic eruptions. These may be divided into two classes, namely, quiet eruptions and explosive eruptions. In the former, lava-flows predominate; in the latter, showers of ashes and great quantities of steam are the principal products of eruption. The fusing point of an eruptive rock is dependent largely upon the amount of magmatic water present in the magma. Thus, Daubrée has shown that all silicious rocks and glass mixtures in the presence of superheated water will become more or less liquid at temperatures much below that necessary to produce true fusion. At 400° F. such rocks become pasty, at 800° completely fluid. The same takes place at even lower temperatures if a little alkali be present. True igneous fusion of the same materials only takes place at a temperature of 2500° to 3000°. It has further been shown that the temperature of quiet eruptions is generally much greater than the temperature of explosive eruptions. There is no doubt that the same difference exists in the case of magmas which solidify underground. This is shown by the difference in the character of the metamorphism which various rock masses have produced in the adjoining rocks. Sometimes the latter have been completely fused by contact with the eruptive rock. In this case the metamorphosed zone is always very narrow, often not more than a few feet in width. In other cases the adjoining rock has not been fused at all, and shows little sign of having been subjected to high temperatures, but here the zone of contact metamorphism is often extremely large, and the formation of new minerals very abundant. The former kind of contact metamorphism is believed to have been produced by an igneous rock at a high temperature with little magmatic water; the latter by an igneous rock at a relatively low temperature with much magmatic water. In the former case the agent producing metamorphism is heat; in the latter case it is believed to be magmatic water, which is expelled from the magma, and penetrates into the surrounding rock. In Tasmania we have examples of the former class in the diabase (dolerite) which occurs in such abundance over a large part of the Island; while the granite and gabbros on the West, North, and East Coasts are representatives of the latter. It is a significant fact that wherever the granite and gabbro occur in Tasmania, we also find numerous ore deposits, whereas not a single deposit has yet been shown to have any connection with the diabase.

Contact metamorphism often takes place without considerable migration of material from the eruptive magma to the rigid neighbouring rocks, and in this case the molecules are merely re-arranged into new compounds under the influence of the injected steam. In other cases, however, a considerable migration of material takes place, as, for example, in the conversion of beds of limestone into garnet rock, epidote, &c. Sometimes the migration of certain metals is so great that very considerable ore deposits are formed.

There is no doubt that some deposits may have been produced directly by sublimation. The small deposits of specularite which are formed in the crevices of recent lavas and in the craters of active volcanoes are evidence of this. These are true sublimates formed after the reaction:—

$$2\,Fe\,Cl_3 + 3\,H_2O = Fe_2O_3 + 6H\,Cl.$$

After Bensen, the process by which minerals are formed by reactions of gases on one another is known as pneumatolysis. In the metallurgical processes of roasting and smelting, products of sublimation are often formed which possess the same characters as natural ores. As, for example, artificial galena, zinc blende, realgar, &c. Besides these, a whole series of minerals have been artificially produced by experimentalists in pneumatolysis.

Contact Metamorphic Deposits.

This class of deposit we may regard as having been scientifically proved to have derived its metallic contents directly from eruptive rocks. After Von Groddeck,* these deposits are known as the Christiania type, for they occur in large numbers in the Christiania district in Norway. They are now known to exist in almost all countries, but in proportion to their distribution they have not proved of very great commercial importance.

* Lehre von die lagerstätten der Erze, 1878, p. 260.

These deposits always occur within the zone of contact metamorphism, either at or near the contact of plutonic eruptive rocks with the adjoining sedimentaries, or within the eruptive mass, but in the latter case they are always found attached to fragments of the country-rock which have become included in the magma. The most important criteria for recognising these contact deposits is to be found in their mineralogical composition, namely, in the presence of minerals which we already know to be formed by contact metamorphic agencies. Where, as is frequently the case, the ores have been metasomatically deposited in limestones, dolomites, or other calcareous rocks, we find as contact minerals, garnet, epidote, light-coloured pyroxene, wollastonite, vesuvianite, and other lime silicates; whereas ore concentrations in slates, &c., are accompanied by chlorite, andalusite, chiastotite, cordierite, scapolite, &c.

The proof of their direct derivation from the eruptive rocks is based on the following facts:—The deposits invariably occur within the zone of contact metamorphism, great numbers of them lying directly at the contact of the eruptive rock, and some lying within the eruptive rock itself; but in that case they are always attached to fragments of the country-rock which have been included in the magma. The latter kind of occurrence disproves any lateral secretion theory whereby it might be supposed that the metallic contents were derived from the sedimentary rocks. The included fragments to which the deposits are attached are too small to yield the amount of ore which is often found attached to them.

The fact that the ore deposits are never found within eruptive rocks, except where the latter contain fragments of the neighbouring country-rock, proves that the deposits were formed before the granite solidified, for otherwise we would expect to find them, like tin veins and apatite veins, which will be next considered, within the eruptive rock itself.

The most common metallic constituent of these contact metamorphic deposits is magnetite, but sulphide ores are nearly always present in smaller quantities; of these, pyrrhotite, iron, and copper pyrites are the most abundant, and after these, zinc-blende and galena. Moderate quantities of gold and silver are generally present, and often a trace of tin. In shape, the deposits vary very greatly. They very often form regular lodes, running either parallel to the strata or crossing it at an angle, the former being the most common. Sometimes they form irregular lenticular masses, and in other cases they follow the contact of the eruptive rocks.

Contact metamorphic deposits are usually associated with acid rocks or rocks of medium basicity.

Several of these deposits are known in Tasmania. At the Shepherd and Murphy Mine,* in Middlesex, a garnet epidote rock occurs, which is plainly a product of the contact metamorphism of the granite and a limestone bed. Certain portions of this rock are very highly charged with magnetite, which is often present in practically solid bands running through the stone.. This rock is traversed by one of the Shepherd and Murphy tin veins, the walls are sharp and well-defined, and it is evident that the tin vein is younger than the metamorphic rock and its contained magnetite.

In the Comstock district, near Heemskirk, on the West Coast of Tasmania, there are a large number of contact metamorphic deposits. Here they take the form of huge masses or lodes of magnetite, often beautifully crystallised, and associated with a coarsely crystalline light-green coloured mica, which has not been accurately determined. Some of these deposits contain a good deal of zinc-blende and some galena. The deposits have not yet been carefully examined geologically. In the same district there are several big lodes (the Comstock and South Comstock, the Kynance, &c.) which contain payable quantities of zinc-blende and galena. I am at present, however, unable to say whether these have any connection with the contact deposits.† In the North Dundas district also there are deposits of magnetite near the contact of quartz tourmaline porphyry, with highly contact metamorphosed slates, which in all probability are to be referred to this class.

These contact metamorphic deposits are, perhaps more certainly than any others, of true pneumatolitic origin; for they were ejected from the granite while it was still in a molten condition. Beyond this, however, we know very little of the processes which preceded their formation. Even the state of combination of the metals when they were in the gaseous condition is not known. In the case of the next two classes of deposits which we will have to consider, we are justified in the conclusion that the metals were combined with flourine or chlorine, as minerals containing these elements are very abundant in association with the metals; but in the case of contact deposits we have no such clue.

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* G. A. Waller. Report on the Mining Districts of Bell Mount, Five-mile Rise, &c. Mines Dept., Tas.

† Since the above was written I have had an opportunity of examining the ore deposits of the Comstock district. A report thereon will shortly be issued by the Mines Department of Tasmania.—G.A.W., 25.1.03.

Fluorine, chlorine, boron, and sulphur do generally occur in these deposits in small quantities, but never sufficiently to account for the presence of such large quantities of the metals. Carbonic acid has been suggested as a possible explanation, but there is not much evidence in support of this view. It is possible that the recent theoretical proposition of S. Arrhenius,* the eminent Swedish physicist, that "water at high temperatures acts relatively to silica as a powerful acid," may have an important bearing on this subject. If we may assume that the ores are expelled from the granite in the form of volatile hydrates, this would afford a perfectly satisfactory explanation from a geological point of view.

Tin Veins.

Although both contact metamorphic deposits and tin veins have been deposited from emanations from eruptive rocks, their modes of formation are very different. Of the whole magmatic water contained originally in the molten magmas, one portion is expelled before the eruptive rock commences to solidify. This water, as we have seen, produces the phenomena of contact metamorphism. A second portion remains within the magma until the upper portions at least have become consolidated, but finally it also is expelled. Yet another portion remains in the magma to the end, and may be seen in the multitude of microscopic liquid enclosures in the quartz, &c. It is that portion which is expelled from the magma last of all which is believed to be responsible for the formation of tin veins. The complete details of the process by which magmatic water separates itself from the rest of the magmas is, of course, largely a matter of speculation; but so many significant facts have been recorded, and the supposed deposition of tin veins has been so faithfully imitated in the laboratory, that it may be regarded as scientifically proved that this type of deposit has been produced by waters so separated.

Before this question can be discussed, however, it will be necessary to describe the general mode of occurrences of the deposits themselves.

Tin veins are invariably connected with granite, or with the dyke-forming or effusive eruptives that correspond to

* J. H. L. Vogt. Some Problems in the Geology of Ore Deposits. Trans. Am. Inst. M. Eng., 1890.

granite (quartz porphyry, rhyolite, &c.). Corresponding tin-stone deposits never occur with basic eruptives, so that we may at once conclude that tin veins are in some way genetically connected with the acid eruptives. Although tin-stone veins occur in the solid granite, they are sometimes crossed by granitic dykes (aplites), which proves indisputably that they were formed after the consolidation of the upper portions of the granite, but before the last phase of the eruption had been completed. The most characteristic minerals of tin lodes are such as contain the elements fluorine and boron, such as fluorspar with 48·7 per cent. fluorine, topaz with 14 to 18 per cent. fluorine, potassium and lithium micas with 4 per cent. to 9 per cent. fluorine, fluoric apatite with up to 3·8 per cent. fluorine, and the boric silicates, tourmaline with from 8 to 10 per cent. B_2O_3 and 1 to 3 per cent. F, axinite with from 4·6 to 5·6 per cent. B_2O_3, and datolite with from 19 to 22 per cent. B_2O_3, &c. Other minerals frequently met with in tin veins, such as cassiterite, wolframite, columbite, beryl, and tourmaline, also occur in pegmatite veins, and in some localities the pegmatite veins are closely connected with the tin-stone deposits. Of sulphides, there are present iron, copper, and arsenical pyrites, bismuth sulphide, and often small quantities of galena and zinc-blende. One of the most common phenomena connected with tin ore deposits in granite is a remarkable metamorphism of the wall-rock known as greissenisation, and this may sometimes also be observed in connection with pegmatite veins, or at least in veins which are intermediate between tin veins and pegmatite veins. Greissenisation consists of the more or less complete replacement of the feldspar and biotite of the granite with such minerals as potash-mica, topaz, tourmaline, cassiterite, quartz, &c. This greissen often contains so much cassiterite that it becomes the object of mining.

Tasmania is well-known as a tin-producing State, and, as might be supposed, it furnishes examples which have a direct bearing on the origin of tin deposits. Of the several important tin-mining districts, I regret that I am personally acquainted with only one in which typical tin veins occur, namely, the Ben Lomond district, but fortunately this district has been exceptionally favoured as regards the occurence of phenomena which have a direct bearing on the origin of tin veins. I may mention, however, that von Firks has published an exhaustive monograph on the Mt. Bischoff deposits, in which he draws some very interesting conclusions. In this paper I will confine myself to a short account of the tin occurrences at Ben Lomond.*

The granite of the Ben Lomond district is composed principally of quartz and feldspar, with very little biotite. Much of the feldspar (orthoclase) occurs in large well-defined idiomorphic crystals of the Carlsbad twin type, and these are porphyretically distributed throughout the finer-grained ground-mass of the granite. At the Mt. Rex Mine a large tinstone deposit, some 80 feet in width, occurs. This stone is not a typical greissen, as the mica is only recognisable microscopically, but from a genetic point of view the stone is essentially a stanniferous greissen. It is evidently a metamorphosed form of the surrounding granite, for embedded in the greissen are found various pseudomorphs after feldspar, the shape of the Carlsbad twin crystal being distinctly recognisable. During my visit to the mine in June last year I was able to identify the outline of the porphyritic crystals of feldspar in the following minerals:—(1) cassiterite, (2) cassiterite and quartz, (3) confused muscovite and calcite, (4) chlorite, (5) chlorite and quartz, (6) tourmaline (the latter from the section north and adjoining the Mt. Rex Mine). As far as I am aware, the only other locality where cassiterite has been found pseudomorphous after feldspar is at Wheal Coates, near St. Agnes, Cornwall. They were first identified in the Mt. Rex deposit by Mr. W. F. Petterd, of Launceston. They are not so dense nor so clean cut as some of the specimens from Cornwall, but they are unmistakably pseudomorphs. The occurrence of pseudomorphs amounts to a definite proof that all these minerals may occur as a replacement of feldspar. The deposit is traversed by veins of quartz and fluorspar, but no topaz has yet been found in the district. Quartz veins are abundant both in the granite and the overlying Silurian slates, and the latter may often be shown to pass over into veins of pegmatite. In a great many instances I found feldspar with the quartz, and specimens could readily be collected representing every intermediate stage between the pure quartz vein and the typical coarsely crystalline quartz-feldspar-mica pegmatites; the latter, however, are much less common than the quartz veins of the intermediate types. Both the quartz veins and the pegma-

* The following reports on tin mining districts in Tasmania have been issued by the Mines Department of Tasmania since the above was written :—W. H. Twelvetrees, F.G.S., Government Geologist, Report on the Tin Mines of the Blue Tier, County of Dorset; G. A. Waller, Assistant Government Geologist, The Tin Ore Deposits of North Dundas; G. A. Waller, The Tin Ore Deposits of Mount Heemskirk.

tites sometimes contain tin oxide, with or without tourmaline, and there is one instance of an extraordinarily rich patch of tin oxide occurring in a pegmatite vein (the old Lomond Mine). Another stanniferous pegmatite vein contains giant crystals of beryl, which Mr. W. H. Twelvetrees has shown by microscopic examination to contain numerous fluid enclosures of carbonic acid, with moving bubbles. The pegmatite veins are also often accompanied by a certain amount of greissenisation, meaning by the latter term not the formation of typical greissen, but the modified form of that rock, which is common throughout the district. It may be mentioned that true stanniferous greissen occurs at the Roy's Hill Tin Mine, a granite contact deposit some 15 miles from the Ben Lomond district proper.

The age of the tin deposits in the Ben Lomond district, though it has not yet been so accurately determined as in some other districts, is evidently nearly as great as that of the granite itself. The latter is younger than the Silurian strata in which it forms intrusions and has produced metamorphism, and older than the Permo-Carboniferous strata which rest horizontally upon its eroded surface. It is therefore probably of Devonian age. The stanniferous quartz veins penetrate the Silurian strata, but are cut off sharply at the contact of the granite and the Permo-Carboniferous strata. The bottom layers of the latter are also often composed of an old stanniferous wash. This is believed to be the oldest known occurrence of stanniferous gravels in the world.

It is therefore evident that the tin veins were formed before the Permo-Carboniferous, and presumably during the Devonian Period. They belong, therefore, at least to the same geological period as the granite. The granite is traversed by numerous aplitic dykes, but up to the present no case has been recorded in which a tin vein has been intersected by one of these. The aplitic (quartz feldspar) dykes, however, sometimes contain considerable quantities of tin oxide, and even a little galena, both of which have the appearance of being original constituents of the rock.

As early as 1840-50 Elie de Beaumont and A. Daubrée sought to explain the formation of tin veins by pneumatolysis. They proved the stability of stannic fluoride at high temperatures, and assumed that the tin had ascended in this state of combination from the deep-seated "granitic hearth," together with fluoride of boron, silicon, and gaseous chlorine, and phosphorous compounds. They supported this hypothesis by pointing to the prominent part which compounds of fluorine, boron, and phosphorous take in the mineralogy of the characteristic tin-stone deposits. As further evidence, they furnished the results of exhaustive experiments in the production of tin oxide from volatile compounds. In these experiments stannic fluoride could not be used owing to difficulties in manipulation, but they were successfully carried out on the analogous compound stannic chloride. By introducing the vapours of stannic chloride and water into a white-hot porcelain tube, hydrochloric acid and small crystals of tin oxide were obtained. The reaction takes place according to the formula—

$$Sn\,Cl_4 + 2\,H_2\,O = 4\,H\,Cl + Sn\,O_2$$

We have no reason to doubt that the entirely analogous reaction—

$$Sn\,F_4 + 2\,H_2\,O = 4\,H\,Cl + Sn\,O_2$$

would take place under similar circumstances.

By similar experiments, with suitable vapours acting on each other or upon solid substances, many of the accompanying minerals of tin-stone veins were produced, including a substance of analogous composition to topaz.

Recent investigations of the phenomena of magmatic segregation and the formation of pegmatite veins have thrown much light upon the origin of tin veins. For it is now evident from the close connection which exists between tin veins and pegmatite veins, and from the fact that they have so many characteristic minerals in common, that they have been formed from solutions which have a common origin. Now, a similar connection to that which has been shown to exist between pegmatite veins and tin veins has also been proved to exist between pegmatite veins and aplite dykes. As bearing on this point, I might mention the presence of tin oxide in both the aplite dykes and the pegmatite veins at Ben Lomond. It seems, therefore, evident that if aplite dykes are of eruptive origin, so also are pegmatite veins, and after the exhaustive treatment which this question has received at the hands of J. Lehmann, W. C. Brögger, Iddings, and many others during the last few years, the plutonic origin of pegmatite veins is now generally regarded as fully established. The differences between the pegmatite veins and aplite dykes may be satisfactorily accounted for, on the assumption that the pegmatites were deposited from a very much more aqueous magma than the aplites. It appears to be probable that at very high temperatures and pressure magma and magmatic water are miscible in all proportions. If this is the case, we may have a perfect transition from molten magma to aqueous solutions on the one hand, and from eruptive dykes to mineral veins on the other. The series, granite-porphyry dykes, aplite dykes, pegmatite veins, tin veins, is in perfect agreement with this theoretical proposition.

The details of the process by which the magma becomes differentiated into sub-magmas containing varying amounts of water have given rise to much speculation, but there is reason to hope that very soon a sound working hypothesis will be evolved which will explain the division of the magma, not only into highly aqueous and slightly aqueous sub-magmas, but also into acid and basic sub-magmas. The subject is too complex to be discussed in this paper.

Whatever the determining causes are then, the granite magma is believed to separate itself into sub-magmas, containing differing amounts of water. Into the most aqueous of these, Arrhenius concludes, on chemico-physical grounds, that the ions of carbonic acid, hydrogen sulphide, chloric, fluoric, boric acids, silica, the alkali metals, less frequently the alkaline earths and the metals, iron, zinc, lead, copper, and tin would become concentrated. This process has been termed "acid extraction" by Vogt, because fluorine and chlorine are believed to play the principal part in effecting the concentration or extraction of the metals.

The aqueous portion is, of course, very small in comparison to the rest of the magma. Its amount depends upon the original amount of water in the magma, and no doubt in many cases there may not be sufficient water in the magma to produce the division at all. Where it is formed, however, the aqueous portion would be much more mobile than the other part, and would retain its fluid state at much lower temperatures. Owing to the consolidation of the granite, much of it would be expelled through cracks and fissures, and coming up into the cooler portions of the granite would first of all precipitate the normal constituents of the granite, the quartz, feldspar, and mica. The strong acids, still in an excessively hot condition, would attack minerals of the wall-rock, and a series of complex reactions would take place which, after the experimental results of Daubrée, we may well imagine would account for all the phenomena which we meet with in tin ore deposits.

When dealing with phenomena which are so far removed from our observation as the processes of consolidation of deep-seated eruptive rocks, which take place at such high temperatures and pressure that they cannot be imitated in the laboratory, it is not surprising that our notions of these processes should be somewhat vague. This is certainly the case with our modern theories of magmatic differentiation and extraction. Nevertheless, although there may be much that is crude and incomplete in the details of our theories, the main facts of magmatic differentiation and extraction may be regarded as scientifically proved. This is a great step in advance in the theory of ore deposits. For, in magmatic extraction we find an alternative process of concentration to that which has been so carefully investigated by the meteoric school. The adherents of the latter school have shown how concentration may take place after eruptive rocks have solidified. The plutonic school have shown how this may take place before or during consolidation. The working agent of the meteoric school is meteoric water; the working agent of the plutonic school is plutonic or magmatic water. According to some geologists, even magmatic water is of meteoric origin; but this question need not be discussed in the present paper. As far as the origin of ores is concerned, they must be regarded as quite separate.

Apatite Veins.

Professor J. H. L. Vogt* has made an exhaustive investigation of the apatite veins which occur abundantly in Norway, Sweden, and Canada, and he comes to the conclusion that these apatite veins bear precisely the same relation to basic rocks that tin veins bear to the acid rocks.

The following is a very free and somewhat abridged translation of his brilliant comparison of the two types of veins:—

1. Both the tin and the apatite veins represent fairly well-defined groups of ore deposits, both of them intimately connected with eruptive rocks: the tin veins with the acid eruptives—granite and its dyke-forming and effusive representatives; the apatite veins with basic eruptives, such as gabbro.

2. The tin veins, and also the apatite veins, are certainly younger than the eruptive rocks with which they are connected, nevertheless, it may often be proved that the difference in age between the formation of the veins and the consolidation of the eruptive rocks is not great (the apatite veins are sometimes crossed by dykes of diabase, the dyke-forming representative of the gabbro, in the same way that tin veins are crossed by aplite, the dyke-forming representative of the granite).

3. Still more characteristic for both groups of ore deposits is the remarkable metamorphism of the wall-rock, greissenisation in the case of tin veins, scapolitisation in the case

* Zeitschrift fur practische Geologie, 1894-95. Beiträge zur classification der Erzvorkommen, &c.

of apatite veins. This metamorphism is most conspicuous where the veins traverse their own respective mother rocks. This may, perhaps, be referred to the fact that when the veins were being formed, the eruptive rock, although already consolidated, was still in a highly heated condition.

4. From a mineralogical standpoint, we meet with a whole series of very remarkable analogies, and further, also several equally characteristic differences. The tin veins, which are, on the whole, distinctly separate, both mineralogically and geologically, from the common silver-lead veins, are characterised mineralogically and chemically by the following substances:—

Stannic acid (together with tungstic, tantalic, niobic, and sometimes titanic and zirconic acid),
Sulphides,
Silicates (in large quantities),
Borates,
Phosphates (apatite, &c.),
Fluorspar, &c.

The apatite veins, on the the other hand, contain—

Titanic acid (together with iron oxide and a little zirconic acid),
Sulphides,
Silicates (in large quantities),
Phosphates (apatite in large quantities).

4A. Apatite, with other phosphates, is common to both types of ore deposit, with the difference, that in the apatite veins the former is the principal component mineral, while in the tin veins it plays, on the whole, a minor part. Still, apatite is a very characteristic component of tin veins, as proved by the fact that apatite or other phosphates constantly occur in tin veins over the whole world, whereas it is absent entirely, or almost entirely, in the silver-lead veins of Freiberg, Clausthal, Kongsberg, &c. It is true that phosphates are, as a rule, only sparsely distributed in tin veins, nevertheless there are also several exceptions to this; for example, the tin veins in Dakota contain a large amount of apatite and other phosphates, and even in the granite itself, as in Estremandura in Spain, we meet occasionally with apatite veins which, in a broad genetic sense, we may regard as tin veins. Thus, we may follow step by step the transitions of the apatite veins in gabbro to the tin veins in granite.

4B. The stannic acid of the tin veins is represented in the apatite veins by titanic acid, which often occurs in large quantities. In place of cassiterite, we here meet with rutile (together with titanic iron ore, titanite, &c.), but exceptionally; rutile also occurs in tin veins, as at Schlackenwald and Schönefeld in Bohemia.

4c. In both kinds of vein sulphides are present in large quantities, but this is not specially characteristic of these deposits.

4d. In both types of vein the principal vein-minerals consist of silicates, which is of genetic signification, in so far that the presence of silicates in tin veins is one of the distinctions between them and ordinary silver-lead veins.

With regard to the details of the mineralogical differences between the two types of vein, there are also many striking analogies. Thus, in both types of deposit we meet with large quantities of mica—in the tin veins, alkali mica (often lithia mica); in the apatite veins, on the other hand, magnesia mica. Quartz and tourmaline are found in both types of vein, but in tin veins in much larger quantities. The difference lies in the fact that the mineral components of the tin veins—quartz, alkali mica, tourmaline, topaz, beryl, fluorspar, &c.—are in the apatite veins represented by magnesia mica, enstatite, hornblende, scapolite, &c.

5. In both classes of vein we meet a halogen element in very large quantities. In the tin veins fluorine, with occasionally a little chlorine; in the apatite veins chlorine, with sometimes more or less fluorine. In the tin veins the quantity of fluorine which is present in the various fluor minerals (fluorspar, alkali mica, topaz, tourmaline, and fluorapatite) is, as a rule, very great, both relatively to the chlorine and absolutely. Thus, in tin veins and the adjoining metamorphosed wall-rock there is probably more fluorine than tin present.*

6. In the metamorphosed wall-rock of the tin veins a much more considerable transport of material has taken place than in the corresponding wall-rock of the apatite veins. We may explain this phenomenon by the fact that fluorine (in hydrofluoric acid or fluorides) is a much more powerful agent in the tin veins than is chlorine (in hydrochloric acids or chlorides) in the apatite veins. The whole scapolitisation metamorphism is to be referred to an impregnation with chlorides, especially sodium chloride under pressure.

7. In the tin veins, as also in the apatite veins, the minerals characteristic of each vein recur also in the wall-rock. Thus, we find in the tin veins, both in the veins themselves and in the adjoining rock, quartz, alkali mica,

* In a later article, Vogt, quoting J. H. Collins, states that in the tin veins in Cornwall the amount of fluorine is about 100 times as great as the amount of tin by actual weight.

tourmaline, fluorspar, topaz, &c.; while in the apatite veins, both in the veins and wall-rock, scapolite, hornblende, enstatite and magnesia mica.

8. In their chemical and mineralogical characters we meet with many remarkable analogies between the tin and apatite veins on the one side, and their mother rocks on the other side. Thus, in the granites of many localities, cassiterite and tourmaline, and also several other characteristic tin-vein minerals, have been proved to be primary constituents of the eruptive rock; and, in general, all the elements which are characteristic of tin veins, such as tin, silicon, fluorine, boron, phosphorous, lithium, beryllium, uranium, niobium, tantalum, molybdenum, tungsten, &c., also occur in the primary granites. Several of these elements are also especially characteristic of granite-pegmatite veins, for example, minerals like tourmaline, topaz, beryl, elements like niobium, uranium, tantalum, molybdenum, &c. Perhaps even more remarkable is the analogy between the veins and the mother rock of the apatite veins. Thus, we only need remember that both the apatite veins and also the gabbros are remarkable for their richness in phosphorous, titanic acid, and magnesium silicates, also in calcium and sodium silicates. While, on the other hand, potash silicates in both cases play a minor *rôle*. The high iron content (in the titanic iron and specularite), as also the small proportion of nickel, should be noted. The primary differences in the chemical relations between the tin and the apatite veins may be thus summarised:—Tin, boron, potassium, lithium, beryllium, fluorine, and phosphorous (together with uranium, niobium, tantalum, &c.) in the tin veins are replaced by phosphorous, titanium, iron, magnesium, calcium, sodium, chlorine, &c., in the apatite veins.

Titanium occurs in the gabbro and in the accompanying apatite veins, in the place of tin in the granite and the accompanying tin veins. Iron magnesium, calcium, and sodium are, for the most part, replaced by fluorine. The high phosphoric content of the gabbros and the apatite veins may be contrasted with the low proportion of phosphoric acid in the granites and in the tin veins, while more boric acid occurs in the latter than in the former.

In his general description of these apatite veins, Professor Vogt mentions the presence of iron and copper pyrites, small quantities of galena, and zincblende, and also gold and silver. With the exception of the two latter, these are included under the term sulphides in the above comparison. They are not specially dealt with, because they occur in about equal quantities in both kinds of veins.

Pyritic Deposits.

It cannot be claimed that the proof of the plutonic origin of the class of deposits now to be considered is anything like so complete as in the case of tin veins, apatite veins, or contact metamorphic deposits. Still, in some cases there is a great deal of evidence bearing upon the subject. Pyritic deposits do not form anything like such a well-defined class as tin veins or apatite veins, and, of course, there is always the possibility when this is the case, that the various deposits may have originated in several different ways. As, however, my object is not to prove that all ore deposits have been produced by plutonic agencies (a task which would in any case be impossible), but to show that some deposits have been, the fact that some of these pyritic deposits may have originated in other ways does not affect the argument.

Pyritic deposits are noted for their great, often enormous, size. Thus, the largest pyritic deposit at Rio Tinto in Spain measures 3300 feet in length and 600 feet maximum width; the deposit at Sain Bel in France measures 4330 feet in length and 147 feet in width; the Mount Lyell deposit, Tasmania, measures 562 feet in length and 206 feet in width.* They are generally roughly lenticular in shape, but often they are almost irregular masses. Often they are, however, very narrow in comparison to their length. Thus, the famous Rammelsberg pyritic deposit is 3670 feet in length and 70 feet in maximum width, while the largest deposit at Röros, Norway, is 1170 feet in length and 10 feet in width.

Pyritic deposits are generally parallel both in dip and strike to the planes of stratification of the country. Sometimes, however, this is not the case, and very often even if it is, branches or tongues run out from the main deposit into the neighbouring strata. In the Rammelsberg deposit one of these branches has given rise to very heated discussions as to whether it formed part of the original deposit, or whether it had been produced afterwards by crumpling of the strata. Although at Rammelsberg the possibility of the latter having taken place has been demonstrated, in many other cases similar branches have been proved to form part of the original deposit.

In mineralogical composition pyritic deposits vary very considerably. The great bulk of the ore is usually made up of iron pyrites; pyrrhotite is often present in small quantities, and sometimes occurs more abundantly than any other mineral. Copper pyrites and other copper sulphides

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* H. J. Daly. The Mount Lyell Copper Deposits, Tas. Trans. Inst. of Mining and Metallurgy, 1900.

are always present in small quantities. Galena and zinc-blende are sometimes present in considerable quantities, but generally only in traces. Of the non-metallic minerals which occur in pyritic deposits or associated with them, the following are the most important:—Quartz, barite, carbonate spars, magnesia and potash mica, actinolite, chlorite, talc, tourmaline, fluorspar, chondrodite, and axinite. These vary very greatly in the amount in which they occur in various deposits, and none of them can be said to occur in all, except, perhaps, quartz and chlorite. Generally the metallic minerals exceed in amount the non-metallic minerals very greatly.

The structure of the deposits is frequently banded. This used to be always considered to point to a sedimentary origin; now it is more generally believed to be due to the fact that sedimentary rocks have undergone replacement under the influence of mineralising solutions. In many deposits the pyrites is quite dense, as, for example, in many of the deposits in Spain and the Mt. Lyell deposit in Tasmania. In these cases it is uncertain whether the deposits have been formed by metasomatic replacement or have been deposited in open cavities.

Pyritic deposits are almost always connected with eruptive rocks, and sometimes there is proof that they have been formed before the final stages of consolidation, for they are sometimes intersected by the dyke-forming representatives of the eruptive rock with which they are connected. They, however, do not show any preference for any particular rock. Thus, the Norwegian deposits are always found in connection with saussurite gabbro; the Rammelsberg deposit probably with granite; the Spanish with either basic or acid rocks. In this case both acid and basic rocks occur in the vicinity, and it is not known to which class they are to be referred. In the Mt. Lyell district the deposits are associated with acid rocks, quartz porphyries, or felsites, and also with rocks of intermediate basicity, syenite porphyries. It is remarkable that in three districts in which these pyritic deposits occur, namely, Norway, Spain, and Tasmania, the eruptive rocks (in all cases probably intrusive, and in one case, Norway, certainly so) are frequently interbedded with the sedimentary rocks or schists.

The argument in favour of the plutonic origin of these deposits may be briefly stated as follows:—

1. Almost all of these deposits occur in the vicinity of eruptive rocks. The fact that they are not specially bound to one kind of rock, like the tin veins or the apatite veins, is in accordance with what we should expect. The principal

metals of these deposits, namely, iron, copper, silver, and gold, are not specially characteristic of either acid or basic rocks, but occur in both. This we know partly from the results of analyses, which have been made with the object of determining the minute metallic contents of rocks, and partly by the presence of these metals both in tin veins which have derived their metallic contents from granite, and from apatite veins which have derived their metallic contents from gabbro.

2. In some cases the deposits have, as stated above, been proved to have been formed before the final consolidation of the eruptive mass, with which they appear to have a genetic connection.

3. In some cases the deposits are accompanied by minerals containing fluorine and boron, as, for example, fluorite, chondrodite, muscovite, tourmaline, and axinite. In many cases, however, these minerals are either absent or are present only in small quantities. In some cases, on the other hand, they occur in large quantities.

4. In some cases pyritic deposits contain such minerals as garnet, epidote, &c., which are well known as contact metamorphic minerals. They also often contain small quantities of magnetite and specularite, and sometimes these minerals are present in considerable quantities. This seems to point to the possibility of a connection being established between these deposits and contact metamorphic deposits. With the significant exceptions of tin veins and apatite veins, the association of primary sulphide and oxide ores is almost unknown in fissure veins.

5. The suggested sedimentary origin of these pyritic deposits has been definitely shown to be impossible in a great many instances, from the fact that many of them are not conformable, or not strictly conformable, with the strata. There is no more difficulty in explaining the general approximate conformability of pyritic deposits than there is in explaining the general approximate conformability of contact metamorphic deposits. Vogt shows that out of 87 separate contact metamorphic deposits examined by him in the Christiania district, no less than 80 were conformable with the strata. As these deposits are certainly not of sedimentary origin, it is evident that the conformability of ore deposits may have another cause, and the conclusion is not unreasonable that in the case of these two classes of deposits, which are both intimately connected with eruptive rocks, the cause of their conformability is the same.

Supposing, for argument's sake, that both of these classes of deposits have been formed during or soon after the eruption of the granite by gaseous or watery solutions acting under extraordinarily high pressures, we may well imagine that where fissures are absent the solutions would be forced along the planes of stratification of the country. Further, such strata as were especially porous, or especially favourable to the processes of metasomatic replacement, would be proferentially selected by the upcoming solutions. No doubt any fissures which were in existence would be fully used; and many of the deposits have certainly been formed along fissure planes. In other cases, although the solutions may have come up along fissures, deposition has only taken place along certain beds favourable to metasomatic action, which are intersected by the fissures. Under the very high pressures which would be present during the formation of these deposits, it is probable that open fissures could not exist. Under the circumstances, the planes of fissuring might not afford a much more favourable channel of escape for the solutions than specially porous beds in the sedimentary rocks. It seems also probable that, during the process of mountain-building, the fissuring itself would take place largely along the planes of stratification.

The general approximate conformability of the pyritic deposits with the surrounding sedimentary rocks is therefore not an argument against the plutonic origin, though I cannot regard it in the present state of our knowledge as a strong one in its favour.

Notwithstanding these arguments, there are some geologists who still adhere to the sedimentary origin of certain deposits; such, for example, as the pyritic deposits of Rammelsberg, where the non-conformability has not been proved. I do not propose to discuss this question in the present paper. As far as my present argument goes, it is sufficient to know that many deposits have certainly not had a sedimentary origin.

An extremely interesting group of pyritic deposits occurs at North Dundas, on the West Coast of Tasmania. The West Coast is now well known on account of its large deposits of sulphide and pyritic ores; but it is not so well known that some of these deposits contain very considerable quantities of tin. The principal importance of these pyritic tin-copper deposits from a genetic point of view lies in the fact that they appear to form a connecting link between deposits which are of certainly plutonic origin and deposits for which a plutonic origin cannot be directly proved.

At North Dundas the source of the tin is undoubtedly to be referred to numerous dykes of tourmaline quartz-porphyry, which penetrate both the older sedimentary slates and greywackes (Silurian), and the gabbros and serpentines, which also abound in the district. In this tourmaline porphyry, which often shows evidence of intense alteration, especially silicification, veins of tin oxide occur. It is true few of these have so far been observed *in sitû*, but in the alluvial workings large blocks of vein-stone are often found attached to the porphyry, composed of nearly pure tin oxide. The largest of these blocks, which weighed nearly 19 cwts., was purchased by the Tasmanian Government, and may now be seen in the Museum, Hobart.

The pyritic-tin deposits (the Cornwall, the Commonwealth, the Renison Bell mines, &c.) all occur in the sedimentary rocks, and have evidently been formed by the process of metasomatic replacement. This is best seen in the Cornwall Mine, where the rock, which has undergone replacement, is a finely laminated shale in which the various layers or laminae have been affected to a varying extent, some of them having been completely replaced, others only partly, while others have repelled the attacks of the mineralising solutions altogether. The result of this is that the whole structure of the original shale is beautifully preserved in the hard pyritic ore body. The ore consists of iron pyrites and pyrrhotite, with seams of tin oxide, running parallel to the planes of stratification; the latter are sometimes composed of almost pure cassiterite, but in most cases the tin is distributed in small grains throughout the pyrites. In this dense ore there are none of the minerals present which usually accompany tin, but in the centre of the body there is a vein about 18 inches in width composed largely of the highly characteristic mineral, axinite, with small quantities of arsenical pyrites, pyrite, and pyrrhotite. This vein cuts across the lines of stratification of the country and the bands of ore in the deposit, and certainly the filling has at least the appearance of being deposited later than the pyritic body. In the Commonwealth Mine, there are also veins containing fluorite associated with the deposit, as well as axinite. Another remarkable feature of these deposits is the presence of a good deal of actinolite. This is a metamorphic product, and is caused by the alteration of the slates or limestones, as shown by innumerable intermediate rocks between slate or limestone, with here and there a minute needle of actinolite and a rock composed, as far as the naked eye can see, of nothing but a dense mass of felted actinolite.

The Renison Bell deposits are also of metasomatic origin, but here the rock which has undergone replacement is not a finely laminated shale, but an ordinary calcareous slate and sandstone. These are often lying nearly horizontally, and sometimes form flat anticlinal and synclinal folds. The replacement is not so evident in these deposits as at the Cornwall Mine, as the slate is of a more homogeneous nature. In one case a band of slate or limestone 20 feet in thickness has been completely converted into stanniferous pyrrhotite and pyrite for about 300 feet. A remarkable feature about the Renison Bell deposits is the complete, or almost complete, absence of minerals containing fluorine and boron. Only in one instance a small piece of slate was observed which contained some fine needles, which I took to be tourmaline. Tourmaline porphyry, however, occurs in the vicinity.

The beautifully-banded structure of some of the North Dundas pyritic tin ore might, like the so-called "Annual Rings" (Jahresringe) of the Rammelsberg deposit, be taken by themselves to indicate a sedimentary origin. There is, however, distinct evidence that this is not the case. At the Renison Bell Mine several of the deposits are confined to zones of fissuring, and the metasomatic deposition of the pyrites is confined to this zone. In other cases special bands of country have been impregnated or completely replaced for considerable distances away from the zone of fissuring. In the Cornwall and Commonwealth mines, the deposits have hardly been sufficiently opened up to afford definite evidence of this kind; but here the presence of veins containing axinite and fluorite is strongly suggestive of plutonic action. I believe, however, that in this instance the axinite veins were filled after the deposition of the sulphide bodies and their contained tin. A similar conclusion has been arrived at by Von Firks with regard to the tourmaline in the tin-stone deposits at Mt. Bischoff. From microscopic examination he concludes that the process of tourmalinisation was subsequent to the process of topazisation and the deposition of tin. Thus, it would appear that the boric emanations succeed the stannic emanations in order of occurrence. That boric emanations, however, may occur with, or even before, the deposition of tin, is proved by many stanniferous quartz-tourmaline veins and by contact metamorphism accompanied by tourmalinisation. It is evident that this question is one of great complexity. Whether the axinite was deposited subsequently to the tin or not, however, its presence is strong evidence in favour of a plutonic origin of the deposits. For these axinite veins are associated with certainly two, and possibly three, separate pyritic tin deposits. Whereas in this vicinity they are not known apart from pyritic deposits. There is, therefore, some connection between the two. Unless the axinite was deposited at the same time as the pyritic deposits, and from identically the same solutions, the only possible connection which they can have is that the solutions which deposited the pyritic deposits ascended by the same fissures as the axinite. If this is the case, these fissures were formed before the pyritic deposits, and therefore the latter were at the time of their formation in direct connection with the granite hearth.

These arguments are decisive against the sedimentary origin of these deposits, and taken in connection with the fact that both stannic and boric emanations are known to have taken place from the tourmaline porphyry, as evidenced by the presence of tin veins in that rock, and of the tourmalinisation of the adjoining country-rock, they form the strongest possible presumption in favour of a plutonic origin.

The Colebrook Pyritic Copper Deposits.

These deposits are situated two or three miles east of the tin deposits which have just been described. There are here no less than six very large pyritic bodies, varying in width from 20 to 60 feet. Of these, four have been shown to be continuous in strike for from 500 to 700 feet at least. The deposits, however, do not consist by any means of solid pyrites, though bands of practically solid ore occur up to 20 feet in thickness. Perhaps the bulk of the lode-matter, however, consists of axinite and actinolite, with more or less pyrites, and often considerable amounts of copper pyrites distributed through it. The great bulk of the ore presents a similar banded appearance to that already described as occurring at the Cornwall Mine. There can be no doubt of the metasomatic character of the deposit. The rock which has suffered replacement was in part a laminated shale, in part limestone, and every gradation between these two rocks and the normal lode-matter can be observed. The principal minerals present in these deposits, arranged approximately in order of their abundance, are the following:—Actinolite, axinite, pyrrhotite, iron pyrites, copper pyrites, arsenopyrite, calcite, datolite, danburite, and quartz.

These deposits differ from the pyritic tin deposits principally in the absence of tin, the greater abundance of axinite actinolite, and the fact that the latter are more closely associated with the pyrites. In the pyritic tin deposits the axinite, &c., only occur in veins through the pyritic bodies, and here the presumption is that the axinite veins are of later age than the latter. At the Colebrook, on the other hand, the pyritic deposits were formed simultaneously with the deposition of the axinite and the actinolite. At the

Cornwall Mine the axinite veins contain all the metallic ingredients of the Colebrook, namely, pyrrhotite pyrite, arsenopyrite, and chalcopyrite; but here these minerals have been deposited in a fissure, and are not due, at any rate where the vein is in the solid pyrites, to metasomatic replacement. From these differences in the facts of the occurrences of the two classes of deposits, I draw the following conclusions:—

1. Both classes of deposit were formed by emanations from one and the same granite magma.

2. The pyritic tin deposits are probably products of emanations of slightly earlier birth than those which deposited the pyritic copper deposits of the Colebrook; the former having been deposited previous to, the latter contemporaneous with, the axinite.

3. If, however, it is proved at some future time, that in the case of the pyritic tin deposits, the latter are contemporaneous with the formation of the axinite, which I think is still very possible, then I would suggest that the difference in the metallic contents of the pyritic tin deposits and the pyritic copper deposits may be due to the fact that the latter are further removed from the seat of the granitic eruption.

Barn Bluff Pyritic Deposits.

The pyritic deposits in the vicinity of Barn Bluff, on the West Coast of Tasmania, lead us one step further in tracing the origin of pyritic deposits to plutonic agencies. The metallic contents of these deposits are essentially the same as those of the Colebrook Mine, namely, pyrrhotite, iron pyrites, markasite, copper pyrites, arsenical pyrites, with small quantities of gold and silver; to these, however, must be added specularite, which occurs disseminated through the other sulphides. Occasionally the ore consists of an intimate mixture of pyrrhotite, specularite, and fine fibres of actinolite, when it has a very remarkable appearance, and when first found was mistaken by the prospectors for chalcocite. These deposits also are distinctly metasomatic, the solid pyrrhotite being often observed to pass over by imperceptible gradations into practically unmineralised quartzite. The ore-bodies consist of bands from 2 to 20 feet in thickness of ore and actinolite rock, with occasional bands of quartzite. The actinolite rock often contains a fair percentage of copper pyrites through it. Like almost all pyritic deposits on the West Coast, these bands are conformable with the surrounding country, which strikes at this place a little north of west. At the Barn Bluff G.S. & C. Mine, which is the only one opened up to any extent as yet, the ore-body is bounded by a dyke of quartz-porphyry coursing about N.W. and S.E. This porphyry has been completely altered to a chloritic rock, and can only be determined by microscopic examination; the latter reveals the presence of feldspar crystals and corroded phenocrysts of quartz. In the vicinity of the porphyry the sandstones have been impregnated by chlorite, and converted into chlorite schist. This chlorite schist and the chloritised quartz-porphyry are practically indistinguishable to the naked eye.

Although no axinite, fluorite, or other minerals containing boron or fluorine have yet been found in the Barn Bluff deposits, I think that their resemblance to the Colebrook deposits in other respects is so striking that it is impossible to suppose that they can have had an essentially different origin.

I regret that I am unable to discuss the origin of the many other large pyritic bodies on the West Coast of Tasmania, such as the Mt. Read and Hercules, the Rosebery, the Mt. Black, and the world-renowned Mt. Lyell and North Lyell, the numerous deposits at Mts. Darwin and Jukes, Tyndall, and the Red Hills. Although I have visited most of these localities, I have not yet had the opportunity of studying them exhaustively, and without very exhaustive examination it is impossible to arrive at any conclusion with regard to their origin.

True Fissure Veins.

It will be impossible for me to give a complete review of the evidence which has been deduced for the plutonic origin of fissure veins. This is the most complex, and probably the most important, class of ore deposits with which we have to deal, and it is also that class upon which the greatest differences of opinion exist among geologists as to the question of origin. I propose here to describe only a few striking instances in which veins containing the metals, copper, lead, zinc, silver, gold, have been proved to be of plutonic origin. We will then be in a position to briefly discuss the question from a theoretical point of view.

Copper Pyrites Veins.

There are some kinds of copper pyrites veins which are so directly connected with tin veins, that it is not possible to imagine that they can have been deposited by any other solutions than those which deposited the tin. The most instructive case is that of the tin-copper veins of Cornwall, in Great Britain. In the upper levels many of these veins were worked for copper alone, tin being practically absent. In depth, however, the tin content increased, while the copper content fell away, so that during the process of mining three fairly well defined zones were exploited—the upper zone, in which copper alone was won; the middle zone, in which both tin and copper became the object of mining; and the bottom zone, in which tin alone was won. C. Le Neve Foster* illustrates this very well in a projection of the famous Dalcoath lode. The three zones are seen to lie nearly horizontally one above the other. The lode also changes its wall-rock in depth, the upper levels being mostly in slate (killas) and the lower levels in granite. But the diagram shows distinctly that the change in metallic content is totally independent of the change of country, for at the eastern end of the mine workings the granite lives nearly up to the surface, whereas the change in mineral contents has taken place at the usual level. This change of character with depth in the case of the Cornish tin mines is most suggestive of the way in which the same solutions, emanating from eruptive magmas, may give rise to deposits of a totally different metallic content. Many other lodes in Cornwall show a similar alteration in depth. At the surface they are either copper veins or copper-tin veins, the former being as a rule closer to the periphery of the granite masses than the latter.

Vogt describes† a number of copper deposits in the district of Thelemarken, Norway, which present some remarkable similarities to tin veins. They are, in fact, as he remarks, "tin veins with copper ore instead of tin." Mineralogically they are characterised by the minerals chalcopyrite, bornite, chalcocite, with here and there specularite, galena, and zinc-blende, fahlerz, ores of arsenic, bismuth, and uranium, native gold, silver, and copper, titanic iron ore, rutile, &c., in combination with quartz, muscovite, calcite, dolomite, and fluor-spar (sometimes so massive that it becomes the object of mining); further, tourmaline, and, in smaller quantities, beryl and apatite. The deposits occur in connection with dykes of granite, and the latter, in the vicinity of the veins, has been converted into an almost typical greissen.

Silver-Lead Veins.

C. R. Keyes‡ describes a group of silver-lead veins in the Mississippi Valley, 20 miles east of Ironton, Missouri, which bear upon this subject. The wall-rock is the common coarse-grained red granite of the region, composed chiefly of orthoclase and quartz, with some biotite and plagioclase. The veins vary in width from three to five feet, and the country-rock on each side of the vein has been converted into a

* Mining, 1883, p. 452.

† Z. f. P.G., 1895, p. 149.

‡ Diverse origins, &c. Trans. Am. Inst. M. Eng., Nov., 1901.

typical greissen, or a mixture of quartz and mica, the feldspars having been completely replaced. Both in the vein-stuff and in the altered wall-rock a number of minerals are present which are typical of tin veins, namely, lithia-mica, topaz, fluorspar, wolframite, muscovite, &c. The veins themselves are composed largely of quartz carrying argentiferous galena and pyrites and the sulphides of iron and copper. Picked samples of the ore have gone as high as 300 ozs. to the ton, while the average of 50 assays was 46 ozs. to the ton, according to Hawarth, the Missouri State Geologist. The nature of the alteration of the granite walls leaves no doubt that there was genuine fumarole action, during the operation of which vapours from below not only corroded the wall-rock, but also brought up in the volatile form different elements necessary for the production of the several minerals.

In many mining districts tin veins have been shown to pass over into mineral veins of various types, and in some districts whole groups of varieties have been shown to have an intimate connection with tin veins and with one another. Thus, in the Freiberg district, in the Erzgebirge, there are two distinct groups of veins which have been proved to have been formed during separate periods of ore-deposition corresponding to two periods of eruptive activity. In each group there are several varieties of totally different mineralogical composition; but, whereas the two prime groups always keep separate, the different varieties of each group graduate into each other. Thus, in the older of the two prime groups the veins of the tin formation graduate into both the veins of the pyritic copper formation and of the pyritic lead formation, *i.e.*, cases have been recorded in which the tin veins change their character and gradually assume the character of the pyritic copper formation or the pyritic lead formation. In the same way the pyritic copper formation graduates into the pyritic lead formation, and the latter into the noble quartz formation, and this again into the veins of the brown spar formation. But no case has ever been recorded of one of the varieties belonging to the older prime group graduating into one of the varieties of the younger prime group. Perfectly analogous relations exist between the varieties of the older and the younger prime groups in other mining districts of the Erzgebirge, such as Schneeberg, Annaberg, and Altenberg, so that it is evident that throughout the whole of the Erzegebirge there were two distinct periods of ore-deposition, in each of which a number of varieties of veins were formed.

A direct genetic connection between the varieties of each period has been proved, and among the varieties of the older group we recognise tin veins, which we have reason to believe have been deposited by solutions emanating from the eruptive rocks. The conclusion is here irresistible that the other varieties have been deposited either from the same solutions which formed the tin veins or from other solutions which had the same source.

Gold Quartz Veins.

The plutonic theory has been proved to be particularly applicable to gold quartz veins in some very conspicuous instances. The most complete demonstration is furnished by J. E. Spurr*, who has shown that the gold quartz veins in the district of Yukon, in Alaska, contain a large number of accessory minerals which are characteristic of the pegmatite veins. Further, he demonstrated that the quartz-veins pass over by gradual transitions into aplites, or finely-crystalline quartz feldspar dykes, and also into pegmatite veins. G. F. Becker† also has recorded that the gold veins of the southern Appalachians contain 62 accessory minerals which are characteristic of pegmatites, among these being tourmaline, cassiterite, apatite, orthoclase, albite, garnet and scheelite.

Several localities in Tasmania furnish evidence of the plutonic origin of gold quartz veins, though I have not heard of any evidence from the recognised goldfields; with these I am not personally acquainted. The most striking instance is that of the Echo Mine‡ near St. Helens. We have here what I believe to be an intermediate type between gold quartz veins and aplite dykes. The formation is about 40 feet wide, with an extremely silicious aplite rock on either wall, and quartz with some pyrites, markasite, and pyrrhotite in the centre. The aplite consists of much quartz with relatively small quantities of feldspar and muscovite. The aplite is less acid at its contact with the wall-rock than at its contact with the quartz, and there is no sharp line of division between the two. Tourmaline crystals are occasionally seen in the quartz and embedded in the pyrites.

From these examples and from many others that might be given we may draw the following conclusions:—

1. That, besides the deposits like tin veins, apatite veins, and contact metamorphic deposits, which represent the first deposition of ores from plutonic waters, there must be many

* Geology of the Yukon Gold District, Alaska. 18th Ann. Report of the U.S. Geol. Survey.

† Goldfields of the Southern Appalachians.

‡ G. A. Waller. Report on the Mining Districts of Scamander River and St. Helens.

other classes of deposits produced by a subsequent deposition from these same waters.

2. That these latter deposits will be formed largely in the great fissures, for these represent the natural channels of underground circulation.

3. That the plutonic waters may mingle with the meteoric waters, and be carried for long distances before their metallic contents are deposited.

4. That fissure-veins which have derived their metallic contents from plutonic waters may contain all the metals commonly met with in fissure-veins, and especially copper, lead, zinc, silver, and gold.

5. That fissure-veins of plutonic origin which contain these metals are not connected with any one class of eruptive rocks to the exclusion of any other class, but may occur in connection with all eruptives; and that, further, they are not exclusively confined to any one period in the consolidation of the eruptive rock with which they are connected. These conclusions are important, and need a little explanation. We have seen that the metals, tin, tungsten, bismuth, &c., are specially characteristic of granitic emanations, as proved by their presence in tin veins, and that titanium, nickel, and cobalt are specially characteristic of gabbro emanations, as proved by their presence in apatite veins; but the metals copper, lead, zinc, silver, and gold occur both in tin veins and apatite veins. They may vary considerably in amount in the two sets of veins, but are not exclusively confined to either. These metals also occur in veins which represent intermediate types between tin veins and apatite veins. Further, they all occur, often in considerable amounts, in contact metamorphic deposits.

Thus we see that eruptive emanations containing the metals commonly met with in fissure-veins may take place either from acid rocks or from basic rocks, and they may take place either in the early stages or in the latter stages of the consolidation.

6. Fissure-veins of plutonic origin must vary very greatly in their metallic contents, in the character of the vein-minerals, and in the nature of the metamorphism of the wall-rock. The variations may arise from any of the following causes:—

(*a*) The original solutions, emanating from rocks of different composition, and at different periods during their consolidation, would have different temperatures, different pressures, different metallic contents, and different chemical properties.

(*b*) There would be a sequence in the deposition of the metals during the gradual lowering of temperature and pressure, as the solutions ascended from lower and hotter levels to higher and cooler levels.

(*c*) The presence of precipitates for special metals in the wall-rock, or in meteoric waters coming from the wall-rock, might produce special concentrations of metals where the fissure traversed certain rocks.

(*d*) Variations in the amount and kind of metamorphism which the solutions produce on the wall-rock would result from the gradual lowering in temperature of the solution, and from the fact that certain specially-active mineralising agents became exhausted from the solutions.

(*e*) Variations in the composition of the vein-minerals would be produced in part by the same causes which produce variations in the metallic contents, and in part also as a direct result of the metamorphism of the wall-rock. Substances which are taken into solution from the wall-rock in the earlier stages may be deposited from solution during a later stage. From this it follows also that substances such as fluorine and boron compounds, which are deposited during the earlier stages of the journey, may be absent from deposits formed at later stages.

Coming now to the question of the general application of the plutonic theory to the origin of the metallic contents of fissure-veins, it must be admitted at once that there are a great number of types for which little or no evidence in favour of the plutonic theory is forthcoming. In this, however, the meteoric theory is in even a worse dilemma. The only way, as far as I am aware, by which it has been sought to prove the meteoric theory in the case of deep-seated fissure-veins is by analysing the wall-rock, and proving that the same metals which are present in the vein are also present in the rock. But this alone, even if it is shown to be the case, does not always, or even generally, amount to proof that the metal in the vein has been derived from the wall-rock. For there are two alternative possibilities. (1) The metal content of the wall-rock may have been derived as an impregnation from the vein. (2) The metal content of the wall-rock may be totally independent of the metal content of the vein. The latter possibility has been greatly strengthened by the researches of late years, which have shown that most rocks contain minute quantities of the metals commonly found in veins, and therefore that the presence of the same metals in the veins and wall-rock is not at all an extraordinary coincidence. For the further treatment of this question, I must refer to the very remarkable work of J. R. Don*, that indefatigable New Zealand

* (1) Trans. Am. Inst. Mining Eng., Vol. xxvii., 1898.

investigator, entitled "The Origin of Certain Auriferous Lodes," and also to the extraordinarily destructive criticism of Sandberger's theories by A. W. Stelzner.*

On the other hand, it must be admitted that the absence of the metals in the wall-rock, although constituting a disproof of the old lateral secretion theory, does not amount to a disproof of the modern meteoric theory, for the latter does not rely exclusively on the rocks in the immediate vicinity of the deposit to furnish the metallic contents. If the meteoric theory has an extended application in the case of ore-bearing fissure veins, it follows, from the nature of the case, that direct evidence must be wanting in many individual cases.

The definite proof of either the plutonic or the meteoric theory in the case of some fissure-veins being impossible, it remains for us to decide which is the most probable. Personally, I think there can be no doubt that the plutonic theory has by far the more general application. For, in the case of the plutonic theory, there are certain fissure-veins of which there is definite proof of a plutonic origin; and these deposits in numerous cases have been shown to pass over into other types, of which there is no direct evidence of a plutonic origin. Moreover, the causes of variation, which have been proved to be real causes in the case of fissure-veins of known plutonic origin, are sufficient to account for most of the variations which we meet with in veins for which we have no direct proof of plutonic origin.

In the case of the meteoric theory, on the other hand, with the exception of a few highly-specialised types, like the hydrosiliceous nickel veins of New Caledonia and the zeolitic copper deposits (including fissure-veins) of the Lake Superior district, we know of no deep-seated ore bearing fissure-veins which have certainly obtained their metallic contents through the leaching action of meteoric waters. It is true that we are compelled to theoretically admit that circulation of meteoric waters must take place through all rocks which are not in a condition of "flowage." But this need not by any means amount to an admission that this circulation is effective in leaching out the minute metallic contents of rocks.

It is here, I think, that the weak point lies in the general application of the meteoric theory. All experience in deep mines goes to prove the practical impermeability of rocks

* (2) Die Lateralsecretionstheorie u. ihre Bedeutung für das. Pribramer Gebiet. B. u. H. Jahrbuch der K. K. Bergakademie, xxxvii. Bd., 1889. Beiträge zur Entstehung der Freiberger Bleierze und der Erzgebirgischen Linnerzgängen, Z.f. P.G., 1896, p. 377-412.

at great depths. J. F. Kemp* instances several mines which have sunk to depths of 4000 and 5000 feet, in which the water was empounded in the upper levels. In these mines the lower levels (below about 500 feet) are practically dry, the little water which does permeate through the openings in the rocks being removed by evaporation.

I regret that I am unable in the present paper to discuss the many instances of deposits for which there is fairly complete proof of a meteoric origin, and especially that I can give no account of the action of meteoric waters in effecting further concentrations in the upper portions of deposits which are already in existence, and which may have originally been deposited by other agencies. Quite a new light has been thrown on this difficult subject by the investigations of American geologists during the last two or three years, and the conclusions at which they have arrived promise to be of the greatest importance to the mining industry.

* The *rôle* of igneous rocks in the formation of veins. Transactions Am. Inst. Min. Engineers, Feb., 1901.

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NOTES ON THE DIABASE OF TASMANIA AND ITS RELATIONS TO THE SEDIMENTARY ROCKS WITH WHICH IT IS ASSOCIATED.

By T. Stephens, M.A., F.G.S.

The object of this paper is to give a brief retrospect of some of the leading facts and theories already brought forward, to supplement this by evidence furnished by the author's own experience during many years' general acquaintance with the greater part of Tasmania, and to offer suggestions which may help towards the solution of a difficult problem.

The subject naturally divides itself into two principal heads—(I.) the age of the diabase (otherwise described as dolerite, or gabbro, and popularly known as greenstone), in relation to the accompanying sediments, and (II.) its character, present aspect, and mode of occurrence.

I. The earliest systematic attempt to investigate the geological history of Tasmania appears to have been made by Count de Strzelecki during the period 1841-3. His report (1) shows that Strzelecki was fully convinced, after a long course of wide-reaching and arduous exploration, that the occurrence of the diabase is everywhere marked by signs of its intrusive character. Of rocks at Eastern Marshes belonging to the series now known as Permo-Carboniferous, he says (p. 116) that they "have been much fractured and dislocated by the intervening greenstone." Referring to the coal-measures high up on the southern face of the diabase-capped Ben Lomond, he notes (p. 126) the presence of "a seam of coal with conglomerate and sandstone dislocated and uplifted 2100 feet above the actual level of the coal beds." All his other remarks on these rock-relations are to the same effect.

In 1842 Tasmania was visited by the late J. Beete Jukes, whose views respecting the relations of the igneous and sedimentary rocks are recorded in his "Notes on the Palæozoic Formations of New South Wales and Van Diemen's Land." (2) After remarking on the great complexity of the geological structure of South-Eastern Tasmania, owing to the mutual interlacement of the sedimentary and igneous rocks, he gives numerous instances where the Upper Palæozoic marine beds,

(1) Physical Description of New South Wales and Van Diemen's Land. Longmans, 1845.

(2) Quarterly Journal, Geological Society, London, Vol. iii., p. 241.

and the coal-measures, had been tilted up and altered by crystalline greenstone; but he cites two places where the former appeared to him to be of more recent date than the latter. The opinion of so competent and accurate an observer should not be lightly disregarded; but I have shown, in a paper on a section at Frederick Henry Bay, which was read before the Geological Society in 1900, (3) that in these exceptional cases the sections could only have been seen by Jukes from a distance, and that a close inspection reveals unmistakable evidence of intrusion, uplifting, and contact-metamorphism.

In 1848-9 the late Dr. Milligan reported, under instructions from the Government, on the coal formations of Tasmania. He had had frequent opportunities of intercourse with Strzelecki and Jukes, and has recorded many instances of geological conditions which have a direct bearing on the question of intrusion. In his report on the Fingal district (4) he speaks of the greenstone as having "burst through the stratified rocks and overflowed them to a depth of several hundred feet." In that on the Coal River district he notes instances of bituminous coal being converted into anthracite, and shale into chert of flinty hardness in proximity to the greenstone, and of the greenstone "exhibiting on the tableland about Brushy Plains traces of the upper sandstone carried up with it at the time of its elevation." (5)

In 1859 a geological survey of Tasmania was commenced, under the late Charles Gould, but was discontinued six years later because its economic results did not come up to the expectations of the ruling powers. Gould's work was chiefly confined to inland districts, where the actual contact of the igneous and sedimentary rocks is almost always hidden from view, and the absence of distinct proof of their mutual relations made him disinclined to speak authoritatively, as it were, on a question which was then, as now, the subject of much controversy. There was the negative evidence of the absence of any trace of the greenstone in the Permo-Carboniferous conglomerates, and the ascertained fact of extensive faulting in the coal beds and conformable sediments, but the rest was a matter of theoretical deduction. Gould was the first to note the exact external conditions of the Mt. Nicholas Range, which, in his official report on the Fingal district, 1861 (p. 7), he describes as "composed of a narrow

(3) Quarterly Journal, Geological Society, London, Vol. lvi., p 333.

(4) Transactions Royal Society, Tasmania, 1848-50, p. 49.

(5) Transactions Royal Society, Tasmania, 1848-50, p. 69

capping of greenstone, supported on an outlying mass of the coal-measures, about six miles in length and two in breadth," and his section represents this capping as presumably connected with a dyke traversing the underlying sedimentary rocks. Four years later, in a paper on the "Geological Structure of the North-East Coast,"(6) he cites an instance in which the coal-measure sandstone is seen passing under the greenstone, with clear evidence of alteration at the point of contact, as controverting the views held on the subject by some other geologists. And he was in entire agreement with those who regarded all the greenstones of Eastern Tasmania, whether exposed at low levels or on mountain tops, as practically one and the same rock, and on or about the same geological horizon.

I have myself verified most of the facts thus recorded, and the general conclusions have been supported by nearly all who have had opportunities of extended observation, including the Government Geologists, Messrs. A. Montgomery and W. H. Twelvetrees. Mr. R. M. Johnston, who stands without a rival in several fields of scientific research in Tasmania, was at one time inclined to regard the Permo-Carboniferous series as more recent than some of the masses of diabase exposed along the southern coast-line; but, in a note to a paper on this subject, read by him before the Royal Society in 1899, (7) he remarks that he had seen reason to alter that opinion. Professor T. W. E. David, in a paper on "Volcanic Action in Eastern Australia," (8) read before this Association in 1893, refers to and supports some remarks which I made at the previous meeting, to the effect that "the greenstones of Hobart are intrusive masses, probably of the nature of laccolites, which are certainly of newer age than either the Permo-Carboniferous rocks of Hobart or than the Mesozoic coal-measures of New Town, Jerusalem, Fingal, &c."

So much for indirect evidence. On the sea-coast, where erosion still going on prevents the accumulation of talus, &c., that covers the zone of contact inland, there is ample proof of intrusion. Along the deeply-indented shores of D'Entrecasteaux Channel, Bruny Island, Tasman's and Forestier's Peninsulas, and the intervening country, there are very few headlands which are not composed of the typical diabase. This is often flanked or capped by masses

(6) Transactions Royal Society, Tasmania, 1865, pp. 63-5.
(7) Transactions Royal Society, Tasmania, 1899, p. 49.
(8) Report of Australasian Association for the Advancement of Science, Vol. v., p. 403.

of Permo-Carboniferous sandstone, mudstone, &c., so hardened that they yield slowly to the eroding agencies; while, farther away from the outcrops of the diabase, the same rocks have been carved into deep or wide bays by the encroachments of the sea. By far the most interesting of the accessible sections, as showing evidence of intrusion, elevation, and contact-metamorphism, is that at Frederick Henry Bay, to which reference has already been made. On the North and East Coasts the conditions are much less favourable for definite conclusions, but at Port Sorell there are patches of altered sandstone to be seen on exposures of greenstone sheets. At Okehampton Bay, on the East Coast, a band, which is ordinary compact grey shale away from the centre of disturbance, has been altered by similar agency into a black chert-like mineral, with conchoidal fracture. The overlying sandstone has been somewhat hardened, and is traversed by an irregular vertical jointing, an indication of shrinkage during a process of cooling. In a small bay, south of Triabunna, a similar intrusive sheet has converted the coal-measure sandstone into a kind of tesselated pavement, showing the tops of five-sided prisms a few inches in diameter. Other similar instances observed without any systematic exploration might be mentioned, but these may be accepted as affording sufficient proof of the intrusion of the diabase into all the sedimentary rocks, except those of Tertiary age. The latter, in relation to the greenstone, appear to have been deposited after it and the associated sediments had been subjected to extensive and long continued erosion and denudation.

II. The conditions under which the diabase presents itself elsewhere throughout the eastern half of Tasmania, especially where it is seen occupying the summits of all the mountains and principal hills, open up questions much more difficult of solution than that of its relative age. The essential distinction between this rock and the basaltic lavas often in close connection with it, and the consequential difference between their modes of occurrence, have not always been sufficiently recognised. Some writers, even up to the present time, have regarded these huge and widely distributed cappings as the remnants of vast lava flows from a series of volcanoes now no longer in evidence. But the structure of the diabase, at the first glance, suggests that it was not ejected or cooled under sub-aerial conditions. This view was confirmed in 1896 (9) by the report of microscopical

(9) Transactions Royal Society, Tasmania, 1896, p. 89.

examinations by Mr. W. H. Twelvetrees of specimens of the Cataract Hill rock, Launceston, a fairly typical representative of the Tasmanian diabase (or dōlerite). Its essential constituents were found to be plagioclase-felspar, augite, and a little iron oxide, the augite crystals showing ophitic structure on the felspars, and the result of the examination proved the whole character of the rock to be that of one which had crystallised below the earth's surface. A subsequent paper by Messrs. Twelvetrees and Petterd ([10]) gives in admirable detail the results of further microscopical examinations, which fully confirm this conclusion, and coincide with that derived from other evidence already cited.

How, then, is the presence of this uncovered holo-crystalline igneous rock on the summits of so many mountains to be explained? What was its original covering, and how has that covering been removed? Chief among the difficulties that seem to have been encountered in pursuing such inquiries are—the apparent vastness of the area occupied by the mountain-cappings, the absence of visible traces of their former covering, and the great vertical height to which those cappings are supposed to rise above their actual contact with the adjacent sedimentary rocks. The last of these suppositions is a natural one, resulting from the almost invariable concealment of the line of contact by accumulations of talus, &c., at the foot of the cliff-faces exposed; the two former are due to our very scanty knowledge of the immense mountain area which has never been geologically surveyed. Messrs. Twelvetrees and Petterd suggest (*op. cit.*, p. 54) that "the faces and cliffs which we now see are subterranean sections lifted for our inspection by some earth movement"; but, if this is to be taken as meaning that they may have been lifted after consolidation, the theory could hardly be reconciled with the condition of the adjacent sediments where they are exposed to view. Mr. R. M. Johnston has discussed (*op. cit.*, p. 21) the possibility of a lava-flow welling up to the surface by gigantic fissure eruptions, and attaining in places a thickness of 2000 feet or more before cooling, and suggests that the lower portion of such a mass would, through slow cooling, exhibit the structure characteristic of igneous sills. Such a condition is certainly conceivable if sufficient traces could be found of the upper portions of the original mass to show a gradual transition from sub-aerial lava to holo-crystalline diabase; but no such evidence is yet forthcoming.

([10]) Transactions Royal Society, Tasmania, 1898-9, p. 47.

The true key to this hitherto unsolved problem will probably be found in the results of the study of similar phenomena in the southern portion of the Rocky Mountain region in North America. Here the laccolite theory was promulgated in 1877 by G. K. Gilbert, of the United States Geological Survey, as the only possible explanation of the existence of mountain masses of igneous rock, which must have cooled at a great depth below the surface. The history and development of this theory, and its practical application, are exhaustively treated by Whitman Cross in his paper, "On the Laccolitic Mountain Groups of Colorado, Utah, and Arizona." (1) The "laccolite," after all, is only a "sill" on a gigantic scale, and the term is restricted in this paper to a mass of igneous rock which, ascending as a molten magma from unknown depths, has spread out and formed a chamber for itself at a certain horizon, lifting up the load of sediments above it. In some of the instances cited, the uplifted sediments are seen to arch over the porphyrite which forms the mass of the mountain; in others, the igneous rock has been bared to a depth of thousands of feet by their removal. As to other relations of the igneous and sedimentary rocks, there appears to be no general rule. Where the latter are still seen resting on the laccolite they are found to be always more or less altered, while the corresponding strata near the base of the mountain often show little or no trace of effects of intrusion. These, too, are sometimes seen to dip away from the central mass at a steep angle, while elsewhere they abut against it without any sign of disturbance.

The Henry Mountains in Southern Utah were thus described by Gilbert:—"They are not a range, and have no trend; they are simply a group of individual mountains, separated by low passes, and arranged without discernible system. The highest are about 5000 feet above the plateau at their base, and 11,000 feet above the ocean." Of the Mt. Hillers laccolite the report says—"Its depth is about 7000 feet, and its diameters 4 miles and 3¾ miles. Its volume is about ten cubic miles. The upper half constitutes the mountain, the lower half the mountain's deep-laid foundation. Less than one-half has been stripped of its cover of overarching strata; the remainder is still mantled and shielded by sedimentary beds . . . The uncovered part is scored so deeply that not less than 1000 feet of its mass are shown in section." Of the West Elk Mountains, in

(1) Fourteenth Annual Report of the Director of the United States Geological Survey, 1892-3.

Colorado, we read—"These great masses (of porphyrite) lie in the comparatively soft Cretaceous strata, and erosion has removed the overlying sediments entirely or in great part. From the average elevation of the contact to the mountain summits is usually from 2000 to 3000 feet. The thickness now seen in no case represents the original vertical dimensions of the mass." The Ragged Mountain is described as being about eight miles long. "On the west is a very abrupt wall more than 2000 feet in height, presenting an unbroken front for nearly three miles." The Anthracite Range is "a porphyrite mass four miles long from east to west, and quite narrow, possessing a rather sharp crest with several peaks, the highest of which has an elevation of 12,251 feet. To the south this range presents an abrupt face for its entire length. The average height of this steep front is from 1500 to 2000 feet." Mount Carbon is "a single mass of eruptive rock, which rises from 2000 to 3000 feet above the contact with the surrounding Laramie strata." Of Mount Wheatstone the report says—"This porphyrite mass is 4½ miles in length, its breadth from two to three miles, and the summits are 3000 feet above the eastern sedimentary contact." Of Crested Butte, "the western and south-western faces are very precipitous, the cliffs of bare rock rising more than 1000 feet at several places . . . The mass seems to be a huge block of porphyrite resting on shales, erosion having removed all traces of strata from the sides, and obliterated all evidence of the manner in which the eruptive was once covered by them." Of the San Miguel Mountains of Colorado, Mt. Wilson reaches a height of 14,280 feet, and Holmes is quoted as reporting that "all that portion of the summit that rises above 11,200 feet (3080 feet) is of trachyte. This is underlaid by Cretaceous shales in a horizontal position."

Many other instances of the actual conditions disclosed by systematic observation throughout the wide area described are given with full detail in this interesting paper. A few brief extracts may be cited from the remarks on the character of the igneous rocks. The laccolites of the Henry Mountains are described as consisting practically of a single rock-type. "It is a holo-crystalline porphyry, characterised by phenocrysts of plagioclase, with hornblende or augite, and by a granular ground-mass consisting chiefly of orthoclase and quartz. The rock is what has hitherto been called porphyrite by American petrologists, and by some Europeans." The West Elk Mountains show from the character of the intrusive rock that "they are practically identical with the

Henry Mountain bodies in mode of origin. The structure of the rock implies a deep-seated site of consolidation." Speaking generally of the intrusive masses in the region under discussion, Whitman Cross notes as a prominent fact that "the great majority of them belong to one well-marked structural type, with but slight variation in mineralogical constitution." The principal types of the rocks analysed are recorded as *Augite-porphyrite, Hornblende-porphyrite, Quartz-porphyrite,* and *Hornblende-mica-porphyrite.* The variable elements in the series are silica, iron, lime, and magnesia, while alumina and the alkalis remain nearly constant. In the augite-porphyrite there is no distinguishable quartz. As to the geological age of the laccolitic mountains, it appears to have been settled that all the Mesozoic strata now remaining have been disturbed by the intrusion, which in some instances has affected Upper Cretaceous beds, its date being thus brought down to the Tertiary period.

These records are the result of systematic geological examination of an immense area previously mapped out by an accurate topographical survey, with contour intervals of 200 feet. What light can they throw on the history of igneous dykes and cappings in Tasmania, where we have no authentic data beyond the altitudes and approximate outlines of some of the principal mountains, and the results of individual exploration in a few isolated districts? Such conditions afford no grounds on which to base any final conclusions, but an attempt will be made in the remaining portion of this paper to show that the laccolite theory may be accepted as a reasonable explanation of the Tasmanian problem. If the evidence is only of a circumstantial character, all of it, at any rate, seems to point the same way.

As a chief cause of the stupendous development of volcanic energy, as seen in the cappings, sheets, and dykes of diabase which have determined the physical contour of nearly the whole of the eastern half of Tasmania, Professor David long ago suggested heavy sedimentation during the ages following the folding of the Silurian and older strata. There are no data for determining the thickness of the Permo-Carboniferous series, but it is probably not less than several thousands of feet; that of the subsequent pre-Tertiary sedimentation, including the remnants of it which are classed as Mesozoic coal-measures, is quite an unknown quantity, but may have been very considerable.

The first point of resemblance to be noted between these diabase-capped mountains and the laccolites of the Rocky Mountain region is that they follow none of the ordinary laws of mountain elevation. They have no regular trend, and most of them are isolated without any systematic arrangement. Where there is the semblance of continuity in any one direction, a broken or deeply undulating outline suggests eruption from numerous vents along a line of fissure. As typical instances of the more prominent of these mountains, Ben Lomond may be cited in the north, and Mt. Wellington in the south, which, in common with the rest, are more or less bounded by a fringe of Permo-Carboniferous rocks, sometimes supporting conformable coal-measures. The actual contact line is everywhere hidden from view by dense vegetation, or accumulations of talus, the latter a natural consequence of the disintegration of cliffs of columnar diabase exposed by erosion of an original more or less rounded mass. In the Fingal valley the removal of the more or less flat-bedded sediments has in places bared the Silurian strata on which they rest. Sometimes they have been so faulted that they lie in successive benches on the flanks of both mountains; sometimes they dip away from them; while other masses of the same rocks at no great distance appear wholly undisturbed. Elsewhere, and this applies almost to the whole mountain system of Eastern Tasmania, the forces operating in the uplift from below have opened fissures at the points or along the lines of least resistance, so that the molten magma has thrust itself in every direction, becoming visible, after cooling and subsequent denudation, in the form of sills and dykes at great distances from the main centres of disturbance. At one point on the northern flank of the Wellington Range, the removal of talus and forest growth by a great landslip in 1872 exposed massive diabase sloping upwards at a mean angle of about 35° to a height of nearly 1000 feet, and the position of the altered and much-faulted sediments at and near its base suggests that this slope represents the original surface of the igneous mass in contact with the covering removed by local erosion. Space does not allow of any detailed account of the multitude of other somewhat isolated diabase-capped mountains, among which Mt. Field East, Mt. Field West, and Mt. Dromedary, Mts. Seymour, Tooms, and Connection, Mt. Arthur, and Quamby's Bluff, to the south, east, north, and north-west respectively, may be just named as typical instances showing environment favourable to the theory of their laccolitic origin. And it may be noted that indirect evidence of a former covering of sedimentary rocks, or at least of their contact with the diabase, is to be seen in the shingle and gravel beds distributed over some hundreds of square miles in the South Esk basin, and elsewhere. Predominant among their contents are fragmentary remains of altered sandstones, shales, and limestones, which have attained the hardness of quartz through close contact with an igneous rock. Sometimes the evidence is more direct, as at Back River, near Buckland, where the coal-measures at the base of a lofty hill of massive diabase are seen dipping away from it at an angle of about 40°. The continuation of these beds now removed by denudation, at the same angle of inclination, would carry them well over the summit of the diabase in precisely the same way that the sedimentary strata are reported to arch over the Mt. Hillers laccolite.

Some mention must be made of an extensive area of which there is little accurate knowledge, and to which the laccolitic theory is generally supposed to be totally inapplicable. The structure of the elevated region of the interior, commonly called the Central Plateau, and often spoken of as if it were one continuous mass of greenstone, is in reality of a very complex character. It may be described in general terms as a tract of undulating country at an altitude of from 2000 to over 3000 feet, with a general southerly slope, bounded by diabase-capped mountains ranging from 3500 to more than 5000 feet above sea-level, and traversed by lesser ridges of the same rock. The area of this elevated tract of country is, roughly speaking, about 3000 square miles. The outer ring of mountains viewed from the plain-country on the north and east appears to be continuous, but the experience gained in flying visits to the Lake Country from the north, east, and south satisfied me long ago that there are numerous breaks in the diabase capping. Along the greater part of this outer ring there are thick-bedded remnants of the sedimentary rocks already mentioned as fringing mountains of this class, and at numerous points within it one comes upon outcroppings of denuded sandstones, &c., the lateral extent of which can only be guessed at. But for the protection afforded by this elevated outer ring to the greater part of the central upland area from the erosion which has excavated wide valleys and deep gorges outside it, the proof of the actual relations between the igneous and sedimentary rocks would not have been far to seek.

Some old notes of a journey through the centre of this region from east to west, passing north of Lake Echo, are not without points of interest in this connection. The undulating country between the rivers Shannon and Ouse, east of Lake Echo, consists chiefly of rocks of the Permo-Carboniferous series overlaid by basalt of various types, with dykes and masses of diabase showing at intervals. Through these sediments the Ouse has excavated a deep canon on the west of which they rise to an elevation of nearly 3000 feet above sea-level, often showing signs of alteration where a natural section is exposed, especially in some patches of sandstone north of Bashan Plains. On some small islands in Lake Echo there is a grey vesicular basalt, a more compact variety showing itself a little to the north, the typical olivine basalt occupying a considerable area about the Ouse, to the south-west of the Great Lake. Proceeding westerly, north of Lake Echo, we come upon patches of massive diabase, the greater part of the country being extensively covered with the talus derived from it. The basalt just mentioned, which is almost certainly of Tertiary age, is interesting as showing volcanic action in shallow valleys formed at this high elevation by the process of erosion, which may be assumed to have also removed the sediments once overlying the diabase of the higher mountains. Continuing in a direction north of west, this route crosses a patch of flat-bedded hard grey mudstone at an altitude of over 3000 feet, with the diabase showing itself in ridges, and covering the surface in a broken-up condition, until the left bank of the River Serpentine is reached, near which there is an outcrop of the old micaceous schist of the Western Country. The Serpentine here cuts its way through the same Permo-Carboniferous beds that were seen on the right bank of the Ouse, and some distance to the north-east, near a branch of the Little Pine River, almost in the centre of Tasmania, there is a patch of the coal-measures with at-least one seam of coal. A continuation of this line westward to Lake St. Clair would probably show other similar evidence. The country south of it is occupied for the most part by basaltic plains and greenstone ridges. Mt. Olympus (diabase-capped), west of the lake, is flanked in the usual way by sedimentary rocks, and beyond it again is another remnant of the coal-measures resting on Permo-Carboniferous sandstone and marine beds, with plenty of evidence of alteration in the neighbourhood of the diabase.

It should be understood, in explanation of the absence of detail in many parts of this paper, that the geological conditions described were, for the most part, observed by the author during very brief intermissions of official duty, or on forced marches across difficult country, when there was no time available for following up points of interest noted on either side of the route.

Taking the subject as a whole, the conclusions may be briefly summarised:—

1. The first point of resemblance between the diabase-capped mountains—the most prominent feature in the physical contour of Tasmania—and the laccolitic mountains of North America, is that they follow none of the normal laws of mountain elevation. The subterranean forces to which they owe their origin did not act like those which raised ordinary divides, or which compressed and folded the Silurian and older strata along meridional axes, but they operated in all directions alike over an area of not less than 10,000 square miles.

2. The petrological character of the diabase and its remarkable uniformity of type are also strong points of resemblance to the somewhat less basic porphyrites of the Rocky Mountain region. The structure of both necessarily implies deep-seated consolidation of a molten magma.

3. So far as the evidence goes, the intrusion of the Tasmanian diabase and the Rocky Mountain porphyrites appears to have occurred on or about the same geological horizon. The vast interval in the rock record of Tasmania between the Permo-Carboniferous series and the early Tertiaries may reasonably be regarded as a space once filled by a great thickness of accumulated sediments, of which some hundreds of feet of Mesozoic coal-measures are the only existing representatives. It is among such sediments, less compact than the underlying Permo-Carboniferous rocks, that the ascending magmas would naturally spread themselves out along the planes of least resistance under the impulse of the forces below.

4. As to the difficulty presented by the supposed vertical dimensions of the Tasmanian mountain-cappings partially exposed on eroded cliff-faces, it has been shown that they are probably much exaggerated through want of knowledge of the actual position of the line of contact. In any case they sink into insignificance beside the recorded thickness of some of the American laccolites.

5. The same comparison holds good in regard to the removal of the former sedimentary rock-covering; but here again it is only the absence of direct evidence that creates the difficulty, and it is more than probable that some traces of the originally overlying sediments will be found when diligently searched for.

In conclusion I may say that, apart from any interest that may attach to it as a geological problem, the subject discussed in this paper is one of considerable importance to Tasmania, especially as it affects the question of her future supply of coal. The acquisition of accurate information respecting the material resources of the Island is much impeded by the want of a map giving its surface configuration in sufficient detail for the purposes of the geological surveyor, the prospector, the intelligent tourist, or the general public. In a memorandum, written as far back as 1878, ([12]) on the subject of the preparation of what is now the official map of the State, I suggested that the first step should be the delineation of the orographical features of the country, by means of rough contour lines, for the guidance of those to whom the final drafting of the map should be entrusted. A map of this description is urgently required, and sufficient information for all practical purposes could probably be supplied at a moderate cost by the District Surveyors, so far as their jurisdiction extends, and by the other professional officers whose services have been utilised in laying out tracks through the unsettled lands.

([12]) Parliamentary Paper, No. 109 H.A., Tasmania, 1878, p. 5.

ON THE NOMENCLATURE AND CLASSIFICATION OF IGNEOUS ROCKS IN TASMANIA.

By W. H. Twelvetrees, F.G.S.
Government Geologist of Tasmania.

Petrography and petrology are two sides of the study of rocks; the study of the subject as a whole comprises both. For the last forty years, petrography, stimulated by the use of the microscope, has worked its way steadily to the front in this department of geological science. Rocks have been studied as mineral aggregates, and the resources of the world's great opticians and of their scientific advisers have been taxed to the utmost in devising instrumental means for the optical analysis of rock slices. The delicacy of these modern methods compels admiration and wonder. Armed with these aids, geologists have devoted years of toil to petrographical work. The structure and mineral constituents of rocks from every part of the world have been elucidated and minutely described. The latter half of the past century witnessed this reign of petrography. Field geologists brought up in an older school felt themselves out of *rapport* with the new methods, and looked askance upon them. They had some reason, for an exclusive reliance upon optical analysis begets unnatural views. But the devotion to petrography, the description of rocks, did good service. Petrography was the necessary stepping-stone to something higher, petrology, the science of rocks. The one lays the foundation upon which the other builds its generalisations. The pursuit of petrography inevitably led to the creation of an interest in petrology such as had never been witnessed before. Not only the microscope, but also chemical analysis and field observation have been pressed into service to arrive at a knowledge of rock magmas and their consolidation into the known groups of eruptive rocks. As a consequence, the study of magmatic differentiation, of the genetic characters and relationships of rocks, and of their classification upon natural lines, has, during the last decade, occupied the attention of our foremost petrologists. One result has been to impart a healthier tone to the study by restoring to field observation and chemical work some of the consideration of which they had been unjustly deprived for a time by the fascinating pursuit of optical analysis. None of these methods can be divorced from the other without injury to our beautiful science. Under the glamour of the new

GRANITE.—DIORITE SERIES.

SiO_2 52 °/o and upwards.

	(Na + K) > Ca						Ca > Na + K		
	GRANITE.			SYENITE.			DIORITE.		
	Name.	Constituents.	Locality.	Name.	Constituents.	Locality.	Name.	Constituents.	Locality.
Effusive Rocks.	Quartz-porphyry including Felsite, Felsite-porphyry, Microgranite, Granophyre	Groundmass of alkali felspar and quartz. Phenocrysts of quartz, alkali felspar, and lime-soda felspar	Mts. Darwin, Jukes, Huxley, Tyndal, Murchison, Red Hills	Pyroxene quartz-porphyry	Groundmass quartzo-felspathic: phenocrysts of alkali and plagioclase felspar, augite, quartz	Lynchford			
	Spherulitic felsite		Zeehan: and loose at Trial Harbour, Strahan, and Castray River						
	Obsidian bombs	Acid glass sp. gr. 2·45-2·47	In tin and gold-bearing drifts everywhere						
Dyke and Complementary Rocks.	Pegmatite	Quartz + alkali felspar intergrown graphically	Blue Tier						
	Granite-porphyry including Elvans	Microgranitic and granophyric groundmass of alkali felspar and quartz. Phenocrysts of alkali felspar, lime-soda felspar, quartz, biotite.	Alberton, Blue Tier, Schouten Main	Augite Syenite porphyry	Felspathic groundmass: phenocrysts of alkali and plagioclase felspars, augite, quartz, biotite	Gawler River. Beulah (Kentish)			
	Hypersthene-granite porphyry	Micrognanitic groundmass. Phenocrysts of alkali and lime-soda felspars, quartz, biotite, hypersthene.	St. Mary's Pass						
Plutonic Rocks.	Muscovite-biotite Granite	Quartz + alkali felspar + acid plagioclase with muscovite and biotite.	Mt. Cameron, Blue Tier, Mt. Heemskirk	Augite Syenite	Alkali felspar + lime-soda felspar + quartz + augite	Heazlewood, Magnet Range, Schouten Main	Diorite	Plagioclase + hornblende + quartz + biotite	Port Cygnet
	Biotite Granite	Quartz + alkali felspar + acid plagioclase with biotite	Mt. Cameron, Blue Tier, East Coast, Hampshire, Wombat Hill, Mt. Heemskirk						
	Hornblende Granite	Quartz + alkali felspar + acid plagioclase with hornblende	Heazlewood: in boulders on Mt. Black	Hornblende Syenite	Alkali felspar + lime-soda felspar + quartz + hornblende	[illegible]			
	Greisen	Quartz + lithia mica	Gladstone, Blue Tier, Ben Lomond, East Coast, Mt. Heemskirk, &c.						

GABBRO.—PERIDOTITE SERIES.

SiO_2 39 to 52 °/o.

	Ca strongly > (Na + K). Mg < (Ca + Na + K).			Ca and Mg > (Na + K). Low in Al. Ca, Na and K gradually disappear.					
	GABBRO.			PERIDOTITE			PYROXENITE.		
	Name.	Constituents.	Locality.	Name.	Constituents.	Locality.	Name.	Constituents.	Locality.
Effusive Rocks.	Basalt Tuff								
	Hyalo-Basalt	Basic glass with or without phenocrysts of olivine	Sheffield, Bothwell, Richmond, Nietta						
	Olivine Basalt	Basic lime-soda felspar + augite + olivine	*passim*						
	Melaphyre	Basic lime-soda felspar + augite	Zeehan						
Intrusive Rocks.	Variolite	Felspar + pyroxene	Magnet						
	Diabase-porphyrite	Ditto	Ditto						
	Enstatite-diabase	Basic lime-soda felspar + enstatite	Arthur River						
	Diabase (dolerite)	Basic lime-soda felspar + augite	*passim*				Websterite-porphyrite	Groundmass rhombic and monoclinic pyroxene: phenocrysts of bronzite	Magnet Mine
Plutonic Rocks	Quartz Norite	Basic lime-soda felspar + rhombic pyroxene + quartz	Mt. Bischoff						
	Olivine Norite	Basic lime-soda felspar + rhombic pyroxene + olivine	Heazlewood	Wehrlite	Diallage + olivine	Heazlewood Rd.	Websterite	Diallage + bronzite	Heazlewood
	Norite	Basic lime-soda felspar + rhombic pyroxene	Mt. Agnew, Dundas	Lherzolite	Diallage + enstatite + olivine	Heazlewood Rd.	Bronzitite	Bronzite	Heazlewood, Magnet Range, Anderson's Creek, Dundas
	Gabbro	Basic lime-soda felspar + diallage	Heazlewood, Dundas, Mt. Agnew, Burnie	Harzburgite	Enstatite + olivine	Upper Arthur River	Diallagite	Diallage	Heazlewood, Upper Blythe, Hampshire Hills
	Modifications.	*Description.*							
	Saussurite Gabbro	Felspar replaced by saussurite	Heazlewood, Dundas, Tamar						
	Flaser Gabbro	With crush structure	Corinna Road						
	Gabbro-Amphibolite and Zobtenite	Schistose gabbro, with pyroxene replaced by hornblende	Heazlewood, Rocky River						
	Gabbro-Diorite	Massive gabbro, with pyroxene replaced by hornblende	Mt. Agnew						

ELAEOLITE SYENITE, AND THERALITE SERIES.

	ALKALI GRANITE.			ALKALI SYENITE.			ELAEOLITE SYENITE.			THERALITE.		
	Na + K high. Mg and Ca low. SiO_2 72 to 74 °/o.			Al and Na + K high. Mg low. SiO_2 52 to 60 °/o.			Preponderatingly (Na, K). $AlSiO_2$. SiO_2 45 to 60 °/o.			Al, Na + K, Ca, Mg, high. SiO_2 27 to 56 °/o.		
	Name.	Constituents.	Locality.	Name.	Constituents.	Locality.	Name.	Constituents.	Locality.	Name.	Constituents.	Locality.
Effusive Rocks.	Quartz-keratophyre	Groundmass—felsitic, with phenocrysts of alkali felspar, and quartz	Mt. Read	Keratophyre	Groundmass—felsitic, with phenocrysts of alkali felspar	Mt. Read	Trachytoid Phonolite	Sanidine + nepheline + aegirine-augite + melanite	Port Cygnet	Nepheline-basanite	Labradorite, augite olivine, apatite, nepheline	Circular Head, Table Cape
										Nephelinite	Nepheline + augite	Shannon Tier
				Phonolitic Trachyte	Orthoclase + plagioclase + augite + hornblende + quartz, sphene, apatite, zircon	Port Cygnet	Hauyne Phonolite	Sanidine + nepheline hauyne + aegirine-augite + hornblende + melanite	Port Cygnet	Melilite basalt	Melilite + olivine + augite + perofskite	Shannon Tier
										Nepheline-melilite basalt	Melilite + fayalite + nepheline + perofskite	Sandy Bay
										Limburgite	Olivine + augite	Near Burnie
Dyke and Complementary Rocks.							Sölvsbergite	Groundmass—orthoclase felspar, and biotite; phenocrysts, garnet	Port Cygnet			
							Tinguaite	Orthoclase + aegirine augite + nepheline + hornblende + biotite	Port Cygnet			
							Tinguaite porphyry	Groundmass—felspar and aegirine: phenocrysts, sanidine, aegirine aegirine-augite and titanite, melanite	Port Cygnet			
Plutonic Rocks.				Alkali Syenite	Orthoclase + plagioclase + aegirine + quartz	Port Cygnet	Elaeolite syenite	Orthoclase felspar + elaeolite + aegirine-augite + biotite + melanite + natrolite after sodalite	Port Cygnet			

power which the microscope had put into the hands of students, there was a danger of rocks being studied apart from their natural surroundings, and considered too exclusively and artificially as mere mineralogical and cabinet specimens, instead of integral parts of the earth's crust.

Unfortunately, petrologists are at variance in their principles and systems of nomenclature and classification. I am very sure that much of this variance is due to the differing histories of the science in different countries. English, French, and German observers have approached their subject from different standpoints, and international agreement has consequently been made more difficult. A further source of difficulty is the intrinsic nature of the subject. The eruptive rocks are aggregates of minerals which have separated out from eruptive magmas under varying physical conditions, and they share with organic groups or species the disadvantage (from a classificatory point of view) of passing the one into the other through connecting varieties. New types are turning up with startling frequency, and the old simple nomenclature no longer covers the ground. These discoveries sometimes prove disconcerting, for they impose upon us the duty of re-considering and often of re-adjusting our views.

In advocating a few years ago, with Mr. Petterd. a system of classification for our Tasmanian igneous rocks founded upon varying acidity or basicity, it appeared far and away ahead of systems based upon structure, mineral contents, age, or geological occurrence. In that it rests upon a chemical basis, it still appears to me to possess advantages over structural or mineralogical systems. Without committing my colleague to my present view, I may say that the advances in our science during recent years have led me to recognise deficiencies in the old scheme. I venture to think that it fails in assigning the proper values to chemical relationships and differences. By reason of the importance it attaches to the silica percentage, it severs related rocks like granite and syenite, and at the same time associates unrelated rocks like elaeolite-syenite and normal syenite. In nature, the former pair blend together often enough in the same mountain *massif*, the latter never, for they apparently represent distinct magmas, and their respective dyke-rocks and effusive equivalents have their own distinctive stamp and character. The dyke-rocks of elaeolite-syenite, for instance, will be tinguaites, not minettes, and its effusive product is phonolite, not normal trachyte. I look upon a system of classification as faulty if it neglects to take account of these important facts. In nature, too, I may add that granite and diorite often behave in the same way, the one passing by easy transitions into the other in the same rock-mass. The United States Survey Officers have introduced the name granodiorite for this passage-rock. Syenite also graduates into diorite in a precisely similar manner. It would hence appear natural to group these three families of rocks in one great natural division. Rosenbusch, while adopting a totally different principle of classification, propounds a granito-dioritic magma, which corresponds with the division just suggested.

Having marked off the rocks of this magma, there remain only two other great divisions, which are easily appreciated, namely, elaeolitic-leucitic rocks and gabbro-peridotite-pyroxenite rocks. As we shall see later on, chemical considerations support this grouping.

Mr. Alfred Harker, in his interesting little book, "Petrology for Students," adopts plutonic, hypabyssal, and volcanic as the three primary divisions, and groups the rock families in these in order of increasing basicity. Thus, under plutonics he groups granites, syenites, diorites, gabbros, and peridotites; under hypabyssal rocks he ranges granite porphyries, ceratophyres, diabase, lamprophyres; under volcanics, rhyolites, trachytes, phonolites, andesites, basalts.

This is practically the principle followed by Rosenbusch, though the details are not the same, and the German author's dyke-rocks are differentiation products, not merely hypabyssal rocks. It is really the recognition of variety of geological occurrence, involving variety in structural characters. It has the disadvantage of bringing together in one assemblage rock families which are widely separated in constitution. Hence it is, I submit, unavailable for primary divisions.

The other great German petrographer, F. Zirkel, bases his primary divisions on mineral characters; viz.:—1. Rocks with dominant alkali felspar; 2. Rocks with dominant lime-soda and lime felspars; 3. Rocks without felspar. Under this grouping we have granitic and elaeolitic rocks thrown together in the same division.

The French school also classifies according to the felspars. Though the method is empirical, the results approximate to the truth, for the contents and proportions of alkalies are involved. For example, in syenite and granite potash felspars are the dominant ones; in diorite, Na_2O has increased; hence, the felspar is soda-lime. In gabbro, alkalies are low and CaO high; hence, the felspar is lime-soda. In nepheline syenites, the excessive alkalies show themselves in all the characteristic minerals of that division.

The United States petrographers are in general agreement as to a chemico-mineralogical basis of classification, and their groups do not differ from those already familiar to us. In 1897 a committee, comprising Professor Van Hise, J. S. Diller, W. H. Weed, H. W. Turner, and Whitman Cross, was appointed by the Director of the United States Geological Survey, to report upon the nomenclature and classification of eruptive rocks for adoption by the survey. The following scheme corresponds closely with the committee's recommendations:—

Granite-rhyolite family.
Syenite-trachyte family.
Nepheline-leucite rocks.
Diorite-andesite family.
Gabbro-basalt family.
Peridotite family.

The well-known groups are all here, and the recommendations indicate, as it were, the direction in which Anglo-Saxon petrographers may be brought into line. An objection which may be urged, is that a certain want of proportion is apparent if these divisions are to be considered as primary ones.

I ought not to omit mention of a tentative classification of the rocks of New South Wales put forward in 1890 by Professor F. W. Edgeworth David. Its basis is the silica percentage, to which I have previously alluded. As a result, it groups together in one primary division such widely-separated rocks as felspar and leucite basalts. With this principle of classification unnatural unions are inevitable.

I wish to be understood in this matter of SiO_2 per cent. It is of distinct value in sub-divisions, and ought to receive expression in such, but *per se* it is not the all-powerful key which we perhaps have been accustomed to consider it. The more intimately we become acquainted with eruptive rocks, the more definite grows the conviction that no single element has governed the differentiation of their magma, not Si, nor Al, nor Na and K alone; their composition must be considered as a whole. If undue weight is laid on the SiO_2 proportion, the petrographer is sure to go wrong. Take a concrete example, one not far from home. Messrs. Guthrie, Woolnough, and Professor David have lately described a remarkable phonolitic rock from Kosciusko with a large proportion of nepheline, but with a low SiO^2 per cent. (52·4 per cent.) The quantity of silica is lower than that of phonolite proper, and is, in fact, that of typical basalt; but to follow this as a guide would be hopelessly misleading. The authors say—" The Kosciusko rock differs conspicuously from typical phonolites in the following respects:—(1) low silica percentage; (2) entire absence of phenocrysts of sanidine. It is obviously a felspathoid rock, and although its silica percentage allies it with the basalts, its mineral constitution, chemical composition, and low specific gravity link it with the phonolites. As far as the authors are aware, it is unlike any rock that has hitherto been described from any part of the world."*

It is undoubtedly a rock of the foyaitic magma, and has no relation whatever with basalt.

Take, again, the new theralitic rock Euctolite, described by Rosenbusch from Umbria†. It is an olivine-melilite-leucite rock allied to madupite, which is a biotite-leucite-diopside rock. Its SiO_2 per cent. is only 41·4, and would, if alone relied upon, indicate basaltic affinities, while its real relations are theralitic.

Among the signs of a growing discontent with the existing empirical schemes of classification, the critical contributions of Professor F. Loewinson-Lessing are important.‡ His guiding motto is, "chemical composition the basis of rock classification." His application of it is less acceptable. He uses a dualistic nomenclature, referring to the felspar and the colored constituents. Thus, with respect to Syenite, he distinguishes Orthoclase Syenite, Albite Syenite, Anorthoclase Syenite; and secondly, Hornblende Syenite, Augite Syenite, Mica Syenite, Aegirine Syenite, &c. Then, combining both constituents, he adopts such terms as Orthoclase-hornblende Syenite, Anorthoclase-aegirine Syenite, &c. As will be seen later, I propose to avoid this dual terminology, by detaching the alkali granites and syenites from the normal series altogether. We shall then adopt the specific names which have been used for the different rocks of these groups, such as pulaskite, laurvikite, &c.

The plan which I now venture to propose is to arrange the primary divisions in accordance with the rock-magmas assumed by H. Rosenbusch, and we shall then obtain the series, as under:—

1. The Granite-Syenite-Diorite series;
2. The Gabbro-Peridotite series;

The Elæolite or Nepheline series of rocks.

The sub-divisions, as they affect Tasmania, are represented in the attached scheme. For myself, I do not fear that this

* Roy. Soc. N.S.W. Abstract of Proc., June 5, 1901.

† Ueber Euktolith, ein neues Glied der theralithischen Effusivmagmen.

‡ *Vide* Tschermak's mineralogische u, petrographische Mittheilungen, 1900.

scheme will not prove amply adequate to all requirements. I commend it to your criticism.

It is being continually urged upon petrologists by stratigraphical geologists that a nomenclature is needed which can be applied without resort to laboratory analysis. In short, field geologists wish to be able to name a rock at sight. Where it is impossible to determine the nature of rocks in the field, I do not see how a field-term can be anything more than a temporary expedient. The dyke-rocks and the marginally modified plutonics offer great difficulty, and I know of no Linnaean system which will extricate us. Field geologists must not complain if petrologists, before labelling a rock with a name, try by all the methods at their command to find out its mineral and chemical composition, the conditions of its consolidation, and its genetic relations. Nomenclature can then be discussed with some degree of confidence. Others wish to be able to name rocks without knowing their mode of occurrence, but F. Zirkel puts the case convincingly when he says that "petrology is a branch of geology, not of mineralogy, and its problems do not consist in determining specimens from unknown localities, nor are they solved in that manner. A rock specimen is not only an aggregate of such and such minerals, with a given structure and composition, but is also at the same time a piece of the earth's crust, which has played a definite geological rôle in the place whence it was taken; if that rôle be unknown, one essential element of a decisive diagnosis is lacking."*

In the sub-divisions I have followed the usual plan of giving to geological occurrence its legitimate expression under the terms plutonic, dyke and effusive. But these terms must not be used slavishly, or difficulties will be encountered. Moreover, the dyke-rocks are exceptional in that they are not mere intrusives, but have a chemical significance. Granitic, basaltic, diabasic dykes do not come within Rosenbusch's definition of dyke-rocks, though they have the dyke form. Dyke-rocks proper are differentiation products of the magmas of plutonic rocks. Naturally, each group of plutonics may be expected to be accompanied by its own dyke group. W. C. Brögger proposes the term "complementary rocks" for types differentiated out of a common magma. †

Some of the dyke-rocks, *e.g.*, lamprophyres in France and tinguaite porphyry in Brazil, have been shown to occur in

* Lehrbuch der Petrographie, F. Zirkel, 1893, vol. i., p. 840.

†On the basic eruptive rocks of Gran. Q.J. Geol. Soc., 1894, p. 31.

the form of effusive sheets. It seems likely, unless an unusual sense be attached to the word, that the term "dyke-rock" will disappear, and some such term as "complementary rocks" will take its place. The anomaly alluded to deforms the symmetry of our classification; but our schemes must not aim at being more symmetrical than nature.

A basalt or a peridotite rock in the form of a dyke cannot be considered as a dyke-rock, for it does not differ constitutionally from effusive basalt or plutonic peridotites. Those who subdivide eruptives as plutonics, intrusives and effusives, do not transfer an intrusive plutonic to the intrusive sub-division upon geological grounds, nor can they who distinguish the dyke-rocks chemically consent to add to them by transferring to their ranks intrusive forms of normal volcanics. Geologically, two main divisions should be erected—plutonic and effusive. The dyke-rocks occupy an intermediate position, not because they are intrusive, but because they are differentiated products.

Even the normal rocks present difficulties. Diabase in Europe is both effusive and intrusive. In Tasmania we have no evidence of its being effusive, but since, like basalt, it is the normal product of the gabbroid magma, its home cannot be among the dyke-rocks. For the same reason, quartz-porphyry modifications of granite have to be kept among the plutonics. Such instances warn us against aiming at unnatural precision.

Granite.

This may be defined as a plutonic rock essentially composed of alkali felspars and quartz. The felspars are the most acid of their species. The alkalies are present in molecular proportions of about 7 per cent., and the ratio of these to Ca is 2·1. The SiO_2 per cent. ranges from 61 per cent. to 75 per cent., and occasionally even higher, falling in hornblende and augite granites, and rising in muscovite granite.

The sub-divisions of granite have given rise to controversy. Biotite granite is perhaps the most common type, and many have felt that it should be regarded as granite proper instead of being called granitite. Professor Hogg has recently attacked the position of granitite. Zirkel and Rosenbusch are at variance on the same point. There is something plausible in the suggestion, but historical considerations count for something, and the time-honoured idea of granite is that silvery mica is one of its triad group of minerals. I should prefer to see the term granitite dropped altogether, and muscovite-granite, biotite-granite, hornblende-granite, pyroxene-granite used as sub-divisions of granite.

Mr. Hogg restricts the term granite to plutonic felspar-quartz-biotite rocks in which the dominant felspar is monoclinic; and when this felspar becomes the subsidiary one, he uses the term granitite. But seeing that there is a very general agreement among petrologists to classify and name normal granites according to the coloured constituents, I thing it is a pity to break loose from this arrangement and begin to base the nomenclature upon the crystallisation of the felspars. Moreover, if such rocks are to receive a name, it is undesirable to adopt "granitite," which has already been widely used in a different sense. The rocks referred to resemble the passage-rocks between granite and quartz diorite, called granodiorite by some American petrologists, namely, diorites, which vary into granite by the addition of orthoclase. G. F. Becker* described a quartz-diorite or granodiorite as containing plagioclase as an essential felspar, and considerable orthoclase,—next to plagioclase the most abundant constituent is quartz—hornblende and biotite occur sparingly. Mr. Hogg's notice of the increase of plagioclase felspar in certain granites receives expression where it is most pronounced, in the classification by coloured constituents, for the addition is most marked in the hornblendic granites. Mt. Roland is one of the localities in Tasmania where these passage-rocks occur. Plagioclase is in excess, and hornblende and biotite are in nearly equal proportions.

In Tasmania there are everywhere signs of underlying granite. Its age is generally regarded as Devonian. We have an instance of it being intrusive in Upper Silurian rocks at Middlesex, and on the East Coast we have proof of its denudation in Lower Permo-Carboniferous times. The granite on South Mt. Darwin and at Mt. Farrell has a somewhat more ancient look, but it, too, was apparently subsequent to the Silurian.

At Mt. Cameron, the Blue Tier, Ben Lomond, and all down the East Coast *viâ* St. Marys, Seymour, Bicheno, Freycinet's Peninsula, Schouten Island, Maria Island, to as far south as the Hippolyte Rocks there are exposures which must be assumed to be connected underground. Over this area nearly all the manifold types characteristic of large granite *massifs* may be met with. I do not know that we have the granite proper of Europe, namely, quartz +

* Geology of the Yukon Gold District, 1898, p. 229.

potash and oligoclase felspar + biotite and muscovite. The two micas occur together in some of the granite at Mt. Cameron and the Blue Tier, but that rock is tin-bearing, and consequently not in a normal state. As a matter of fact, when the miner sees white mica he looks for tin ore; and the nearer he is to the ore-deposit, the more abundant will be the muscovite. Where the granite is not tin-bearing, biotite is the only mica present, and it is often very plentiful. The biotite in the tin granite loses its iron, gives rise to the formation of talc, and is eventually converted into a colourless non-pleochroic species. This change is evidently due to the agencies involved in the deposition of tin. At the Silver Echo and Stony Ford mines, near St. Helens, golden-yellow mica occurs, probably lithia mica. Lithia bearing muscovite is common in the tin granites. At the Crystal Hill Mine, near Lottah, there is an unusually fine development of apatite in such granite.

As a rule the East Coast granite has a porphyritic structure. Large crystals of orthoclase felspar, one and two inches in length, are developed in a matrix of ordinary grain. These felspars kaolinise, and present a striking appearance on the weathered surfaces of the rock. Apart from the titaniferous iron ore and magnetite, the mica was the first mineral to separate out, as may be seen by the numerous crystals of biotite enclosed in the felspars, then felspar, lastly quartz, which fills the interstices. The colours of the stone range from white through grey to pink. The granite at St. Helens differs from that at the Blue Tier and Mt. Cameron in being somewhat more quartzose.

Cassiterite (tin ore) occurs very generally in the above granites, either in veins, rarely as lodes, and especially at the Blue Tier in floors and irregular zones of greisenised or otherwise altered country-rock (the so-called quartz-porphyry). With regard to the alleged quartz-porphyry dykes, it should be noted that in the eastern workings of the Anchor Mine the massive stanniferous rock underlies the normal country granite, from which it is parted by a horizontal quartz-felspar seam of pegmatitic character. The stanniferous zone is too irregular in outline to justify the use of the term "dyke," and its quartzose character and abundance of mica are characteristically the signs of the greisenisation and stanninisation of granite. Diffused fluorite is noticeable at the Anchor and Liberator mines. In lieu of the popular term quartz-porphyry for this rock, I suggest for discussion, tin-granite, stanniferous granite, greisenised granite. Tinstone has been proposed, but is already a synonym for cassiterite.

It has been reported that cassiterite occurs sporadically in the country granite itself. Even if this be the case, it need not be regarded as a primary constituent. In such instances it may have been derived from adjacent pegmatite or quartz-veins traversing the rock. Beck, in his Lehre von den Erzlagerstätten (1901), quotes cassiterite as primary in many granites, *e.g.*, the tourmaline granite of Eibenstock, of Greifenstein, of Altenberg, in the Erzgebirge, but of no economic value. He says the only instance known where it is of any commercial importance is at Etta Knob, Black Hills, in Dakota, but discounts his example by saying that the rock is not normal granite, but pegmatite.

The granite on the Schoutens is of the same porphyritic variety as at Mt. Cameron and elsewhere, and is likewise traversed by greisenised bands of rock and veins of quartz carrying tin ore. At Gladstone, the margin of the granite at its contact with the Silurian slates is marked by a zone of greisenised rock (at the Fly-by-Night and on the Esk property). The contact of the granite with the Silurian strata at St. Helens is greatly obscured by drift, but of interest where visible. In the road-cutting south of St. Helens Bridge one or two exposures are seen of chloritic schist lying in vertical lenses in the granite, and further west on the same strike is the tin mine at Stony Ford, where the ore occurs in a band of garnetiferous chlorite rock encased in granite.

The East Coast granite was already exposed by denudation in Permo-Carboniferous times, for the conglomerates and mudstones of that period contain fragments of it. Examples are to be seen on Maria and Bruni Islands and at Beltana. At Ross, a huge block firmly implanted in Lower Permo-Carboniferous sandstone at the foot of Macquarie Tier was mined a few years ago, under the impression that it was a protrusion of stanniferous bed-rock. West of Lefroy also a granite boulder lying upon Silurian slates was explored for gold.

At Roy's Hill, near Avoca, is a hard quartz-mica stanniferous rock, which forms the margin of granite upon Silurian strata. The contact is concealed by Permo-Carboniferous sandstones and conglomerates, but the smoothed outlines of the underlying contact rock indicates a denuded surface prior to the Permo-Carboniferous period. Curiously enough this surface carries a concealed stanniferous wash of those days. Mr. W. F. Petterd was the first to point out that the dark patches in the tin ore of the Mt. Rex Mine on Ben Lomond are pseudomorphs of the large porphyritic crystals of the country granite.

At St. Marys the granite, at its contact with the Silurian slates just E. of the bridge on the road to the Pass, forms granite porphyry, and the dark granite of the Pass itself is essentially the same rock, viz., a microgranitic groundmass of alkali felspar and quartz containing phenocrysts of alkali and soda-lime felspars, quartz, and hypersthene. This is the granite-porphyry modification of granite, occurring sometimes towards the margin of large masses. As differentiation has taken place, it belongs properly to the dyke and complementary rocks.

The George's Bay rock is quartzose-biotite granite, with more quartz than felspar. At Moorina the biotite-granite is composed of orthoclase + plagioclase + quartz + apatite. At the Arba Tin Mine it is a muscovite-granite = orthoclase + plagioclase + quartz + muscovite (with very vivid interference colours, probably lithia mica); the quartz contains a few tourmaline prisms. At Weldborough we have a coarse biotite-granite containing much quartz and dominant orthoclase. There is a good deal of radiating talc in this rock. At Gould's Country the granite contains biotite and muscovite, and orthoclase poikilitic with quartz is the dominant felspar.

The granite at Mt. Heemskirk on the western shore of Tasmania is also a biotite-granite, with the addition of muscovite locally, and often contains similar porphyritic felspars to those in the granite on the east side of the Island. On the Lucy River biotite-granite also occurs, containing sometimes a little muscovite, and consisting of orthoclase + plagioclase + biotite, with accessory apatite. The structure is often graphic.

At Wombat Hill, 5 miles from Waratah, biotite-granite occurs with dominant orthoclase and a little hornblende. At the Heazlewood, too, is a large-grained biotite-granite, with a little yellowish-green hornblende. At the Hampshire, 2 miles from the railway, the biotite-granite is coarse; the dominant felspar is orthoclase, and the structure is highly graphic and perthitic. At Golden Hill, Middlesex, the granite is the biotite variety, and its felspars are greatly pinitised.

Augite-granite, so far, is not recorded, but some of the augite-syenites of the Heazlewood District tend in that direction by an increase of quartz, and pass over into granite.

Hornblende-granite is rare in the Island. It has been found so far, *in sitû,* in only one district, the Heazlewood, where, by insensible gradations with diminishing quartz, it passes over into syenite. At Bell's Reward, south of Jupp's, the granite consists of orthoclase (dominant) + plagioclase + green hornblende (no mica). It contains some large crystals of sphene, and some radiated chlorite.

Hornblende-granite has also been seen in boulders at the Rosebery Mine on Mt. Black.

Dyke and Complementary Rocks of the Granite Series.

In the tin districts of the East Coast dykes of pegmatite traverse both the ordinary biotite-granite and the greisenised modification of it. These dykes usually carry cassiterite. Their constituent minerals are quartz, orthoclase and microcline felspars, with accessory muscovite. The broad cleavage surfaces of the felspar show irregular sections of quartz, denoting inter-growth, and constituting the graphic or pegmatitic structure. Naumann applied the term pegmatite to extremely coarse granite. In Tasmania we have an exceedingly coarse variety of granite at the Fly-by-Night Creek near Gladstone, but the graphic structure is absent, and it ought not to be called a pegmatite. Some of the pegmatite dykes on Mt. Cameron carry crystals of topaz. The origin of pegmatite is evidently to be sought in what Vogt calls the eruptive after-action of granite, commonly known as pneumatolytic. Good examples are to be found near Lottah, on the Blue Tier. Descending from the township to the Laffer Mine, and at the mine itself, coarse pegmatite is seen in biotite-granite. It is also visible on the road-saddle between the Crystal Hill and Liberator mines in tin-granite, and pegmatitic segregations are extremely common in the tin-stone at the latter mine. In pegmatites it will be noted that the crystallisation of the quartz was not subsequent to, but synchronous with, that of the felspar.

A peculiar differentiation product (or intrusion) is a granite-porphyry, rich in biotite, in biotite-granite on the Corinna Road, 5 miles from Waratah. A panidiomorphic matrix of clear orthoclase and quartz is crowded with crystals of biotite. Strictly speaking, primary quartz is very rare in true minettes, and hence, as a rule, they are placed among the dyke-rocks of the sub-acid series. In this case the abundance of biotite suggests at the first glance the thought of minette, but quartz is far too plentiful. The rock appears rather to be a variety of granite porphyry. A somewhat similar occurrence is to be noted at Weldborough, only there muscovite is equally abundant with biotite, perhaps even dominant, and the rock is finer-grained.

Typical elvan or muscovite-bearing granite-porphyry occurs in the Silurian slates at Alberton, Mt. Victoria, where it has been cut through in the level of the Ringarooma Mine. A strong muscovite elvan with phenocrysts of quartz, alkali, felspar and lime-soda felspar strikes through biotite-granite on Schouten Main. Elvans are not uncommon on the Blue Tier.

At the Silver Echo Mine near St. Helens is a wide dyke of aplite, part of which passes over into pyrrhotite, and ultimately into pure quartz. Similar instances are recorded in petrographical literature. The transition appears to be characteristic of aplite and pegmatite dykes. The dyke-rock consists of quartz grains and small crystals of felspar surrounding larger lumps of quartz and orthoclase and oligoclase crystals giving isometric sections. Large crystals of biotite and irregular shreds of muscovite are present, the latter rather abundant. The dyke is in Silurian strata, and the lode portion of it has been prospected for gold and silver. It apparently has its source in the tin-granite.

The granite at St. Mary's Pass at its contact with Silurian slates, and for a width of two or three miles, has acquired a granite-porphyry facies. Specifically, it is hypersthene-granite porphyry, for phenocrysts of hypersthene are abundantly developed in it. The other porphyritic constituents are orthoclase, oligoclase-andesine, biotite, and quartz. These are cemented together by a ground-mass of allotriomorphic quartz and idiomorphic felspar. This rock is unique in the Island. The specific gravity, 2·68-2·69, is low, considering the quantity of hypersthene present. We have here an instance of a rock of the dyke division occuring as a marginal differentiation of a plutonic mass, and not in the form of a dyke.

A normal granite-porphyry occurs on the road to Corinna, 4 miles from Waratah. Large phenocrysts of orthoclase, oligoclase, and biotite exist in a coarse ground-mass of granular quartz, idiomorphic felspar, and biotite.

Acid Effusives.

The effusive forms of the granite magma in Tasmania consolidated prior to Permo-Carboniferous times, and are known under the names of quartz-porphyry, felsite-porphyry, felsite, and granophyre. It is not settled whether any of them were poured out at the surface as sheets of rhyolite lava; hence the American term "aporhyolite" is inapplicable here. The trend of the evidence is so far rather in the direction of their occurrence as dykes, apophyses of granite masses, and as the quartz-porphyry facies of granite.

The most important development of these rocks is along the axis of the West Coast range, where they are depositories of copper ores. They prevail on Mts. Darwin, Jukes, Owen, Huxley, Tyndal, Murchison, and at the Red Hills, usually flanked by slates and schists, but on Mt. Darwin and on the east side of Mt. Farrell in contact with granite. The exposures of granite close to the quartz-porphyries are significant in connection with the genesis of the latter, but the whole line requires careful examination before anything decisive can be said. Associated with the copper deposits are large lenses of magnetite and hematite.

These rocks present varied types of structure. There is the granophyric type, in which the ground-mass is holocrystalline, and consists of isometric forms of alkali felspar and quartz mingled with granophyric intergrowths of quartz and felspar. Porphyritic crystals of pinitised felspar are sparsely scattered through this ground-mass. A frequent feature in the ground-mass is the presence of a kernel of clear quartz in the centre of a felspar individual. Occasional small crystals of biotite are noticeable, and aggregations of secondary muscovite.

On Mt. Huxley some of the rock is not granophyric, but a holocrystalline granular admixture of quartz and felspar, with phenocrysts of quartz and alkali and lime-soda felspars. The same feature is sometimes noticed at Mt. Jukes.

There is a type, too, in which the ground-mass assumes a felsitic aspect, and the felspar and quartz phenocrysts float widely apart.

The forms with porphyritic quartz may be called quartz-porphyry; those with porphyritic felspar only, felsite-porphyry; those without visible porphyritic crystals, felsite. The holocrystalline granophyric forms may be termed granophyres; the holocrystalline granite porphyry-like forms, micrograuites; and generally, forms with felsitic ground-mass, felsophyres.

Dykes of topazised and tourmalinised quartz-porphyry, carrying cassiterite, traverse the Silurian slate at Mt. Bischoff. Topaz and tourmaline have largely replaced the felspathic constituent of the rock, and a silicification of the ground-mass characteristically accompanying the introduction of tin has also taken place. Where the dyke-rock has escaped the pneumatolytic action, as in the North Valley, phenocrysts of quartz and felspar in a felsitic matrix give a clue to the nature of the original porphyry. The silicified rock is not always topazised, and is then a modified quartz-porphyry, in which substitution of silica has taken place. At

Renison Bell Mine and South Renison Bell, Dundas, similar tourmaline-quartz porphyry dykes occur; also at the Upper Emu River, above the Hampshire Mine; but these belong rather to the class of veins than to rock-masses.

There are a few occurrences of spherulitic felsite in the Island. One of these has been found *in sitû* in the swamp between the Montana and Western mines at Zeehan. At first the stone was believed to be a loose boulder, but last year it was ascertained to be a reef which traverses the Silurian strata. It has a certain degree of interest when considered in connection with the neighbouring stannite-lode at the Oonah Mine. The rock is charged with closely-packed spherules, showing a dark cross between crossed nicols. The little ground-mass which there is between the spherules presents the speckled aspect of felsitic substance in polarised light, but contains no distinct crystals of felspar. Loose pieces of essentially similar rock have been found at Trial Harbour, at Strahan, and in the bed of the Castray River, Heazlewood. These spherules are identical with those familiar to petrologists as occurring in rhyolite-glass, but in this case they probably belong to the selvages of dykes proceeding from the granite.

Obsidian bombs in the form of bolts, buttons, and other sub-spheroidal lumps of natural glass are found in the Tertiary tin and gold-bearing drifts in different parts of the Island. So long as they were considered as derived from the volcanic centres which overwhelmed the country with basaltic lava in Tertiary times, these objects attracted little attention beyond that which they excited as curiosities. In 1897, in conjunction with Mr. W. F. Petterd, I pointed out that their ascription to any basaltic source is inadmissible, for the glass is not basic, but acidic. Their specific gravity ranges from 2·45 to 2·47, while that of different specimens of Tasmanian tachylyte was found to be 2·72 to 2·77. The specific gravity of rhyolite obsidian from Mexico and United States is given by Rosenbusch as 2·360 and 2·344 respectively.[a] F. Zirkel cites that of obsidian from Lipari, Iceland, and the Yellowstone National Park, U.S., as 2·37, 2·42, 2·441.[b] No analyses of the Tasmanian bombs have been made yet. It is highly desirable to sacrifice a specimen, and obtain a complete analysis. Similar bombs in Australia have been analysed, and their SiO_2 percentages are 64·68, 71·22, 71·38, 73·40, 73·70, with specific gravity varying from 2·44 to 2·47.[c]

(a) Elemente der Gesteinslehre, H. Rosenbusch, 1898, p. 255.
(b) Lehrbuch der Petrographie, 1894, vol. ii., p. 280.
(c) Die Herkunft der Moldavite, F. E. Suess, 1900, p. 238.

None have been found yet in sub-basaltic drift; one was found 5 or 6 feet deep in the clay capping of tin-bearing drift, and the evidence points to them being younger than middle Tertiary.

It has been surmised that they have been introduced into the Island and distributed by the aborigines, but this theory must be rejected in the face of their discovery at a depth of several feet from the surface, in one instance, at Lisle, in gold-bearing drift 18 feet below heavily timbered soil.

The difficulties surrounding an explanation of their occurrence have given birth to several theories of their origin, all more or less unconvincing. Some of the most acute minds in geological science have been at work upon the problem, without solving it. The theory of their cosmic origin has lately been advanced, and re-inforced by some weighty considerations. Its advocates are Verbeek, Suess, P. G. Krause, Moulden, Walcott. I think before resorting to this explanation we must be quite sure that we have exhausted terrestrial sources. The suggested terrestrial sources are—1. Bubbles in lava; 2. Rocks vitrified by lightning; 3. Former lava sheets, now denuded; 4. Geysers; 5. Acid segregations in basaltic lava; 6. Volcanoes in New Zealand or the Antarctic.

Mr. F. Stephens obtained an opinion from the late Professor Le Conte, of California, who advanced a suggestion by Professor A. C. Lawson, to the effect that the bombs might be the result of the bursting of bubbles on the surface of some liquid, stiffly-viscous lava, ready to solidify. The suggestion fails to account for the round form of the under-surface, and seems irreconcilable with the existence of steam pores, both superficial and internal. The theory also leaves the question of the origin of the lava quite untouched.

Mr. Frank Rutley, an authority on fulgurites, throws out a suggestion that the objects may be fragments of rock struck by lightning and vitrified. The purity of the glass no doubt suggested the idea. The similarity of shape and sculpture negative this, and a glance at the bombs is sufficient to dispel it.

The supposition that acid lava sheets formerly existed and have since utterly disappeared, derives no support from Tasmanian geology, and may be dismissed decisively. We have no signs anywhere of Tertiary acidic volcanoes. The improbability of these buttons being the sole survivors of such eruptions is very great.

A suggestion has been made to me recently that the buttons may be drop-like forms of siliceous sinter or geyserite.

I merely mention this to show that every conceivable explanation has been thought of. The analyses of Australian specimens show that the substance of the bombs is not hydrated silica. There is consequently no need to dwell upon the complete absence of any signs of geyser-action in the districts of the respective discoveries.

At first I could see no other source open than New Zealand or Antarctic volcanoes. I must confess, however, that the great distances involved are unfavourable to the theory. The non-discovery of such bombs in New Zealand in the vicinity of the mountains which are, on this theory, presumed to be the points of origin, is disconcerting. The conclusion after all seems irresistible, that if the buttons are of terrestrial origin, they must be derived from some near source. We know that quartz-basalts occur in California, and quartz-diabase in Europe and Canada. The former have a quartzless ground-mass, and contain porphyritic crystals of quartz; the latter has granophyric aggregates of quartz and felspar, and occurs sparingly in Tasmania. The presence of the quartz in basalt is generally explained by supposing a mixture of dacite and basalt magmas to have taken place. If this had happened in Tasmania, it is just conceivable that siliceous glass might have separated and given rise to these bombs. It is, on the other hand, very unlikely that all such material should have gone into the bombs, and none be left behind in the basalt sheets. None of these objects have been found in the basaltic lavas, and no quartz has ever been seen in any of the numerous slides of basalt which have been prepared. Moreover, their presence in the infra-basaltic gravels indicates an older date for them than that of the basalt outflows. They are found, too, in non-basaltic districts, *e.g.*, Schouten Main.

From this brief review of terrestrial theories, it will be seen that every suggested explanation is surrounded by grave difficulties. At present the extra-terrestrial theory is most in favour. Dr. Suess of Vienna published a treatise in 1900 on the origin of moldavites and allied glasses, strongly supporting a meteoric origin. He has given the objects the general name of Tektites, distinguishing the varieties found in Europe, Billiton, and Australasia as Moldavites, Billitonites, and Australites respectively. Mr. R. H. Walcott of Melbourne had previously called our bombs "obsidianites." Their occurrence in Australia, both in drifts and on the surface far distant from any volcanic centres, and here as there, in a manner independent of local geology, their similarity of type, even though scattered all over the vast area of Australia, lend undeniable weight to this hypothesis. Their sculpture presents suspicious points of resemblance to that obtaining in some meteorites. The basic constitution of meteorites is an opposed fact, but Dr. Suess replies that no valid reason can be adduced for denying to cosmic bodies the presence of acid silicates corresponding to the most acid magmas of the earth's crust. Professor F. Exner states that he has determined spectroscopically the presence of nickel in Bohemian moldavite glass. If this determination is substantiated, it forms a strong support of the theory of cosmic origin. The glass of the Australites fuses with difficulty and without intumescence, unlike many obsidians. Mr. T. Stephens* in his most recent note on the subject, advocating a new terrestrial origin, says:—"The ellipsoidal shape, which is not uncommon in Australian specimens of the buttons, is inconsistent with the theory of a long rotatory flight through the air, for any such volcanic ejectamenta must have cooled too quickly to allow of any change of form on reaching the ground." This appears a valid objection to the derivation from distant volcanoes. It does not apply to the meteoritic hypothesis, which supposes the bombs to be re-fused fragments of a cosmic body which exploded or burst possibly within the limits of the earth's atmosphere. It is, however, evident that the last word has not been said on this subject.

Syenite.

Syenite is a near relation of granite. It is virtually a granite deprived of its quartz, or at all events of most of it, for there are few cases in which it is absolutely quartzless. The silica contents, generally 55 to 65 per cent., cause it to be regarded as a rock of the series intermediate between granites and gabbros, acid and basic. The molecular proportion of alkalies reaches about a unit in advance of the granites, averaging about 8 per cent. Normal syenite consists of an alkali felspar, usually orthoclase, with a subordinate amount of lime-soda felspar, usually oligoclase-andesine, accompanied by biotite, hornblende, and (or) augite. Like granite, the family is best sub-divided according to the coloured minerals. Consequently we have hornblende-syenite, biotite-syenite, augite-syenite, none of these minerals absolutely excluding the other.

So far in Tasmania, I have not met with a syenite in which biotite is the dominant magnesian ingredient. The other two divisions are represented. Hornblende-syenite, or

* A further Note on Obsidian buttons: Proc. Roy. Soc. Tas., 1900-01.

syenite proper, occurs at the Heazlewood, all round Jupp's at the 13-mile on the road from Waratah to Corinna. It is evidently a part, and a marginal part, of the Magnet and Meredith Range of granite near its contact with the serpentinised gabbro and pyroxenite which are so well developed in that district. It is noteworthy that the rocks become excessively amphibolitic along this contact-line, and it is sometimes difficult to determine whether they were originally gabbroid or granitic. On the Heazlewood River, below Nickel Hill, is a typical dark-coloured hornblende-syenite, a quartzless rock composed of dominant orthoclase + plagioclase + hornblende. The hornblende is abundant, and tends to occur in nests. Another variety from here, lighter in colour, has a moderate quantity of quartz in granophyric intergrowth with felspar, and little lumps and grains (also crystals) of gray sphene. Iron ores are scarce; no mica is discernible in either of these rocks. At the Heazlewood Mine is a hornblende-syenite with not quite enough quartz for a granite, containing green hornblende in fine crystals. Nests of actinolite occur in this rock.

The absence of biotite in our hornblende syenites is a noteworthy feature.

Augite-Syenite.—The Heazlewood also furnishes augite-syenite, consisting of orthoclase + plagioclase + augite + hornblende, + a little quartz. Augite-syenite also occurs in the biotite-granite of Schouten Main at the head of Freycinet's Peninsula, on the East Coast, where the rock (called green granite locally) is composed of orthoclase + plagioclase + augite + biotite.

None of these syenites are independent *massifs,* but are invariably subordinate portions of the great granite ranges. The syenite, in fact, may almost be regarded as a facies of the granite.

Augite-Syenite Porphyry.—This rock occurs at the Gawler River, North-West Coast. It contains a little quartzo-felspathic ground-mass, with phenocrysts of alkali and lime-soda felspars, augite, and rarely biotite. It is a dark-green rock, much resembling a somewhat similar rock at Lynchford, except that the latter has porphyritic quartz; and I have not seen any biotite in it. This rock, too, is more coarsely granular. A similar rock is met with at Beulah, Kentish.

Pyroxene-quartz Porphyry.—This rather peculiar syenitic effusive occurs at Lynchford. It very closely resembles the Gawler rock, but has differences, as just mentioned, and seems to be connected either with the quartz-porphyry of

Mt. Huxley or the felsites of Mt. Read. The decomposed clayey portion on the King River is sluiced for gold. The rock contains porphyritic alkali and plagioclase felspars, augite, and quartz. Such quartz-porphyries are not common. For some time this rock has been considered to be a syenite porphyry, of which it is evidently a near ally.

Gabbro-Peridotite Series.

This series is essentially connected with the preceding, notwithstanding a continuous increase of basicity. The foyaitic rocks are higher in SiO_2 and in that respect, but in that only, are intermediate between granite and gabbro. They are, however, never found associated with these, and must be regarded as being more distant from them than either is from the other. Accordingly, granite often assumes a gabbro facies, but never an elaeolitic one, and in fact a continuous series exists of granite, syenite, diorite, gabbro, with various passage-rocks difficult to define. It follows that the three divisions, granite, gabbro, elaeolitic rocks, are not equivalent in value, the two former being connected by passage-rocks, while the nepheline series is absolutely independent, as far as we know.

Gabbro.

Geologically, plutonic: chemically with $Ca > (Na + K)$: mineralogically, consisting of basic lime, soda felspars (labradorite-bytownite-anorthite), + pyroxene (monoclinic or rhombic), with or without hornblende or olivine: structurally, like granite. SiO_2, mostly between 44 and 54 per cent. The subdivisions of the family are mineralogical, and its representatives in Tasmania are—

(1) Gabbro proper = diallage + plagioclase.
(2) Norite = plagioclase + rhombic pyroxene.
(3) Olivine norite = plagioclase + rhombic pyroxene + olivine.
(4) Quartz-norite = plagioclase + rhombic pyroxene + quartz.

Modifications.

(5) Saussurite gabbro.
(6) Flaser gabbro.
(7) Gabbro amphibolite, Zobtenite.
(8) Gabbro-diorite.

Gabbro has not been found in the southern or eastern parts of the Island. It occurs at the Heazlewood, Forth, near Beaconsfield, Dundas, and Mt. Heemskirk, and always carries with it a development of pyroxenite; and these masses of gabbro and pyroxenite have been largely converted into serpentine. Owing to the disappearance of the felspars, it is difficult to determine whether our serpentines were originally gabbro or pyroxenites. Analogy suggests the derivation from pyroxenites and peridolites.

The rock generally is intrusive in the Silurian slates and sandstones. These intrusions may be seen very plainly in the Heazlewood district, along the road between the Arthur River and the Heazlewood Bridge, at the Magnet Mine, &c. Later, the Devonian granite has intruded in the basic rocks, as shown by the amphibolites at the Heazlewood and the gabbro-diorite at Mt. Agnew.

The freshest sample of the rock hitherto met with is from 2½ miles west of Ringville, where it is as well preserved as any of our Mesozoic dolerite. Some very fine rocks, however, are obtainable at the Heazlewood, where gabbro proper frequently varies into a norite and olivine norite. On the north slope of Mt. Bischoff a serpentinised gabbro occurs, with rhombic pyroxene, and interstitial quartz = quartz norite.

The metamorphic modifications of gabbro may be studied to advantage at the Heazlewood and Mt. Agnew, and apparently also at the Rocky River, where magnetite beds, with nickel and pyrrhotite, are enclosed in hornblende schists and gneissose amphibolites (with zobtenite).

One result of metamorphic agencies is the development of the albite-zoisite mixture, called saussurite, which replaces the felspar. This change is apparently a phase of regional metamorphism. Some very pure milk-white saussurite occurs in loose blocks on the Heazlewood River. A very singular saussurite-gabbro occurs in the Anderson's Creek serpentine area, consisting of long prismatic brown hornblende, set in a white saussuritic matrix. This idiomorphic hornblende must be a secondary development, and the rock will have to be called a gabbro-amphibolite; there is no shistose structure in it, however.

The rock at the Comstock Quarry, near Zeehan, is gabbro-diorite; the pyroxene has been converted into hornblende, the gabbroid structure of the rock still remaining. The gabbro all along the Trial Harbour Road, at the foot of Mt. Agnew, shows this kind of metamorphism. The new mineral is pale bluish green, and often shows the cleavage lines of hornblende. It must be remembered that this is the contact-line with the intrusive granite of Mt. Heemskirk.

The gabbro at the Heazlewood, along the line of contact with the great Magnet-Meredith granite range, presents many amphibolitic varieties, often losing its gabbroid structure and becoming a reconstructed rock, amphibolite. Some beautiful amphibolites may be collected between the Heazlewood and Mt. Hope mines, also on the Forth River. Some of the dykes which traverse the Silurian slates on the Waratah-Corinna Road show good examples of flaser-gabbro, and metamorphic gabbro with a granulated structure.

At the mouth of the Blythe, and between Burnie and Cooee Creek, a gabbroid rock runs out to sea as reefs. The felspar is not so basic as the ordinary gabbros, and the pyroxene is exclusively monoclinic. It does not belong to the same series as our gabbros generally. It may be connected with some of the rather obscure basic rocks found between Mt. Bischoff and the Magnet.

There is a very interesting group of hornblende schists at the Rocky and Whyte rivers, enclosing large deposits of magnetite, with pyrrhotite and copper ores. The area is one of regional metamorphism, and the schists are gabbro-amphibolites. Roth gave the name of Zobtenite to rocks which belonged geologically to the crystalline schists, and petrographically to gabbro; but the term has not gained general acceptance. Rosenbusch has dropped it, and now includes such rocks among dynamically-metamorphosed gabbros, and calls them variously flaser gabbro, gabbro schist, felspar amphibolite, amphibolite schist. Zirkel says that their position in the crystalline schists is such that there is no proof of any intrusion, and that their origin is bound up with the genesis of the schists. The rock at the Rocky River consists of green hornblende, plagioclase, quartz, apatite, epidote. This belt of country, with deposits of magnetite, extends N. 20° W. for a minimum of 14 miles, and is said to continue even for 25 miles.

Peridotite and Pyroxenite.

These ultra-basic rocks are nothing more nor less than felsparless modifications of gabbro, and contain ferro-magnesian minerals exclusively. The percentages of Al and Si are the lowest known, the latter sinking to about 40 per cent. Ca Mg $>$ Na + K. Ca contents are more considerable in pyroxenites than in peridotites, but Mg is high in both. Al is low. Na and K gradually disappear. The peridotites contain olivine; the pyroxenites are pyroxene rocks. In Tasmania they may be classified as under:—

Peridotites:

Wehrlite = diallage + olivine.
Lherzolite = diallage + enstatite + olivine.
Harzburgite = enstatite + olivine.

Pyroxenites:
Diallagite = diallage.
Bronzitite = bronzite.
Websterite = diallage + bronzite.

These rocks occur firstly over broad areas as serpentinised and partially serpentinised masses; secondly, as dykes traversing Silurian slates and even gabbro or serpentine. In the latter case they may be considered as belonging geologically to the gabbro. and bearing the same physical relation to it as elvans do to granite. In some cases, too, they may be marginal differentiations of the gabbroid magma.

Dykes of wehrlite and lherzolite occur on the Waratah-Corinna Road, the latter rock containing very little pyroxene, and approximating very closely to the olivine rock dunite. We have a very fresh harzburgite from the Upper Arthur River; unforunately, it is only known from a single specimen, and the precise locality is not known.

The pyroxenite rocks occur as diallagite at the bridge over the Heazlewood River, at the Upper Blythe River, Hampshire Hills, and as bronzitite near the Heazlewood Bridge, at the Bald Hill, Anderson's Creek, New West Colebrook, in the North-East Dundas district. Websterite is found at the Heazlewood in serpentine rock.

The large dyke containing the Magnet galena lode is a dark-green rock containing porphyritic crystals of enstatite and augite. Professor H. Rosenbusch has examined this rock, and terms it a websterite-porphyry. He says:—"If we follow the rock back to its original and unaltered state, we shall find phenocrysts of bronzite, or enstatite (now bastite), in a ground-mass of rhombic and monoclinic pyroxenes (now a mixture of serpentine and a chlorite mineral). It is, therefore, a porphyritic form of websterite—a websterite-porphyry. Its nearest relations are certain bronzite-serpentines (without olivine). In the structure of the ground-mass it resembles the South African Kimberlite and the mica-peridotites of Kentucky, described by Diller. In this purity of form the type is quite new to me."

A very singular pyroxenite occurs to the W. of the Magnet lode, and half a mile north of the North Magnet Mine. It is a yellow-brown soft pyroxene rock, mostly weathered, and crowded with spheroids of the same mineral from the size of marbles to that of cannon-balls. The spheroids assume sometimes the shape of dumb-bells, and fall out of the matrix very readily upon handling.

Diabase: Its Geological Occurrence.

Both Zirkel and Rosenbusch, as well as A. Lacroix, place diabase among effusive rocks, while stating that it occurs also as an intrusive. Its effusive habit need not detain us now, for all the signs of its occurrenee in Tasmania indicate its intrusion into overlying rocks. It contains no glass, no scoria, has no horizontal partings between separate lava-flows, has no development of microlites or zeolites, is coarsely holocrystalline, sometimes almost gabbroid. It is found in Permo-Carboniferous and Mesozoic strata, as well as in Devonian granite, preserving a wonderful uniformity in structure and constitution, which would be truly singular if its occurrences in these different systems were prolonged contemporaneous lava-flows. Zirkel mentions that the effusive diabases carry on their surfaces fluidal signs, ropy twists, glass crusts, and are associated with tuffs. In spite of this, he goes on to say that, in respect of internal structure, no thorough-going difference can be drawn between the effusive diabases and those which occur as intrusive sheets (Lehrbuch der Petrographie, vol. ii., p. 651). A. Lacroix, in his "Gabbro du Pallet et ses Modifications," 1899, pp. 27-30, has an interesting chapter on the terms gabbro and diabase. He adopts the English use of the term gabbro, which includes gabbro proper and a portion of the old French diabases (those with gabbroid structure). It is curious to note how usage in different countries affects nomenclature in different ways. M. Lacroix rejects the term "dolerite" for nearly the same reason that has influenced English petrographers in rejecting "diabase," viz., because the question of age is implicated. In France dolerite has been applied to the Tertiary rock and diabase to the pre-Tertiary—hence modern French petrography drops the term dolerite. In England, as a protest against the same usage, diabase has been dropped by a section of English petrographers, and dolerite retained. Rutley uses the term dolerite to denote holocrystalline basic dyke and intrusive rocks which pass upward into the basalts. At certain points in their passage they may be regarded as truly volcanic rocks. Harker calls the larger intrusive bodies of hypabyssal pyroxenic rocks diabase, and the minor intrusions of the same rock dolerite.

The intermediate position of these rocks between plutonics and volcanics inevitably gives rise to varieties where the line is difficult to draw—such varieties are gabbroid and effusive diabases. The typical ophites, or diabases, of the Pyrenees are intrusive bosses, but Lacroix also points out an occurrence there where it is strictly effusive, accompanied by tuffs and ejected blocks, and without any contact phenomena. He goes on to say that the most crystalline varieties collected in these lava-flows are scarcely different from the normal type of the intrusive diabases.

Rosenbusch admits that fresh diabases are indistinguishable from dolerite and intersertal basalt. Of this we have a striking illustration in the structure of the doleritic basalt north of Lefroy. The rock evidently formed part of a thick lava-flow, and must be regarded from its structure as olivine dolerite. Strictly speaking, the structure of an igneous rock is governed, not by its geological occurrence, but by the physical conditions of its consolidation. We are, however, often in a position to deduce either of these from the structure.

Those who contend that the heavy diabase caps which rest on the summits of our mountains are the lower parts of sub-aerial lava-flows must show a slaggy contact with the underlying sedimentary strata. This has not been shown yet. In some instances it is difficult to avoid the inference that the eruptive rock does overlie the Mesozoic sandstone, as, *e.g.*, at the Douglas and Denison rivers, where the streams have cut down into the diabase-crowned range, carving their channel through the overlying igneous sheet into the sandstone below. But here, again, the actual contact is hidden by a heavy overburden of fallen blocks of columnar diabase. The very profusion and size of these prostrate columns lying on the sandstone bedrock lead me to infer that they have not been transported from further up the slope, but are simply the stationary remains of the former extension of the igneous cap. If, however, this igneous cap was not a sub-aerial flow, it must be explained as a lateral thrust from a hypabyssal intrusive mass, *i.e.*, a sill or a laccolitic extension. For aught we know, the cap itself may in its central parts be a core.

The bore at the Cascades, on the flanks of Mt. Wellington, passed from 509 to 519 feet through the Permo-Carboniferous marine mudstones, and then struck the underlying diabase, into which it penetrated 120 feet before boring was suspended. This may mean either of two things: (1) The underlying diabase is part of a mighty core which has intruded into the sedimentary strata, like a laccolite; (2) the lower diabase and the upper one now forming the cap may be two separate sills at different horizons.

Minor intrusions and dykes are numerous all over the eastern and south-eastern parts of the Island, converting sandstones into quartzite and adinole, the latter a cherty or flinty looking rock, which furnished the aboriginals with much of the material which they chipped into the forms of their rude flakes. The coal seams in the neighbourhood of these dykes are injured by the proximity of the intrusive rock, the coal being rendered brittle, stony, and unfit for use.

Our views of the probable extension of our coal-measures will be materially affected by the theory we form of the occurrence of the diabase. If the apparent igneous caps be real caps, our coal seams will pass through the mountain ranges underneath the horizontal sheets of diabase; but if they are only apparent, the area of our coal-bearing strata will be wonderfully curtailed. From a practical as well as from a scientific point of view, it would be interesting to see some deep bores put down into the igneous rock which crowns the Tiers. If these reached sedimentary rock below, boring for coal where the cap is likely to be thin would be undertaken freely.

Ophitic Structure.

The diabase often has this strongly developed. In it the pyroxene forms a cement, enwrapping and moulding itself on the felspar prisms, which then have the appearance of cutting up a formless mass of augite into different sections. The augite, however, suffers no solution of optical continuity, as is easily seen by rotating it between crossed nicols. Rosenbusch calls this the diabasic-granular structure. Fouqué and Levy had already called attention to it as ophitic, from the ophite of the Pyrenees. In some of our diabase it is developed quite typically, and it is to be found in the more crystalline of our basalts, though among the latter the intersertal structure is more common. This is the structure in which an interstitial ground-mass makes its appearance. Rosenbusch remarks that the intersertal structure is more usual in fresh diabases than in those found among the older rocks. If this be so, it is difficult to explain, for these structures must be considered as original, not superinduced after consolidation. Fouqué and Levy have reproduced it artificially in their synthetical experiments. Loewinson-Lessing (Bull de la Soc. Belge de Géol., &c., tome ii., 1888, pp. 84-87) contends that it has been produced by lava-flow under the pressure of the sea. Now the ophitic gabbros of the Western Isles of Scotland (see Judd's papers) have been shown to have had a sub-aerial origin. North of Lefroy, in Tasmania, some of our subaerial Tertiary basalt is ophitic or coarsely intersertal—a typical dolerite. Consequently, we are not called upon to accept submarine conditions for the eruptions of our diabase by reason of its structure alone.

Although the structure of the rock throughout the Island is monotonously uniform, there are slight variations in two opposite directions.

On the Brown's River Road the coarse diabase contains stouter prisms of felspars, which in sections show correspondingly broad forms, but not so isometric as in true gabbros. Occasionally this variation is prolonged until quite gabbroid diabases are developed. The other direction in which it varies is towards the development of an intersertal and even porphyritic structure. This is illustrated by the quarry at the Railway Station, Hobart, where porphyritic stone may be picked out sometimes. Such structure may be explained by proximity to the margin of the intrusion.

Mineralogical Constitution.—Our diabase is essentially a mixture of lime-soda felspar (labradorite) and augite, accompanied by magnetite and ilmenite, and always a little apatite. Occasionally hypersthene occurs sporadically, more rarely biotite, and possibly olivine. Chlorite is always present in more or less quantity. Quartz occurs, often in granophyric intergrowth with felspar, which is probably orthoclase. This is seen in the diabase of some of the mountains round Hobart. (Mt. Faulkner, Organ Pipes on Mt. Wellington, Brown's River Road, &c.)

A rhombic pyroxene has been noticed in the rock at Bothwell, Ross, Tiers west of Tunbridge, Mt. Direction, Killafaddy, Devonport. The augite in the diabase dykes which traverse the granite at the Blue Tier appears to be largely uralitised.

Mention may be made of the Bothwell Tertiary basaltic lava having been extruded through the Mesozoic diabase cap, as evidenced by included fragments of the latter detected microscopically in a slide of the basalt.

Chemically the rock is identical with basalt, and as any structural difference is due to geological occurrence, and not to differentiation of magma, it cannot be ranked among the dyke rocks, even though it be intrusive.

The preceding remarks have reference to the diabase of Upper Mesozoic age, but there is a group of imperfectly-known rocks on the Magnet Range of much older age. These can at present only be generally mentioned as diabase and diabase porphyrite. Their geological horizon has not been definitely determined yet, but it is apparently higher than the Silurian and lower than the Permo-Carboniferous. Among these older diabases, allusion may be made to a remarkable nodular variolite which bounds the west or hanging-wall side of the websterite dyke containing the lode of the Magnet Mine. It varies into a vesicular diabase-porphyrite. Professor Rosenbusch has kindly determined this rock, as follows:—"If a slide be made of the soft dark-green ground-mass (which is soft enough to be scratched with a knife), it can be seen to consist of a scaly aggregate, the scales of which can often be recognised as chlorite, with very weak double refraction, and optically positive: optic axial angle very small. Pleochroism weak, normal = green for rays vibrating parallel with the surface of the flake, yellowish-white for those vibrating perpendicular thereto. In it are lying colourless sections, variously bounded, but always with crystallographic contours, long, rectangular, and prismatic, also nearly quadratic, extinguishing sometimes straight, sometimes oblique. In convergent light these often show the emergence of a positive bisectrix of a not very large axial angle, sometimes the emergence of a negative bisectrix of a very large axial angle. In the first case, no structure is recognised; in the second, a more or less scaly or fibrous structure. Their refractive index differs very little from that of the main mass, and there are often seen lying in these apparent crystals green heaps of scales without any clear boundaries, but passing into the colourless substance and having the same optic orientation. In the colourless sections there are also lying homogeneous and homoaxial pseudomorphoses of chlorite, poor in Fe (Leuchtenbergite) after a pyroxene mineral, but I cannot say whether the latter was monoclinic or orthorhombic. Further, in the green mass, there are circular hollow spots (nearly always surrounded by cracks), which were no doubt originally amygdaloidal cavities, but are now filled with mixed chloritic and quartz spherulites of irregular architecture. It is quartz (optically + and uniaxial), not chalcedony (optically — and biaxial). Finally, in the ground-mass, are little aggregations of iron ore, which I have not examined more closely. They dissolve easily in HCl, which also strongly attacks the chlorite and leuchtenbergite. Now, if a slice be made through the nodules, which are much harder than the ground-mass, and sometimes cannot be scratched with the knife, here and there chloritic spots are seen, containing small sections of chalcedony amygdules. Inside the nodules is sometimes some ground-mass. More frequently, however, the nodules consist of colourless substances. Large aggregates of granular or even radiating quartz are seen, sometimes without any regular external boundary, sometimes plainly, and without doubt showing the form of felspar. These are replacement metamorphoses of quartz after felspar, of such beauty as I only know in quartz porphyries. Between these pseudomorphoses of quartz after felspar there are roughly-radiate bundles and spherulitic crystals of felspar, which, from their optical behaviour, clearly belong to orthoclase or andesine. They are partly converted into sericite, and, when this happens, the nodules can be scratched with a knife. Finally, the nodules are much intersected by veins of quartz, the fillings of cracks in the rock. Iron ores are absent; but from the often quadratic and trigonal outlines of the quartz aggregates, I believe we must conclude that the ores have been removed, and their place taken by quartz. After all said and done, I regard the rock as a characteristic variolite, but certainly in a much-altered state."*

Basalt.

This rock is the effusive form of gabbro, and its mineral constituents are lime-soda felspar, and pyroxene, with or without olivine. As in other groups, the aim in classifying should be to get behind mere structure, and found subdivisions upon mineralogical constitution. The time-honoured divisions of dolerite, anamesite, basalt, applied to this group may well be allowed to lapse; the terms are of merely textural significance, and may be used in describing any of the sub-groups, but not in defining them. The sub-groups met with in Tasmania are:—

1. Olivine-basalt ... ... *Passim.*
2. Hypersthene-basalt ... ... Circular Head.

The Tertiary basalt which has so widely overspread the Island is olivine-bearing. The olivine is extremely abundant in some varieties, usually in rounded or corroded crystals, but occasionally perfectly idiomorphic, as in the vitrophyric lavas of Sheffield, &c. Serpentinisation is frequent.

Every variety of structure is represented—hypocrystalline, vitrophyric, and hyaline. Near Lefroy the basalt is often intersertal in structure. In many parts of the Island (Waratah, Hampshire, Conara, Benham Plains, Bothwell, &c.) it is highly vesicular. It is vitrophyric and hyaline at

* Report on the Mineral Fields between Waratah and Corinna, W.H.T., 1900.

Sheffield, Bothwell, &c.; is hydrated at Perth; and tuffaceous at Ringarooma, Leven, &c. Tachylyte of a beautiful blue colour occurs at Richmond and Nietta; the hue, no doubt, due to soda.

Columnar joincing may be seen at Burnie and on the North Coast, east of the Tamar. No cinder cones have been found yet, and so far we have not been able absolutely to define any volcanic necks which served as conduits for the lava. The Tertiary olivine basalts appear to have been poured out at the end of the Palæogene epoch. They choked the river valleys at that time, covering up stanniferous and auriferous gravels, and giving rise to deep leads. These basalts require more detailed study than they have yet received; there would seem to be associated with them nepheline-bearing lavas, which cannot well be distinguished in the field from the flows of normal basalt.

A Silurian basalt or melaphyre occurs at Zeehan, where it is known as the "white rock." It is there interbedded with the slates, and is generally vesicular—often tuffaceous. The vesicles are filled with calcite or a chlorite mineral.

Associated with the nepheline-bearing basalt at the Bluff or Nut at Circular Head is a variety of basaltic rock, containing porphyritic hypersthene. The rock is only known by a slide, and its unexpected discovery is perplexing.

Elæolite Rocks.

A family bond unites the whole series of nepheline rocks, viz., an excess of alkalies. Accordingly, in nature, rocks with this characteristic will be found associated, and we shall not find them genetically connected with normal acidic and basic rocks. Hence I detach alkali-granites and alkali-syenites from the normal granites and syenites, and put them into the elæolite series. H. Rosenbusch treats them as resultants from the foyaitic magma, and I submit he is logically pledged to take the further step of giving them a place among the foyaitic rocks. Both alkali-granites and alkali-syenites occur in association with elæolite syenites, pass into them, and contain related dyke-rocks. Their Si per cent. is higher than in their normal equivalents, Mg and Ca less, but Na and K higher. Hence mineralogically the alkali-granites are characterised by an alkali-amphibole (riebeckite or arfvedsonite), ægirine, soda orthoclase, microcline, microperthite, albite, and anorthoclase. The alkali-granite lavas, comendite, and pantellerite contain similar soda minerals. For the same reason, alkali-syenites have to be transferred also. They are characterised by soda orthoclase, microperthite, anorthoclase, arfvedsonite, riebeckite, barkevikite, ægirine, and ægirine-augite—often sodalite and nepheline. Soda trachytes are their effusive equivalents.

Before passing to the very distinctive and complex group of nepheline rocks, which are developed in great variety at Port Cygnet, it will be well to consider briefly our aberrant members of the system. Keratophyres and quartz-keratophyres (soda-felsites and soda quartz-felsites) are recognised as effusive forms of alkali-syenite and alkali-granite. They occupy, however, an abnormal position, in that they have always been found hitherto associated with diabase or diorite, and not, as might have been expected, with alkali rocks. In Tasmania they form no exception to the rule as regards any connection with elæolitic rock-masses. The nearest rocks with which they can be said to have any connection are the quartz-porphyry and pyroxene-quartz porphyry of the West Coast.

A zone of greenish felsitic rock, sub-schistose in aspect, flinty and often red-streaked, passes north and south along the western slope of Mt. Read, conformable to and enclosed in the copper and silver-lead-zinc sulphidic schists for which that mountain is famous. It has been traced north to Mt. Black as far as the Pieman River. It is doubtful whether the copper-bearing rock at the Hawkesbury and Cutty Sark on Mt. Black is not a micro-granitic modification of it. A rather singular feature is, that at Mt. Read it is non-metalliferous. The rock is greatly obscured by age and metamorphism, but its microscopic examination shows plagioclastic felspars to be abundant. This gave rise to the suspicion that it might be a member of the small group of soda felsites (in their metamorphosed, sheared form often termed porphyroids). Professor H. Rosenbusch, after examining specimens sent to him, wrote with his characteristic good nature, as follows:—"Undoubtedly we have here strongly dynamically altered forms of the acid eruptive rocks. The typical porphyritic structure, the nature of the phenocrysts, the still recognisable fluidal structure, the nearly entire absence of dark constituents, the occasional spherulitic forms still recognisable in their replacement products (quartz-albite), all point with certainty to members of the quartz-porphyry family; and, with great probability, not to quartz-porphyry in the narrower sense, but to quartz-keratophyre and keratophyre . . . The rocks greatly resemble our German occurrences in Westphalia, the Fichtelgebirge, and Thüringen, and especially the occurrences in Wales. These are the forms which in Germany were originally called porphyroids and flaserporphyries."*

An analysis of this rock from exposures on the North Hercules section was made by Mr. W. F. Ward, Government Analyst of Tasmania, with the following result:—

	Per cent.
Silica	75·73
Alumina	12·70
Oxide of iron	2·25
Lime	2·00
Magnesia	0·60
Potash	2·04
Soda	3·48
Loss at red heat	1·20
	100·00

It is not high in Na_2O for a keratophyre, but not low enough to exclude it, while the excess of soda over potash is very distinctive. A few more analyses are desirable to place the determination upon a thoroughly satisfactory basis.

All round the arm of the Huon called Port Cygnet, and crossing it in a N.E.-S.W. direction, is a belt of alkali rocks, which are developed as elæolite-syenite, alkali-syenite, tinguaite, and sölvsbergite, phonolite, or trachyte, containing nepheline, haüyne, ægirine, analcime, and sodic augite, melanite gravel, with all the accessory minerals of the nepheline group of rocks. The zone extends north to Oyster Cove, and to an undefined distance on the south side of the River Huon. The sediments into which some of these eruptive rocks have intruded are Permo-Carboniferous; some of the trachytes are apparently contemporaneous. As the axis of the peninsula between Port Cygnet and D'Entrecasteaux Channel is crowned with Mesozoic diabase, the relations of the latter to the nepheline belt will be a crucial test of age, as far as the Tertiary period is concerned. The district is economically interesting from a good deal of alluvial gold having been shed into the flat at Lymington from the trachytic rocks, apparently from their contact-line with the sedimentary strata. The rocks at the contact are silicified, and carry minute quantities of gold (and silver up to 6 ozs. per ton). The search for fissure lodes as sources for the gold has been futile.

* Felsites and Associated Rocks of Mount Read and vicinity, W.H.T. and W. F. Petterd. Proc. Roy. Soc. Tas., 1898-9.

The rocks are developed in surprising variety, and have an unusual facies compared with elæolite syenites and phonolites in other parts of the world. Beyond a preliminary study* nothing much has been done in the direction of their definite nomenclature, which is a subject inviting attention. They have been broadly assigned to three physical groups—soda-syenite, soda-aplite, soda-trachyte. Further examination has resulted in a tentative division, as follows:—

Alkali Syenite group—
Phonolitic trachyte.
Alkali Syenite.

Elaeolite Syenite group—
Trachytoid Phonolite.
Haüyne Phonolite.
Sölvsbergite.
Tinguaite.
Tinguaite-porphyry.
Elaeolite-Syenite.

Theralite group—
Nephelinite.

N.B.—It is very doubtful whether volcanics really occur; hence, the terms trachyte and phonolite are provisional.

At the Regatta Ground a grey medium-grained plutonic rock is exposed on the beach, varying a good deal in places, but all the varieties evidently belong to one plexus. The coarse variety is an elaeolite syenite, rich in biotite; pyroxene is apparently absent; idiomorphic natrolitic pseudomorphs after nepheline are abundant. A fine variety carries quartz, garnet, and ægirine-augite; this is an alkali-syenite, and must be allied to nordmarkite, but no hornblende is present. This rock has its effusive, or probably dyke, equivalent, a (soda) hornblende-quartz holocrystalline trachyte on the back road from Lymington (near Marten's). This is a striking rock, light grey, resembling a fine-grained granite, and carrying porphyritic glassy felspars, often with rhomb-shaped sections (anorthoclase). A specimen of one of the elaeolite syenites south of the Regatta Ground was sent to Professor Rosenbusch, who communicated the results of his examination, as follows:—" No. 87 is a medium to fine-grained elaeolite syenite. It is not at all poor in elaeolite, or nepheline, in idiomorphic, somewhat dusty crystals. In hexagonal cross-sections, I observe the interference figure

* On Haüyne-trachyte and allied rocks in the districts of Port Cygnet and Oyster Cove. W.H.T. and W. F. Petterd. Proc. Roy. Soc. Tas., 1898-9.

with — sign. Besides orthoclase felspar and elaeolite, or nepheline, ægirine augite is abundant, also a peculiar biotite, and melanite garnet, in beautiful crystals (110), often with splendid zonary structure, and in grains as well. The biotite has a plainly oblique extinction, as occurs mostly in the alkali rocks. In addition to the fresh elaeolite, or nepheline, there are natrolitic pseudomorphs after sodalite. You would lay me under an obligation if you could send me a few larger specimens. Compared with the numerous elaeolite syenites known to me, this Port Cygnet rock has decided characteristics of its own."*

On the same beach, near the Regatta ground, holocrystalline tinguaites are common, carrying nepheline, ægirine-augite, hornblende, and abundant biotite. Some distance south a remarkable tinguaitic dyke-rock is met with, greenish in colour, and containing glistening layers of tabular crystals of sanidine. Under the microscope the green tint was found to be due to a fluidal mass of needles of aegirine, and the rock was referred to aegirine-trachyte. This was also transmitted to Professor Rosenbusch, who has replied, as follows:—"No. 83 I would call a tinguaite-porphyry, or, perhaps better, sölvsbergite-porphyry; but I have no objection to your name, although I can scarcely believe the rock was effusive. There are phenocrysts of sanidine, and a strikingly light-coloured aegirine (and aegirine augite), with a : c up to 20° in 010, in a ground-mass of felspar and aegirine needles. Staining in the colour-bath shows the ground-mass to contain very small quantities of nepheline. The aegirines often contain a kernel of amphibole, with a : c equal to 17°. It is noteworthy that the sanidine phenocrysts often contain aegirine as an inclusion. I also saw melanite twice in the same relation. The rarer elaeolite minerals are more plentiful than in No. 84, but I could not determine them with certainty. There is also some titanite present."

The presence of melanite garnet is a strong characteristic of rocks of the whole series, and different varieties of it appear to exist.

In 1889, Mr. O. E. White and Mr. W. A. M'Leod described a new variety of garnet, to which they gave the name of Johnstonotite, occurring in a trachytic dyke-rock south of the Regatta Ground. This rock, too, has been submitted to Professor Rosenbusch, who writes:—"No. 84, with the beautiful crystals of garnet (211), I would call a garnetiferous mica-sölvsbergite. Apart from the garnet

* Petrographical Report. W.H.T., 1900.

phenocrysts, the rock is essentially composed of orthoclase felspar laths, and whisps of a peculiar brownish-yellow mica, slightly pleochroic, optically negative, apparently uniaxial; its cross in convergent light does not open out appreciably. This mica takes readily the form of rosettes, which, in one place, have collected into a rectangular aggregate, the outline of which reminds one of the form of amphibole. Besides these, iron ores are present in very small quantity (titaniferous magnetite and some pyrite), and in one place, so far, a colourless mineral in short laths, which, judging from its refraction and double refraction, might possibly be mosandrite; but I have no certain proof of this. At all events, it belongs to the numerous elaeolite-syenite minerals of the titano, or zircon, silicates. There is, further, present sporadically, in separate grains, a strongly-refractive, rusty-brown, transparent mineral, which I cannot identify. Between the laths of felspar there is a colourless mineral, the refraction of which is only a little stronger than that of the felspar, and its double refraction is weak. On staining, it is shown to be not nepheline, but albite. Under the glass, I see, in two casts of the garnet left behind on falling out of the rock, that there is a fine violet coating, which may be fluorspar, and that often the garnet was immediately surrounded by pyrite, in which the former left its imprint."

A dark-green plagioclase-hornblende rock is found at the Regatta Ground. With other associations it would be classed as diorite, but seeing that diorite has never been recorded in association with the elaeolite rocks, further examination is requisite. If it should turn out to be diorite, the occurrence will be a remarkable one.

A green rock of dense structure and laminated habit is found strewn in pieces over the ground just above the Mary Mine on Mt. Mary. This is referred to tinguaite-porphyry. The ground-mass consists of small felspar prisms, nepheline, needles of aegirine, and shows distinct fluidal structure. The phenocrysts are sanidine, nepheline, aegirine-augite. Instances of fluidal aegirine are now recorded more frequently than formerly. An accessory mineral in the above rock is melanite.

Certain trachytoid rocks on Mt. Mary occupy an unsettled position. Some of them may be effusive, others intrusive. Both on Mt. Mary and Mt. Livingstone a singular häuyne phonolite occurs, with large porphyritic tabular felspars, and pseudomorphs after häuyne. The black iron oxide spots scattered through the rock are pseudomorphs after garnet. A light-grey rock on Mt. Livingstone, sometimes with a faint bluish tinge, also contains porphyritic häuyne.

Somewhat similar rocks are found in the Oyster Cove district.

It is proposed that members of this section be afforded an opportunity during their stay of visiting Port Cygnet, and inspecting this interesting series of rocks.

The theralitic magma is also represented in Tasmania. In this magma, Al, Na + K, Ca, Mg, are all high, and SiO varies from 27 per cent. to 56 per cent. The rocks are basic nepheline ones. Plutonic and dyke-rocks have not been met with yet in this State. The discoveries hitherto may be tabulated as follows:—

Trachydolerite, at Circular Head and Table Cape.
Limburgite, near Burnie.
Nephelinite, Shannon Tier.
Melilite basalt, Shannon Tier.
Melilite basalt, Sandy Bay.

The bluffs at Circular Head and Table Cape were referred by the late Professor Ulrech to nepheline basalt, but the determination was afterwards withdrawn in favour of apatite, which is present in fair quantity. The felspar is plagioclastic, and olivine is abundant. The latter mineral serves to separate the rock from tephrite. The nepheline is not easy of detection, lying concealed as it does in the groundmass. Its determination has been confirmed by staining. I have this week received a letter from Professor Rosenbusch, who, with his usual kindness, has examined this rock, and determined it to be trachydolerite. The habit of the rock is basaltic. In these bluffs the ordinary Tertiary olivine basalt is also met with, and the geological relations of the two have not been examined.

A dyke of limburgite occurs on the Emu Bay railway line, 7 miles from Burnie. This felsparless rock is no doubt connected, not with the ordinary olivine basalts of the district, but with the nepheline-bearing rock of the bluffs just referred to.

Nephelinite, or nepheline-augite rock, occurs at Hunterston, at the top of the Shannon Tier. This rock here is very coarse, abounding in long prisms of augite, which have been mistaken for tourmaline. The remainder of the rock consists of nepheline, which has largely decomposed to natrolite. This zeolite takes the form of radiated aggregates of snow-white aspect. I have not been able to match the rock exactly with any European occurrences in respect of texture. Ours is much coarser in grain, but the structure is that of the nephelinite of the Katzenbückel.

Melilite basalt is associated with the nephelinite. This is an olivine-augite-melilite rock, forming certain little conical hills on the top of the Tier. A recent visit has shown the nephelinite and melilite basalt to be Tertiary.

It is noteworthy that the discovery of the entire series of elæolite and nepheline rocks in Tasmania has been due to microscopical examination.

A few weeks ago melilite was microscopically determined in the Tertiary fayalite basalt at the Alexandra Battery, Sandy Bay. This interesting occurrence is now under examination.

A beautiful augite-biotite-nepheline rock from Port Cygnet beach has just been determined by Professor Rosenbusch as nephelinite.

Contact Rocks.

Limurite.

The augite-axinite rock at the Colebrook Mine, near Ringville, is the same as that which occurs in the Pyrenees, and to which Professor F. Zirkel has given the name Limurite. It consists of axinite, augite, actinolite, and calcite, with the other boric minerals, datholite and danburite. It carries or is associated with large masses of pyrrhotite containing from 1 per cent. to 3 per cent. of copper. Portions of the ore-body are somewhat richer in that metal. The mass as a whole appears to be divided into parallel bodies in metamorphic slate. Serpentine and bronzitite form the country to the west. No tin ore has been found in the deposit, but stanniferous pyrrhotite lodes and tourmaline quartz-porphyry courses traverse Silurian slate country further west.

The Pyreneean rocks are described by M. A. Lacroix from the pic d'Arbizon and the neighbourhood of Barèges. In the latter district he refers to a series of banded limestones nearly 100 metres thick, which, at their immediate contact with granite, are wholly altered to a mixture of axinite and epidote. M. Lacroix describes some of the Pyreneean axinite as almost in itself forming enormous masses of distinct rocks (limurites). Pyrrhotite is there also a constituent of the rock.

In Cornwall, England, axinite has been produced by the action of granite upon basic rocks. The question which requires to be answered in the Colebrook instance is, whether the pyroxene in the rock is original, and the rock basic; or whether the present rock is the product of the action of granite on limestone. My first impression was that the rock was genetically connected with the serpentines and gabbros of the neighbourhood, but it now appears more probable that the pyroxene is secondary, and that association with lime-bearing rocks supplies an explanation of the occurrence. Mr. F. J. Ernst, who has been devoting some attention to the problem, recently forwarded to me a slide prepared from limestone, which forms a 30-foot band in the body of the formation, and drew my attention to the green-tufted actinolite everywhere present in it. Mr. George A. Waller, Assistant Government Geologist of Tasmania, has quite recently investigated the occurrence. He informs me that a series of parallel metalliferous belts of the rock which we have called limurite* runs in calcareous slates and limestone, conformable with these in strike and dip. His conclusion is that the ore-bodies are replacement deposits in the slates and limestones.

The question of nomenclature remains; but the nomenclature has largely flowed from and been implicated in the preceding exposition of classification. It is only necessary, therefore, to dwell upon first principles and some of their applications.

A perfect system of nomenclature would be such as should give expression to the principles upon which the classification is founded. It might be possible to elaborate such a system if we were beginning *de novo*. But we have to take things as they are, and we find the field already occupied to a large extent with familiar and well-understood terms, *e.g.*, granite, gabbro, syenite, diorite, basalt, rhyolite, andesite, trachyte. These names are sanctioned by use, and bear well-known meanings. The intrusive rocks, and especially the numerous varieties of them which have sprung into existence, as it were, since the establishment by Rosenbusch of his dyke-division, have given rise to a wonderful crop of new terms. The petrologist now-a-days has hard work to keep abreast with the ceaseless tide of new names.

1. A first principle should be to disturb existing nomenclature as little as possible. A faulty name may have won so wide an acceptance that its replacement by a more correct one may be disadvantageous.

2. Provisional names may be used, but should be dropped when definitive ones become possible. Thus greenstone or trap may be applied in the field to rocks which upon the application of laboratory methods reveal themselves as gabbro, diabase, or even diorite, and this use is justifiable. But its discontinuance after a proper determination has

* One the occurrence of Limurite in Tasmania. W.H.T. and W. F. Petterd. Proc. Roy. Soc. Tas., 1897, pp. 1-6.

been made is unwarranted. For instance, to speak of the Mesozoic diabase or dolerite in Tasmania as greenstone or trap in a scientific assembly is unpardonable. The field-terms may be excusable, however, in accommodating ourselves to our audience.

3. As a rule a single substantive is preferable to a descriptive term, because it is less cumbrous. The more cumbrous a term is, the less suitable it is as a working instrument. Thus "granite" is better than "orthoclase-quartz-mica rock." But in sub-divisions a descriptive nomenclature is, I submit, desirable when not allowed to grow unwieldy. For example, I prefer biotite-granite to granitite, because it is self-explanatory, as well as in harmony with the other sub-divisions, hornblende-granite, muscovite-granite, &c.

Elvan is a single term, and may be used advantageously, if we know what we mean by it; but my personal preference is for the more comprehensive, and also scientifically more precise, "granite-porphyry." The "blue elvans" of Cornishmen are chiefly dykes of diabase.

Quartz-porphyry is a descriptive term which I would confine to devitrified rhyolites and other effusive forms of the granitic magma. If its ground-mass is felsitic, it may be called felsophyre; if granophyric, granophyre; if micro-granitic, micro-granite. If it carries no phenocrysts, it is felsite. Granite porphyry dykes sometimes have an identical structure, which is assumed, too, by the marginal parts of granite masses. In such cases it is permissible to speak of the quartz-porphyry *facies* of granite, &c. Thus, if the quartz-porphyries and felsites of our West Coast range are devitrified rhyolites, they may be regarded as quartz-porphyries purely and simply; while, if they are intrusive tongues from granite, we have to do with a quartz-porphyry facies.

In pursuance of the descriptive method, I would banish the terms tachylyte and hyalomelane, and substitute hyalo-basalt. The same prefix is available for the glassy forms of rhyolite, trachyte, and andesite, doing away with the substantival terms applied to the former (pitchstone, vitrophyre, obsidian, &c.). Hyalo-rhyolite, hyalo-trachyte, and hyalo-andesite are far more precise; or, if wished, rhyolite-glass, trachyte-glass, andesite-glass may be used, as suggested by Judd long ago.

When these glassy rocks bear plentiful phenocrysts, the adjective "porphyritic" may be added. For instance, instead of the old term "pitchstone-porphyry," we can use "porphyritic hyalo-rhyolite" or "porphyritic rhyolite-glass."

4. A singular blending of principles of nomenclature is noticeable in the gabbro and peridotite families, where names have been given sometimes on mineralogical, sometimes on geographical, bases. Thus we have hornblende gabbro, mica gabbro, mica peridotite, and harzburgite, lherzolite, &c. The terms are so familiar that to disturb them would be wanton pedantry. In giving names to new rock-varieties, I think geographical reasons are the most desirable. Physical peculiarities do not seem sufficiently distinctive, as they may be repeated in different families, and the name loses its *raison d'être*.

With the above considerations in view, I submit a few remarks upon the rock-names in use in Tasmania.

The country consisting so largely of mineral lands, which have been explored by mining operations, miners' terms for all sorts of rocks are common, as might be expected.

(*a*.) First comes the time-honoured designation of diorite for any obscure eruptive rock, though occasionally we have a wilder flight in the use of the term dioritic sandstone. In these days there is no excuse for applying the term to an unknown rock. It has a definite meaning in petrology, viz., a mixture of lime-soda felspar with hornblende, mica, and occasionally pyroxene; and to use it in any other sense is misleading. Apart from the unexpected diorite in the Port Cygnet group, I do not know of any diorite proper in Tasmania. The term epidiorite is only applicable to diabase altered by dynamometamorphism, and some obscure rocks in the North-Western district may eventually come within this definition.

(*b*.) Secondly, porphyry enjoys a good repute among a mining population. Many English petrographers, and, I think, the United States Geological Survey officers, have discontinued the use of this term, and employ only its adjectival form, "porphyritic." In Germany porphyry is a porphyritic rock with orthoclase, and porphyrite, a rock porphyritic with triclinic felspar. So long as quartz-porphyry is used as the name for a familiar rock-family, the word cannot be altogether excluded. American authors overcome the difficulty by employing the term aporhyolite for devitrified acid lavas. I fear it will be difficult to secure European acceptance of this. Fortunately, in Tasmania we are saved from an incongruous extension of the term, as we have no triclinic porphyritic rocks. The local designation of the Port Cygnet trachytes, phonolites, syenites, &c., is "porphyry," and as a field-term is not objectionable, since the bulk of the felspar is orthoclastic. But the application of the term to our tin granite, which is not porphyritic but hypidiomorphic in structure, appears to me a mistake. Our biotite-granites are often porphyritic, with large orthoclase felspars, but the rest of the stone is not a ground-mass, nor is there any porphyritic quartz. We cannot, therefore, call them granite-porphyries, only porphyritic granites. On the other hand, the hypersthene rock in St. Mary's Pass is a true granite-porphyry, and the dykes at Mt. Bischoff may be called topazised quartz-porphyry, though more strictly the rock is the quartz-porphyry facies of granite-porphyry dykes (elvans).

(*c.*) *Diabase or Dolerite.*—If petrologists would only agree to call the fresh rock dolerite, and the chloritised rock diabase, most of the Tasmanian occurrences would be dolerite. Here and there are patches which are chloritised; the dykes in the East Coast granite are invariably so. The older diabase rocks in the Magnet district carry large quantities of chlorite. Dolerite is a very convenient term for those holocrystalline plagioclase-augite rocks which have never reached the surface as lavas; but so long as American and Continental authors adhere to the name diabase, the latter will have to be retained. Continental petrographers keep the term dolerite for the holocrystalline parts of thick lava-flows. At present diabase has it on the voices, but a waiting attitude is the correct one, and during the next decade we shall see how petrographical opinion shapes itself. The Tasmanian diabase occasionally varies into gabbro-like forms, *e.g.*, summit of Mt. Faulkner, and then there is barely any difference between it and gabbro, for diallage is no longer considered an essential of the latter. The structure here is that of a plutonic rock.

(*d.*) *Gabbro-amphibolite and Gabbro-diorite.*—Our gabbros have now and then suffered dynamometamorphism along a line of contact with granite, sometimes becoming amphibolitic and laminated. When they have become schistose in character, and a secondary hornblende is developed in them, I propose to use the term gabbro-amphibolite. When the development of amphibole is unaccompanied by any tendency to a schistose habit, the rock may be called gabbro-diorite. For example, the hornblende schist of the Rocky River would be gabbro-amphibolite; the massive hornblendic gabbro near Mt. Agnew would be gabbro-diorite.

(*e.*) *Limurite.*—This contact-rock is omitted by Rosenbusch from his text-books, probably as lacking the characteristics of an independent rock. On the same grounds, greisen, too, might be logically ignored. The appearance of Limurite in Tasmania, as well as in the Pyrenees, favours the inference that it will recur wherever the necessary conditions prevail. Where emanations from cooling granite act upon calcareous strata, there axinite rock may be expected. There seems no reason why it should not bear the name first given to it by Frossard, after Count Limur.

In concluding this review of the eruptive rocks of Tasmania, I may mention that I have omitted allusion to many occurrences which are known from hand-specimens, but which have not been examined in the field.

From a scientific point of view the rocks which are the most interesting are those which possess unusual associations, such as the melilite basalt at Sandy Bay, the diorite at Port Cygnet in a plexus of elæolitic rocks, the trachydolerite at Table Cape associated with normal olivine basalt, the hypersthene basalt at Stanley. All of these require careful working out on the spot. The nephelinite and melilite basalt at Shannon Tier are also in a part of the Island where normal olivine basalt occurs. The recent discoveries show that the basalts of the Island are far more varied than has been anticipated, and the relations of their magmas to each other demand rigid study.

Average Analyses of the principal Rock families, calculated from analyses given by H. Rosenbusch in his Elemente der Gesteinslehre, 1898.

	SiO_2	TiO_2	Al_2O_3	Cr_2O_2	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	H_2O	P_2O_5	CO_2
Granite.														
Percentage analysis	69·23	0·31	14·43	...	1·79	1·76	0·04	1·24	2·52	3·7	3·90	0·69	0·12	...
Molecular per cent.	74·3	0·25	9·11	...	0·72	1·57	0·04	2·01	2·89	3·8	2·68	2·49	0·06	...
Syenite.														
Percentage analysis	58·69	0·51	16·30	...	3·55	4·02	0·18	3·64	4·74	2·78	4·72	1·19	0·26	...
Molecular per cent.	62·54	0·41	10·21	...	1·42	3·57	0·16	5·83	5·42	2·87	3·21	4·23	0·11	...
Diorite.														
Percentage analysis	56·57	0·22	17·43	...	3·97	4·55	0·03	4·09	7·18	3·41	1·44	0·96	0·17	...
Molecular per cent.	60·43	0·18	10·95	...	1·59	4·06	0·03	6·55	8·21	3·53	0·98	3·41	0·07	...
Gabbro.														
Percentage analysis	48·67	0·23	19·62	...	2·6	5·55	0·03	7·74	10·93	2·76	0·73	1·52	0·65	..
Molecular per cent.	49·75	0·18	11·79	...	1·0	4·73	0·02	11·87	11·98	2·73	0·48	5·18	0·28	...
Pyroxenite.														
Percentage analysis	52·97	...	2·03	0·28	2·43	6·42	0·10	24·76	10·35	0·15	...	0·45	·011	...
Molecular per cent.	47·9	...	1·08	0·11	0·83	4·84	0·08	23·59	10·03	0·13	...	1·36	0·04	...
Peridotite.														
Percentage analysis	41·34	0·96	4·01	0·28	5·56	7·28	0·04	31·39	3·86	0·23	0·74	4·31	0·1	0·41
Molecular per cent.	34·04	0·59	1·94	0·1	1·56	4·99	0·03	38·78	3·41	1·83	0·39	11·83	0·03	0·46

													Cl
Alkali Granite.													
Percentage analysis	74·03	0·01	12·88	...	1·50	0·95	...	0·19	0·34	4·91	4·48	1·03	...	...
Molecular per cent.	78·11	0·01	8·01	...	0·59	0·84	...	0·30	0·39	5·02	3·02	3·65	...	...
Alkali Syenite.													
Percentage analysis	60·42	0·38	19·21	...	2·76	1·81	0·07	0·83	2·90	6·62	4·64	0·66	0·10	0·02
Molecular per cent.	66·36	0·31	12·42	...	1·14	1·65	0·07	1·39	3·41	7·04	3·25	2·44	0·40	0·04
Elaeolite Syenite.													
Percentage analysis	55·20	0·17	21·60	...	2·47	1·42	0·07	0·52	1·91	8·55	6·2	1·82	...	...
Molecular per cent.	60·48	0·14	13·92	...	1·01	1·30	0·08	0·86	2·13	9·06	4·34	6·65	...	...
Theralite.													
Percentage analysis	45·42	...	16·24	...	4·87	4·60	0·15	6·32	10·29	5·0	3·28	2·51	...	...
Molecular per cent.	47·04	...	9·89	...	1·88	3·97	0·13	9·82	11·43	5·01	2·17	8·63	...	...

AN INTERESTING OCCURRENCE OF GOLD IN VICTORIA.

By Henry C. Jenkins, A.R.S.M., Assoc. M.Inst., C.E.

At Clombinane, about six miles from Wandong, on the Melbourne to Sydney Railway, there are two mines—the "Golden Dyke" and the "Golden Dyke Extended"—that present some features of interest, as bearing upon the general problems connected with the occurrence of gold in Victoria.

The mines are both in a true dyke, cutting roughly east and west across Upper Silurian country. Its width is from 50 up to 200 feet, and it belongs to the so-called intermediate class of rocks. The present workings of the two mines cover about a quarter of a mile in length; along the dyke, and midway between them, there is a gully that has been very rich in alluvial gold, just where it crosses the line of dyke, the gold being evidently derived from the denuded dyke-mass, which latter so readily decomposes and softens that, at the time of my first inspection, I could not obtain any satisfactory specimens for slicing; it is, indeed, only very recently that some have come to hand from the deeper workings—too late for full examination and analysis.*

The general mass of the dyke is quite worthless as a gold ore, notwithstanding that it carries arsenical pyrites in its partings, but transversely across the dyke, and nearly at right angles from wall to wall, numerous groups of small cross-seams occur; these extend vertically or else are replaced by others, so that each level in the mine presents somewhat similar features to those of its neighbour. The veins are found by driving levels along the line of the dyke, and they are stoped from crosscuts along them as they are found. The workings are now about 360 feet deep from the surface at their deepest part.

The veins are filled in with quartz, limonite, stibnite, and derived oxide of antimony, and are rich in gold. They can be followed across the dyke up to the wall of the same, where they disappear rapidly, and within a foot or so of the contact-plane, just as though they only occupied fissures in the dyke-mass caused by a shrinkage of the same, such as would be produced by cooling. Some of the quartz is beautifully crystallised, and gold is found upon and in it;

* The rock proves on examination to be an andesite almost entirely composed of minute felspars, with phenocrysts, also of felspar.

but the bulk of the gold is found in a finely crystallised form upon rather than in the stibnite, exactly as though it has been precipitated with quartz at a much later period than that at which the filling of the veins with antimony had taken place, and probably by the direct action of the latter. At times much of the gold can be separated in quite coarse grains from the rest of the vein-fillings by simple crushing or rubbing.

The evidence of precipitation upon an earlier deposit of antimony is a feature that is well worth special notice, and sometimes this is particularly well marked; one specimen in my possession is a small sheet of antimony about a quarter of an inch thick, once part of a much larger sheet, thickly coated over with finely crystalline gold. This was from a crevice that had somewhat exposed the mineral. In the denser parts of the deposit the gold seems to occur more in crevices in the antimony.

The deposit is interesting, as showing clearly that the auriferous contents were acquired at the last stage of formation, and has been precipitated on stibnite that had been deposited at a prior date.

ROCK TEMPERATURES AND THE RATE OF INCREASE WITH INCREASED DEPTHS IN VICTORIA.

By Henry C. Jenkins, A.R.S.M., Assoc. M.Inst. C.E.,

Government Metallurgist, Victoria.

The importance of some knowledge as to the rate of the increase of temperature as we descend in the earth appeals both to the geologist and to the miner; to the former as being the starting-point of many interesting and important speculations, and to the latter because it points out at once a superior limit of depth beyond which he cannot hope to carry on his work without availing himself of some means by which he can cool his workings. The taking of steps to secure this end must add to the cost of his operations, and finally put a stop altogether to them by making them unprofitable; indeed, the rise of temperature must put a limit to the depth at which mining operations can be carried on, either upon purely physical grounds or upon purely economic ones.

A great many determinations have been made of this rate of increase at various times in Europe and in America, for, as regards Europe, it would be difficult to say when the fact that there was a rise in temperature was first discovered, the matter being so obvious as soon as mine operations were of any depth, not to speak of the evidence afforded by warm springs; but an inspection of the results of such measurement very soon showed, either that the problem of taking the temperature of rock was not quite so simple as it looked, or else that there was a considerable divergency in the rate of increase in different districts. A repetition of the measurement in the same districts by other and later workers, as opportunity served, has clearly shown that many of the results that were first put forward, and are even now in text-books, were inaccurate, but that, even when these inaccuracies were eliminated, there still remain, as might be expected, local divergencies in the rate. The measurement reminds one of the more marked instance afforded by the determination of the composition of the atmosphere, where the larger differences in composition noted by early and unskilful experimenters disappeared when more attention was given to methods employed, so that finally only differences of a smaller order of magnitude were proved to exist, unless there were manifestly local and accidental reasons for the difference also to be noted.

One must, even to-day, refer to the methods to be employed. There are two main ways by which we can get the measuring-instrument down to the place at which the temperature is to be taken. Either we can make use of a borehole made by a diamond-drill or by a percussion-drill, as for the purposes of exploration, or else we must take advantage of a mining shaft, by which we can ourselves approach very near to the point of observation, and take our reading.

The case where a vertical borehole is used has a few little difficulties of its own. In the first case, the act of sinking the borehole often involves local alteration in the temperature of the walls of the bore, for there is actual work done on the rock in order to bring about the removal of the latter. There is a disturbance in the temperature by the insertion of the iron lining-tubes, the material of which is a far better conductor of heat than the rock. The iron boring-rods that must be inserted in order to carry the instruments introduce a disturbance of the same kind; but all these disturbances are small, and, whilst an allowance of ample time before a reading is taken will eliminate most of them, the loss due to conductivity is of the nature for which a correction can be applied if necessary. The effect of water upon the temperature of the walls of the borehole is a rather more troublesome factor. There is often a strong current flowing for a long time in connection with the drilling operations. This happens to be flowing, however, down the centre and up the sides, in the way in which it does the least possible harm. Circulation of water in the borehole during the experiment is the more serious thing to fear, and discs are often used in the rods in order to prevent it. But against this fear must be placed the observations made at Wheeling* (U.S.A.), where the temperature was taken at the bottom of a deep bore 5 inches in diameter. The hole, left without diaphragms for two years, was found to be full of water, but its temperature to be within 0·2° Fahr. of what it was originally. This, however, is not quite conclusive, as the steady state may have been reached before the first experiment was made, and unfortunately the full paper is not available here for the detail that would determine the point.

The deepest reading that we have of underground rock temperatures is that of the bore put down by the Prussian Government at Paruschurtz, near Rybrick, in Upper Silesia, that reached a depth of 6573·7 feet on 17th May, 1893. During the next three months a test for the temperature was made, and the hole was then started again, but was lost a few hours afterwards; 64 stations were taken down the hole, with six weight-thermometers at each station, and they showed a regular and proportional increase of the temperature, from 12° C. at the top to 69° C. at the bottom, or a rise in temperature of one degree Centigrade in about 115 feet (34·1 metres) of depth.

There can be no doubt, that all things considered, the weight-thermometer, or large elongated bulb of glass, filled with mercury, and provided with a capillary overflow, is generally the best possible instrument to use for verticle boreholes, although it is troublesome, and requires highly skilled treatment in order to get the best results.

The author has not up to the present had any opportunity to take the temperatures of deep bores in Victoria, for at the present time no suitable ones are in progress; but he hopes to do so at the next opportunity.

Circumstances have, however, been favourable for the determination of the rock-temperature by the other method,

* School of Mines Quarterly N.Y., 1897, p. 148.

§ Vereins Mittheilungen zur Oesterreichische Zeitschift fur Berg-Lund Hutten Wessen, 1895, p. 108.

namely, by the approach to the spot by means of a mine-drive. Some figures have already been published by Mr. J. Sterling* for the temperatures met with in "Lansell's 180" Gold Mine, Bendigo, showing that there was at a depth of—

454	feet a	rise of	1°	Fahrenheit	in 110 feet
1294	,,	,,	1°	,,	in 182 ,,
1750	,,	,,	1°	,,	in 173 ,,
2295	,,	,,	1°	,,	in 152 ,,
2701	,,	,,	1°	,,	in 137 ,,
3110	,,	,,	1°	,,	in 110 ,,
3250	,,	,,	1°	,,	in 118 ,,

and an everage for the whole distance of 1° Fahrenheit for every 135 feet, or a rise in temperature of 1° Centigrade per 243 feet. But it did not appear that the proper precautions had been taken to secure the experiments against serious sources of error; and the hopeless difficulty that the author met in trying to reconcile this abnormally small rate with the temperatures actually met with in the neighbouring mines was one cause for the present piece of work to be undertaken.

It must be remembered that old mine-drives or shafts are always more or less cooled by circulating air or water, and hence cannot be at once utilised for the necessary measurements. The mines in the Bendigo saddle-reefs present rather an extreme case for this rule, and a few readings that the author took near old workings were sufficient to show how great was the interference of the latter. It might be convenient to here state the conditions under which the temperature readings should be taken in the case of a mine.

1st. The reading must be made in "new" ground; that is to say, away from all other workings, particularly deeper ones, and in a heading or a sinking quite recently and rapidly driven, so that its walls have not been unduly cooled by the ventilating current of air.

2nd. The rock must be free from minerals that are easily oxidised. The reactions that take place between minerals and water and air are eothermic, and would seriously affect a reading if appreciable action were taking place. Fortunately, the rocks of a deep mine are usually dense ones; but in the case of some loose ground containing marcasite, and that was being worked for gold, the author once noticed a rise in temperature at that spot of 15° C. over what was

* Australasian Institute Mining Engineers, 1898, p. 94.

due to the depth of the mine. Ground containing such minerals will give abnormal temperatures.

3rd. Very wet ground must be avoided. It will generally involve a lower temperature reading than the true one, for in the ordinary cases of percolation the water will be practically all coming from higher ground. Occasionally the water will come from below, but this can nearly always be recognised and avoided.

4th. Sufficient time must be given to the hole that has been drilled for the insertion of the thermometer, in order to allow the ground near it to come back after boring to the original temperature of the rock. Under the ordinary conditions of drilling, about two days seem to be quite sufficient, the hole being plugged up meanwhile.

5th. The hole must be deep enough, in order to get rid of the disturbance of temperature of the rock at the face. Agassiz appears to have used holes 10 feet deep from the face; this seems excessive for new faces, and the author has ordered "6-feet" holes as a standard depth; this has generally given a distance of 5 feet 6 inches from the thermometer coil to the face.

The holes under these conditions of determination have to be horizontal ones, and the weight-thermometer would need to be of a shape fatal to accuracy of work before it could be made symmetrical about an horizontal axis, it is, therefore, quite inapplicable. The author has used several other forms of mercurial thermometers, but finds that an ordinary high-class chemical thermometer, having divisions to 0·10° Centigrade, can be easily withdrawn from a hole and read off, if its bulb has first been wrapped around with about three layers of finest flannel, and the thermometer supported upon cork mounts then enclosed without pressure in an outer and sealed glass tube. The correction under these conditions proved to be of no practical moment at all, if the instrument be read off promptly, say within 10 seconds of the time of its withdrawal.

The handiest *maximum* thermometer for this work is undoubtedly an ordinary clinical one, in which the thread of mercury is broken by a constriction in the bore, and so prevented from returning. With reasonable care there is no danger of alteration of reading on withdrawal. Some patterns of these clinical thermometers can be obtained with an open scale, reading from 90° Fahr. up to 115° Fahr. by 0·05 degrees, and are used by veterinary surgeons. For other ranges of temperatures the thermometers must be specially made, or a stock instrument opened, and its mercury contents adjusted and then calibrated. The thermometer is removed from the metal case in which it is bought, and mounted on corks in an outer-sealed glass tube, as before. All the thermometers should, of course, be compared against standard instruments, and their behaviour noted under both varying and steady temperatures.

Electrical thermometers present advantages, in that, once inserted, they can be left *in sitû* indefinitely, and be cemented in, so that the changes of temperature that take place at the base of the hole many feet from the face of the rock can be watched, and measured time after time, without any disturbance, and the rate noted at which the rock cools under the action, say, of a ventilating air current, in mines and tunnels.

Siemen's resistance-thermometer is naturally far more suited to the conditions of these particular experiments than is any method involving the use of thermo-junctions, and the author has employed both the original form of circuit and the one with separate compensating leads, as used by Callender. Against the slight theoretical advantage of the latter form must be set the disadvantage of the rather more complicated circuit, to make which several pieces must be put together in a dirty mine drive in a bad light. The thermometer coils that the author has latterly used have been of platinum, and of about 25 ohms each, with the leads of 16 or 18 B.W.G. copper. The bridge should, of course be worked with equal ratios to the arms, on account of the varying resistances of the compensating leads; these arms have been made of 10 ohms resistance.

The difficulties met in the insulation of a thermometer coil intended for use at high temperatures are not met in the present case, and the important thing to consider is, perhaps, the fixing of the coil to the leads, so that deformation does not take place subsequent to the calibration. A coil wound upon a groove in a glass cylinder, or on a mica one, is thus better than one upon a mica plate; but in some of the author's instruments a grooved ebonite reel was used, and the very stout copper leads (No. 10 B.W.G.) were made into rigid terminals, passing through the reel, and on which the coil could be adjusted to its resistance.

There are two good methods by which the resistance can be read off, and the reading made. One is by the ordinary Wheatstones bridge (as used by Calender), with two equal ratio arms, and a set of resistance-coils that can be adjusted to the resistance of the thermometer. For work underground this is not easy to use; the insulation of the terminals is a troublesome matter when water vapour and mineral salts are everywhere, and it is moreover necessary to know exactly the temperature of the measuring-coils. This has led the author to devise a form in which the coils will be in an oil bath, and the terminals quite covered.

The mode of working the Wheatstone bridge by means of a temperature adjustment has, however, proved extremely convenient. The apparatus used for this purpose consists of a duplicate thermometer coil (precisely similar to the one in the rock) immersed in a bath of liquid, and made the comparison-coil of the bridge. The two equal ratio arms of the bridge can also be immersed in the same bath Then, upon slowly raising the temperature of the liquid to that of the rock, there will be a point at which perfect balance will be obtained, and the temperature can be taken directly from the liquid by a mercurial thermometer of suitable range—it is that of the rock when all the temperatures are steady. The difference of temperature between the rock and the working place in which the reading is made is never very great, and this much facilitates the working; and, should the coils be slightly out of adjustment, they may be calibrated, and a correction applied that, if small, is practically constant for a wide range.

Description of the Apparatus.

The apparatus used by the author consists of a metallic vessel, 10 inches high and 5 inches in diameter, provided with a vulcanite top, upon which are four tall vulcanite pillars for the thermometer connections, and with four other pillars for the battery, and the galvanometer keys. All the important parts are thus well insulated. The coils, that are permanently connected in a mass of insulating material, hang from the vulcanite top plate in glass tubes, the ratio coils wound side by side in one layer on a long reel, and the comparison coil also in one layer upon a long reel, being each enclosed in a separate tube, the tubes having metallic sheaths to protect them from injury.

The vessel when in use is filled with water and warmed by spirit-lamp, but we in future shall use a small heating coil and an accumulator, as being more convenient for final adjustment. The temperature of the vessel is raised very slowly, and steadied until the bridge shows equilibrium on repeated zero-readings. The temperature of the bath is then read off by means of a sensitive mercurial thermometer. The bridge and the reversing keys stand on a covered board, and all fit into a box about 2 feet 6 inches long by 1 foot wide and 8 inches high.

One of Compton's reflecting galvanometers with coil on a bifilar suspension was used, but this was far better than is needed.

The following results have been obtained:—At the South German Mine, Maldon, at a depth 1700 feet. The test was made in a heading that had been driven two months previously, but through which no current of air, save that from the rock-drill, had passed. The rock temperature was 81° Fahr., and, on the assumption that the mean surface temperature is 60° Fahr., the rise is equivalent to 1° Fahr. per 81 feet, or 1° Centigrade per 145 feet. At Ballarat, at the Band and Albion Mine, depth 2080 feet, and conditions as at Maldon, the rock temperature was 86° Fahr., and, on the same assumption as before, this is equivalent to a rise of 1° Fahr. in 80 feet, or 1° Centigrade in 144 feet. These two tests must be considered preliminary ones, the mean temperature of the surface, at least at Ballarat, is probably lower than stated, and opportunity is being awaited for some new bore or shaft in new ground by which to obtain the figure more accurately.

The more exact work, so far, has been done at Bendigo, and at the "North Garden Gully, Carlisle, and Passby" Mine, at a depth of 3000 feet, under very good conditions, the temperature was found to be 99° Fahr. by a delayed thermometer, reading only to ·5°, and 99·1° Fahr. by the resistance-thermometer and adjustable bridge. This, on the same assumption as before as to mean surface temperature, is equivalent to 1° Fahr. in 77 feet, or 1° Centigrade in 138 feet. At the "New Chum Railway" Mine, also at Bendigo, several readings have been taken at a depth of 3645 feet. The first was at the foot of a winze sunk at the full rate of progress for the last 400 feet, and the second one at the end of a short drive from the bottom of this winze. The temperature found by the aid of the resistance-thermometer and the new form of bridge both gave 106·95° Fahr., and, under the assumption as before as to the surface temperature, this corresponds to a rate of 1° Fahr. in 77·5 feet, or 1° Centigrade in 139 feet. It has been difficult to find a suitable shallow shaft near to these mines, by which to obtain the mean surface temperature, but at the Don Mine, about two miles away, the temperature at a depth of 182 feet was found to be 63·7° Fahr., whilst at the Government shaft at Ellesmere, at a depth of 247 feet, the temperature was found to be 64·9° Fahr. Both readings were by the delayed type of thermometer just described. Neither of these cases, although under good and in quite new ground, were absolutely ideal, but they both point to a mean surface temperature (61·4° Fahr. and 61·9° Fahr. respectively) distinctly higher than the one commonly assumed for Bendigo by nearly a couple of degrees. By adopting the value 61·4° Fahr. as being from a spot nearest to the deep holes, we obtained a rise of 1° Fahr. for each 80 feet, or 1° Centigrade for each 144 feet, from both the experiments at "New Chum Railway" and "North Garden Gully, &c.," a figure that is of interest in view of the note already published by Professor David as regards the temperatures met with in the sinking at Sydney Harbour, and the approximate figures for Maldon and for Ballarat given above.

The above work is merely put forward as giving some results that may be of interest, of work that is still proceeding at the present time, and needs the co-operation of a great many persons before enough data can be considered to have been collected for generalisation as to the temperature gradients of this part of the Southern Continent; and it is intended to take all opportunity to test whether the rise is uniform within the limits of experimental error.

As against the above figures, the following have been obtained by known observers recently in other parts of the world:—

At St. Gothard a rise was noted of	1° C.	per	108	feet
*At Paraschartz, near Rybrick ...	1° C.	per	111·9	feet
At Schladebach	1° C.	per	114·8	feet
At Sennewitz...	1° C.	per	118·1	feet
†At Saarbrücken	1° C.	per	90·2	feet
In the Ruhr Coalfield	1° C.	per	92	feet
To say 80 as time				
At the Sperenberg bore	1° C.	in	105	feet
‡At Pittsburg, U.S.A., a 5000-feet bore showed	1° C.	in	111	feet
§At Calumet and Hecla, Lake Superior, to depth of 4580 feet...	1° C.	in	402·6	feet

* Vereins Mitthutlingen zur Oesterreichische Zeitschift fur Berg. und Hütten Wessen, 1895, p. 108.

† Glückauf, 1900, p. 733.

‡ School of Mines Quarterly N.Y., 1897, p. 148.

§ Agassiz Amer. Jour. Science, Vol. i., 1895, p. 503.

And earlier figures at Lake Superior give—

‡At Atlantic Mine	1° C. per 179 feet
At "Central" Mine	1° C. per 182 feet
At "Conglomerate" Mine	1° C. per 171 feet
At "Osceola" Mine	1° C. per 135 feet
At "Tamarack" Mine...	1° C. per 199 feet
At "Quincy" Mine	1° C. per 220 feet

Wheeler notes that the mine furthest from Lake Superior gives the highest rise; the others in proportion. All are within five miles of the lake, the waters of which are at 38·8° Fahr., but a continuation of the experiments made at the Calumet and Hecla Mine and publication of the detail is much to be desired.

As already mentioned, it is intended that the author's results now approximately given should be but the preliminary settlement of procedure for a much larger series of determinations to be carried out as opportunity offers, and which must necessarily be extended over a long period of time, but which may assist to clear up several outstanding points of interest, particularly as regards any possible change of rate with depth, and the cooling of rock in mine workings.

In conclusion, the author must thank several members of the Victorian staff of Mine Inspectors, the managers of the various mines who have so kindly assisted, and to his assistant, Mr. A. M. Henderson, who has entered very fully into the pleasure of preparing for and subsequently making physical measurements in a very dirty kind of laboratory, sometimes as hot as 39° Centigrade, and half full of water.

NOTES ON THE MORPHOLOGY OF THE LAND SURFACE OF AUSTRALIA AND TASMANIA.

By Prof. T. W. E. David.

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‡Wheeler Amer. Jour. Science, Vol. xxxii., 1886, p. 125.

Section D.

BIOLOGY.

PRESIDENTIAL ADDRESS.

By W. B. Benham, President, D.Sc. (Lond.), M.A. (Oxon), F.Z.S., Professor of Biology in the Otago University, New Zealand.

THE GEOGRAPHICAL DISTRIBUTION OF EARTHWORMS AND THE PALÆOGEOGRAPHY OF THE ANTARCTIC REGION.

[Plates.]

The study of the geographical distribution of organisms, or Biogeography, as it has been called, has in recent years given rise to such interesting problems in regard to the former disposition of land and sea, that it needs, I think, no apology from me if I take some facts about the distribution of animals as the subject of my address to the Biological Section.

It has long been a matter of common knowledge, and is a familiar fact to everyone who has travelled, that the animals and plants in different parts of the world are more or less different. The organisms found in Europe are quite distinct from those natural to Australia; but what perhaps is less generally appreciated, is the striking difference, in respect of their native fauna and flora, between Australia and New Zealand.

In the early decades of the 19th century, when the teleological views of Paley held sway, this fact, that different continents harbour different kinds of animals, meant nothing beyond the fact that "the world was fitted to its inhabitants so well that it was obviously made for them, down to the minutest detail." But how differently we view the subject now, thanks to the light shed upon it by Charles Darwin. By his theory of Natural Selection, he led men to recognise that the fitness of this earth to its inhabitants results, not from its being made for them, but from the organisms having been, so to speak, shaped by it.

It is my intention, then, to discuss the geographical distribution of certain earthworms, and to indicate some of the problems of the former geographical relations of those oceans and lands that immediately surround us here in Australasia, more especially in the Antarctic region. My original purpose was to deal with the entire group of earthworms, but that became too vast, and I felt that I should be trespassing too much upon your patience if I took you so far from home.

Even with this limitation to Australasia, we shall have to wander some distance, and we shall have to rearrange the geography of the Southern Hemisphere, and try to imagine the geography of by-gone ages. To this old-time geography I would apply the term "Palæogeography"—a word that, so far as I am aware, has not hitherto been employed—and it seems to me useful to have such a word to express the geography of former geological epochs.

In an attempt to deduce any valuable results from the study of Zoogeography, it is recognised that some groups of animals are preferable to others, more especially terrestrial animals, to which continuity of land-surface is a necessity for migration from one part of the world to another. The Mammalia is one such group; Amphibia and Reptilia are also of value, for to many of them a wide arm of the sea acts as a barrier to migration. And, amongst the lower animals, there are few so valuable, in certain respects, as the soft-bodied earthworms.

But the study of the distribution of earthworms is attended by certain disadvantages, as well as by its advantages. For, in the first place, there is no possibility of the discovery of any undoubted fossil remains of worms; we have no geological record to fall back upon in support of, or in contradiction of any hypothesis we may formulate as an outcome of the study; and, secondly, these animals have been much neglected, owing, no doubt, to their cryptozoic habit, and to the absence of any attractive characters whereby the attention of collectors may be drawn to them; thus it comes about that there is still much to be discovered about the earthworm fauna of several parts of the world.

The mode of life of earthworms is such that the possibilities of dispersal are extremely limited. They live, usually, under stones, under logs, and amongst the roots of plants; while many form burrows in the soil, which may reach as much as 2 or 5 feet in depth. In many cases, the worms live near the bottom, though some remain near the mouth of the burrow. The earthworm rarely leaves the burrow, except at night, and it appears that normally it never wanders far away; indeed, the tail of the worm generally remains in the mouth of the burrow, so that, on a


India
Burmah
Siam
Philippine Is.
Ceylon
Malay Penª
Borneo
Halmahera
Sumatra
New Guinea
Bismarck Ar.
Celebes
Solomon Is.
Java
Timor
Distribution of the genera
Pheretima ----
Megascolex
Notoscolex
Plutellus
Notiodrilus --- ●
Australia
Tasmania.


0°
Cape of G Hope
Marion Is.
S. Georgia
South America
Falkland Is.
Fuegia
Enderby
Kemp.
Kerguelen Is.
Graham's Land
W. 90°
Antarctic Region.
90° E
Victoria land
Wilkes land
Map of the Antarctic Region showing the distribution
of the Acanthodriline genera:- Notiodrilus- ●
and Chilota - +
Marquarie Is.
Auckland Is.
Snares
Chatham Is.
New Zealand
Australia
180°

slight disturbance, the animal can rapidly withdraw into safe quarters. It is outside the burrow that the process of procreation takes place, the result of which is the formation (at a subsequent date) of a cocoon containing the eggs, which, in all the cases known to us, is deposited in the burrow.

I am not taking into consideration the fresh-water worms (so closely allied to the earthworms), for the bionomical facts are different, as, indeed, are the distributional facts, of which but little is known.

Let us consider for a moment the means by which earthworms may be dispersed over the surface of the planet.

The animals are killed by immersion in salt-water, as also are their eggs; so that, even if they be carried away from their home embedded in the earth amongst the roots of a tree, or even in a rotten log, or any such object, they would soon perish, owing to the splashing of the sea, the rolling of the tree, or the rapid disintegration of the earth at its roots.

The chances of adhering to the feet or body of birds or mammals are extremely limited; for, if the worm were on the surface, the bird would devour it, rather than tread on it. Nor need we involve the agency of a mammal, for, in general, where a mammal can go, there also can an earthworm travel.

As to transference of cocoons on the feet of birds—in the way that small molluscs and some insects are believed to be carried—the fact just mentioned, of the subterranean deposition of the cocoon, renders this method improbable, except, perhaps, on very rare occasions, when some far-flying bird follows a plough, which may turn up cocoons. But this avails but little in discussing transference beyond the sea; for the cocoon would either dry up, and the eggs die, or it might be washed off in the sea if it happened to have become attached to such a bird as a seagull.

Dispersal by means of wind is equally out of the question, and that by icebergs or ice-sheet must be very rare. Still, we must bear in mind the possibility of the dispersal of small worms in this manner; for small *Enchytrœids* have been found embedded in ice on frozen ponds, and even in the glaciers of Alaska; but this will apply to but very few earthworms, since it is rare for them to live in water. In fact, any mode of assisted dispersal appears to be out of the question. There only remains the active migration of the earthworm in the earth.

As you are aware, dispersal may be interfered with by barriers. What barriers exist in this case?

We have seen that the sea is impassable. Not so rivers, for fresh water does not kill earthworms—which will withstand immersion in fresh water for weeks, or at any rate for several days; whilst several species live habitually in the bottom of rivers or ponds; while a few are "amphibious"—and, moreover, rivers imply continuity of dry land. High mountains do not deter earthworms, for I have examined worms collected at considerable heights by Mr. Ed. Whymper, the well-known Alpinist, from 8000 feet in the Swiss Alps, and from the great height of 15,871 feet at the very summit of Corazon, in the Andes. It appears that so long as soil, with some vegetation, exists, worms may traverse even high mountain ranges. But a desert, by its dryness, and by the absence of food in the form of vegetable matter, forms an insuperable barrier to earthworms.

We are thus led to the conclusion that, like mammals, earthworms can only be dispersed over the surface of this planet by their own active locomotion over a continuous tract of land-surface in which vegetation of some sort grows.

But it is important to bear in mind that, at the present time, there is a constant chance of alien earthworms being introduced into all lands and countries occupied by civilised races, or in trade connection with other countries. This introduction is effected by the agency of man.

Plants, with a small quantity of soil around the roots, are sent to and from various parts of the world, and in the soil small earthworms or their cocoons are frequently embedded. At any rate, at such centres of horticulture as Kew Gardens, in London, it is a frequent occurrence for foreign earthworms to be found in the wardian cases containing plants received from distant foreign countries.

We must also remember that the Polynesians, like the Maoris, were great travellers by sea, and carried with them vegetables, such as the taro, kumara, and so on; and this is a possible means of introductions of cocoons into distant lands.

But, whatever may be the actual means by which alien worms are introduced by man's agency, it is a fact, well known to all lumbricologists, that, as soon as settlement has been long enough to enable settlers to cultivate gardens, European earthworms, of the genera *Lumbricus* and *Allolobophora*, make their appearance in the soil. In and around towns, both in New Zealand and Australia, we know how difficult it is to find native earthworms; they are driven out of the cultivated land, and have to be sought for further and further away from closely-inhabited areas. The fact that all the species of the European genera thus collected in Southern lands are identical with the European species indicates their alien origin and recent importation. And we know that species of several other genera are capable of establishing themselves as aliens far from their native soil.

Thus, *Pheretima* (Perichæta) *hawayana* (Rosa), originally collected in Hawaii, has been found in Borneo, China, Mauritius, Bermudas, Barbadoes, Teneriffe, and Brazil; while *Ph. heterochœta* (Mich.) is practically cosmopolitan. There is reason to believe that the "home" of both these species is the Oriental region.

Further, *Eudrilus eugeniœ* (Kinb.), having its home in Equatorial West Africa, has been met with all over the Tropics—in Central America, Antilles. Bermudas, British and Dutch Guiana—as well as in St. Helena, Madagascar, Ceylon, New Caledonia, and New Zealand.

Pontoscolex corethrurus (Fr. Müll.) has been met with in Mexico, Antilles, and South America, as far south as Brazil; also in Madagascar, Mauritius, Ceylon, Singapore, Sumatra, Nias, Borneo, Java, Celebes, Ternate, Sangir, Hawaii, Queensland, and New Zealand. It has been carried from its home in Tropical America to the ends of the world.

Benhamia bolavi (Mich.), whose home is Tropical Africa, occurs also in Mexico, various islands of the West Indies, in South America, Madagascar, India, and even in Hamburg.

Microscolex dubius (Fletcher), originally discovered in Australia, where it has been met with in several spots, occurs also in Tasmania, New Zealand, Norfolk Island, Port Elizabeth (in South Africa), the Canary Islands, Bahamas, various parts of South America, and in North Carolina.

M. phosphoreus (Dugés) was described from specimens found in France, but it occurs in Chili, Patagonia, South America, South Africa, Teneriffe, Sardinia. and various parts of Europe. There is little doubt but that the home of these two species is the American continent.

Again, *Megascolex mauritii* (Kinb.) is now known, not only in Mauritius and Seychelles, but in North-West Madagascar, Zanzibar, China, India, and various islands of the Malay Archipelago. There is little doubt that its home is the Oriental region.

And there are several other species capable of establishing themselves in foreign lands.

Now, when we find a species at a locality far distant from the habitat of the rest of the genus, which genus has an otherwise limited and well-defined area of distribution, we are entitled to regard it as accidentally imported by man's agency, when these places are separated by sea; and this becomes still more probable when there is evidence of commercial intercourse between its home and this foreign outpost. Naturally, this explanation is not necessarily always the right one, or the only one possible. Later, I shall have to refer to a worm found in Central Australia, which belongs to a genus characteristically Neo-Zealanian, and scarcely represented in Australia; but there is no probability of its having been accidentally imported to Australia by man.

New Zealand Earthworms.

After these introductory remarks, let me turn to a consideration of the earthworm fauna of Australasia. It would, perhaps, be polite to our hosts if I were to deal with Tasmania first; but, for reasons that will become apparent later, I will commence with New Zealand.

The earthworm fauna of the New Zealand area, including those outlying islands usually associated with New Zealand itself, viz., the Chathams, Norfolk Island, New Caledonia, The Snares, Campbell Island, Auckland Islands, and the Macquarie Islands, is as compact and as characteristic as any other part of the fauna.

Taking the mainland first, *i.e.*, the North and South Islands, there have been described only 23 species, belonging to nine genera (exclusive, of course, of undoubtedly introduced species). This is a comparatively small list, and is, practically, confined to one small district, in the province of Canterbury, where Mr. W. W. Smith has been so active in obtaining material. But I have several species, as yet undescribed, from various other parts of the South Island. Very few earthworms have been described from the North Island.

Of the nine genera, the following six are absolutely confined to the New Zealand area, viz.:—*Maoridrilus* (with seven species), *Neodrilus*, *Plagiochæta*, *Diniodrilus*, *Octochætus*, and *Rhododrilus*. The remaining genera, viz., *Notiodrilus*, *Microscolex*, and *Diporochæta*, are represented in other parts of the world. To them I will return.

Of the fauna of the outlying islands we have very scanty information.

From The Snares, due south, I have received a species of *Notiodrilus*—*N. haplocystis* (Benh.).

The Chatham Islands have yielded, in addition to European aliens, *Diporochæta chathamensis* (Benh.), from a flax swamp, and *Rhododrilus huttoni* (Benh.) from the bush, together with a peculiar species of *Pontodrilus* (*P.*

chathamensis) from the sea-shore, which may be omitted from our tabulation.

From Norfolk Island I received, in December, 1901, in addition to some European aliens, some ill-preserved specimens of a worm which belongs to the genus *Megascolex*.*

New Caledonia possesses, as far as we know, two peculiar species—*Notiodrilus obtusus* (Perrier) and *Acanthodrilus ungulatus* (Perrier)—the latter genus being confined to this island.

In the south, the New Zealand area includes—

Macquarie Island, which has yielded a single species—*Notiodrilus macquariensis* (Beddard)—the only earthworm that has been collected there, but which has been obtained by three different people at different times.

The Auckland Islands have provided me with a single peculiar species of *Notiodrilus*, a description of which I have not yet published, but which agrees even more closely than does *N. macquariensis* with the Patagonian species.

From Campbell Island I have as yet obtained no worms.

EARTHWORMS OF NEW ZEALAND AND OUTLYING ISLANDS.

		N.Z.	Snares.	Macq.	Auckl.	Chath.	Norfk.	N. Cal.	Total.
1. Maoridrilus	*Mchlsn.*	7	...	...	...	...	...	...	7
2. Neodrilus	*Bedd.*	1	...	...	...	...	...	...	1
3. Plagiochœta	*Benh.*	3	...	...	...	...	...	...	3
4. Acanthodrilus	*Perr.*	...	...	...	...	...	...	1	1
5. Dinodrilus	*Bedd.*	1	...	...	...	...	...	...	1
6. Notiodrilus............	*Mchlsn.*	2	1	1	1	...	...	1	6
7. Octochœtus	*Bedd.*	5	...	...	...	...	...	...	5
8. Microscolex	*Rosa.*	2	...	...	...	...	...	...	2
9. Rhododrilus	*Bedd.*	1	...	...	...	1	...	...	2
10. Diporochœta	*Bedd.*	1	...	...	...	1	1	...	2
11. Megascolex	*Temp.*	...	...	...	...	...	...	...	1
		23	1	1	1	2	1	2	31

On the whole, these outlying islands agree with the mainland in their earthworm fauna; and, neglecting the doubtful Norfolk Island species, and the marine Chatham Island worm, we have as a total at least 30 well-established species, belonging to 10 genera, of which seven genera are unknown outside this area. The three genera known elsewhere are

* This I have identified since the address was read.

Notiodrilus, *Diporochæta*, and *Microscolex*, and these I must trace further.

Notiodrilus is a comparatively large genus, containing altogether 30 species, some of which occur in Australia, others in South Africa, and others in South America.

There are four species hitherto recorded from Australia:—

N. eremus (Spen.), found by Spencer in three localities, separated by desert, in Central Australia, during the Horn Expedition.

N. macleayi (Fletcher), on the Napier Range, in N.W. of the continent.

N. australis (Michaelsen), at Cape York, in Queensland.

N. schmardæ (Beddard), in fresh water, in Queensland.

These four species are all somewhat divergent from the New Zealand species, and, with the exception of the first, are imperfectly described.

Passing westwards, we meet with one species on Kerguelen Island, and the same species is found in Marion Island.

At the Cape of Good Hope five species have been recorded.

From South Georgia one species.

From Falkland Islands two endemic species.

From Fuegia, Patagonia, Chili, and Argentina, five other species, of which one also occurs in the Falklands.

Quite recently, moreover, three species have been recorded from Guatemala, and one from Mexico, while the remaining two species come from Madagascar.

This is certainly a very interesting distribution, and becomes more so when we find, as Beddard was the first to point out, that the Macquarie Island species is more closely allied to the Patagonian and to those from the Antarctic islands than to the New Zealand species; while I find that the Auckland Island species bears still closer resemblance to the South American forms. Further, Beddard states:—"The Cape species are so like those of South America that I have more than once doubted whether I had not before me identical forms from these widely-distant localities."

Now, the genus *Notiodrilus* is allied to, and ancestral to, another genus, *Chilota* (Mchlsn.), distinguished from it by possessing one pair of testes, just as *Neodrilus* is distinguished from *Maoridrilus* by having only one pair of certain organs instead of two pairs.

Chilota, containing 30 species, is abundant in South America, where 18 species are recognised. Falkland Island possesses one peculiar species (*Ch. dalei*), while the remaining

11 species occur in the neighbourhood of Capetown and Port Elizabeth, and from this area no other earthworms but *Chilota* and *Notiodrilus* were collected.

To those who have paid attention to the earthworms, some of these generic names will appear strange. The genera *Maoridrilus*, *Neodrilus*, *Notiodrilus*, and *Octochœtus* and *Chilota*, have, till recently, been included under one name, *Acanthodrilus*, but this name is now employed only for the single species occurring in New Caledonia. These genera, with *Plagiochœta*, *Dinodrilus*, *Microscolex*, and *Rhododrilus*, will be referred to in the sequel as *Acanthodrilids*, and are characteristic of New Zealand, Cape of Good Hope, South America, and the Antarctic islands; and it is a remarkable fact that the only earthworms hitherto collected on these islands belong to one or other of the genera *Notiodrilus* and *Chilota*.

Turning now to the distribution of *Microscolex*, of which we have two species in New Zealand—one from the South Island and one from the North Island.

There are six other well-defined species, and three more which Michaelsen considers as only doubtfully distinct.

Of the six species, three occur in California, and elsewhere in North America (*M. hempeii*, *M. troyeri*, *M. benhami*); two in South America (*M. dubius* and *M. phorphoreus*), both of which have been introduced into far-distant lands (including Europe and New Zealand); while, finally, one (*M. horsti*) came from Hawaii, whither it is probable that it was introduced by traffic between Honolulu and San Francisco. Of the three doubtful species, one is Algerian (*M. algierensis*), one is Madeiran (*M. poultoni*), one Californian (*M. elegans*). As the species of *Microscolex* are evidently readily transported, and easily become acclimatised to their new surroundings, it might be thought that the two species occurring in New Zealand are aliens. But it is closely allied to *Rhododrilus*, as well as to a characteristic South American genus from which it has been recently separated—*Yagansia* (Mich.)—of which 12 species out of the 13 occur on that continent, and the thirteenth at the Cape of Good Hope—*Y. kinbergi* (Mich.).

Here then, again, though in a less pronounced manner, we find a similarity between New Zealand, South Africa, and South America; a closer association of New Zealand and the West Coast of South America, and, moreover, with the northern part of that coast.

But it is entirely otherwise with *Diporochœta*, of which we possess in the New Zealand area at least two species. The genus is characteristically Australian. Of the 33 species recorded by Spencer, Victoria possesses 24; Queensland, 4; Tasmania, 5.

It seems probable, or at any rate not by any means improbable, that the worm is an alien in New Zealand, introduced from Australia by man's agency.

Before leaving New Zealand, I must refer to Mr. Hedley's "Melanesian Plateau," a land area which, from evidence provided by the distribution of certain operculated land-snails, is believed to have existed in the Mesozoic period, and to have included not only New Zealand, and the islands usually associated with it, but extended further northward, so as to embrace the Fiji Islands, Solomons, and New Hebrides; while, westward, the islands of New Caledonia, Norfolk, and Lord Howe also formed part of it.

One very interesting genus of land-snails (*Placostylus*) is represented in all these islands, except the Kermadecs, Chathams, and the most southerly outliers.

This "Melanesian Plateau" corresponds with, but is more extensive than Forbes' "Antipodea," which he proposed from certain facts in the distribution of birds; in that the latter ancient land area is supposed to have embraced the Kermadecs, but excluded the New Hebrides and Solomons.

It will be convenient to further limit this term in referring to the earthworms, and to exclude therefrom the Fiji Islands, and probably also the Kermadecs, of whose earthworms nothing is known.

What does the earthworm fauna tell us in regard to this? Unfortunately, we have at present but scanty information; but, so far as it goes, it indicates an early separation of Fiji, New Hebrides, and Solomons on the north from the rest of the "Antipodea" of Forbes, on the south.

I have already referred to the earthworms of most of the islands.

The earthworms from Lord Howe Island do not appear to have been studied, though some have been collected.

From Norfolk Island we have only the facts already referred to—a species of a European genus, and a species of an Australian genus. New Caledonia possesses New Zealand genera; this points to separation of the island, probably in mid-Tertiary times. In addition, two species have been recorded from this island, which are very widely distributed, *Eudrilus eugeniæ* and *Pheretima heterochæta*—aliens, imported by man.

From Fiji three earthworms have been obtained, which indicate relations with New Guinea, and thence with

Malayia. These are *Ph. godefroyi*, the only species peculiar to the islands; a second species of this genus (*Ph. montana*) is Malayan; while the third worm belongs to a distinct genus (*Dichogaster damonis*), closely allied to an African and Central American genus (*Benhamia*), and there is some reason to believe that it is an accidental importation.

The New Hebrides present us with one peculiar species of the Malayan genus (*Ph. esafatæ*), while a second species (*Ph. upoluensis*) is found also in Samoa.

In the Solomons there is one peculiar species (*Ph. solomonis*), while *Ph. loriæ* occurs in New Guinea, and *Ph. montana* is found in several of the Malay islands, as well as in New Britain.

Even in New Guinea, only five species of earthworms as yet have been recorded. Of these, four species of *Pheretima* appear to be endemic, but evidently Oriental in origin; while *Benhamia malarmata* is African, and is regarded as an imported alien.

So that, apart from New Caledonia, the earthworm fauna of the northern part of the "Melanesian Plateau" shows no affinity to that of New Zealand, but is decidedly of Indo-Malayan origin.

We have, then, some confirmation of Hedley's views as to a centre of radiation from New Guinea eastwards and southwards; but New Guinea must have received its earthworms from Indo-Malayia before the isolation of the individual islands, but after the separation from it of Antipodea.

In concluding these remarks upon Antipodea, I will again emphasise the facts.

New Zealand and its outlying islands contain 30 recorded species of earthworms (included in 10 genera), of which 19 species belong to seven endemic and peculiar genera, which are all *Acanthodrilids*. Of the non-peculiar genera, one (with only two representatives in New Zealand) is Australian; a second (with only two species) appears to be American in origin; while the third genus (*Notiodrilus*) has most of its remaining representatives in the Antarctic islands, the Cape of Good Hope, and South America, with a sparse representation in Australia. And it is a specially noteworthy fact that the species from Macquarie Island, and that occurring in the Auckland Islands, are more nearly allied to the South American and South African species than to those of the mainland of New Zealand.

Australian Earthworms.

Before considering in detail the outcome of these facts, I will pass across the Tasman Sea to Australia, and deal with the earthworms of that continent. Here we may note that the worms have been gathered almost entirely from the coastal region of New South Wales and Victoria; and it may be that an examination of those of Western Australia—the *Autochthonian* region of Tate—will present some interesting differences.

On the mainland of the Australian Commonwealth 136 well-defined species have been recorded, thanks to the labours of Mr. Fletcher and Professor Baldwin Spencer, in addition to some three or four others of less certain validity.

These 136 species fall into 15 genera, as follows:—

		Vic.	N.S.W.	Qnsl.	C. Aust.	S. Aust.	W. Aust.	Tasm.	Total.
1. Plutellus	*Perr.*	23	6	3	...	...	...	7	39
2. Dinephrus	*Spcr.*	1	...	...	...	...	...	...	1
3. Fletcherodrilus	*Mchlsn*	...	1	...	...	...	...	...	1
4. Trichœta	*Spcr.*	1	...	...	...	...	...	...	1
5. Diplotrema	*Spcr.*	...	...	1	...	...	...	...	1
6. Megascolides	*McC.*	3	1	...	...	...	...	...	4
7. Trinephrus	*Bedd.*	1	3	...	...	...	...	3	7
8. Notoscolex	*Fl.*	4	9	1	...	...	...	4	18
9. Digaster	*Perr.*	...	3	3	...	...	...	...	6
10. Perissogaster	*Fl.*	...	2	1	...	...	...	...	3
11. Didymogaster	*Fl.*	...	1	...	...	...	...	...	1
12. Diprochœta	*Bedd.*	24	...	4	...	...	...	5	33
13. Megascolex	*Tmpln.*	17	13	3	...	2	...	1	36
14. Pheretima	*Kinb.*	...	...	1	...	...	...	...	1
15. Notiodrilus	*Mchlsn*	...	...	2	1	...	1	...	4
		74	39	19	1	2	1	20	156

The majority of these genera fall into a group, which used to be regarded as a family or sub-family (*Cryptodrilini*), and for convenience of reference I will speak of the members of the first twelve genera as "Cryptodrilids." The next two genera are "Perichœtine" in character, while the last is "Acanthrodriline."

Of these 15 genera, the first 13 are characteristically Australian, though, as we have seen, *Diporochœta* occurs in New Zealand; while the Perichœtine and Acanthodriline genera are also known outside the Australian area. Indeed, *Pheretima* is a late invader of the Commonwealth, while *Notiodrilus*, as will be seen, is an Antarctic form.

Turning to Tasmania, and the islands of Bass Strait, we find 20 recorded species, which fall into the five genera—*Plutellus, Trinephrus, Notoscolex, Diporochœta*, and *Megascolex*. We have, in fact, as in the case of other groups of animals, a typically Australian fauna. There are no genera peculiar to the island, though all the species are endemic, and belong to the largest and commonest genera of the mainland.

This confirms Spencer's view, that "Tasmania has had no direct land-connection with Australia during or since the Pliocene period."

There are thus 156 species of earthworms in the Commonwealth, and the mere enumeration of the genera found in New Zealand on the one hand, and in Australia on the other, shows the great contrast between these two adjacent faunal areas; for we find in New Zealand only one genus (with two species) which is typically Australian; and in Australia only one genus (with four species) which, while not being confined to New Zealand, belongs to a sub-family which is characteristic of that area. In fact, I may quote the words of Mr. Hedley, who, in comparing the operculated land-snails of Queensland and New Zealand, says, "Than which two faunas could hardly be more distinct."

An analysis of these Australian worms shows that, of the 15 genera, nine are endemic and peculiar to this region, but account for only 25 species out of the total of 156. Of the remaining six genera, one species belongs to the Oriental genus *Pheretima*, four species (already referred to) belong to the Antarctic genus *Notiodrilus*, while the majority (more than 80 per cent.) of Australian species, viz., 126, are contained in the four remaining genera, one of which (*Diporochœta*), accounting for 33 species, is endemic, and is practically confined to this area; having only two species outside it—in New Zealand. The remaining three genera, viz., *Plutellus* (with 39 species), *Notoscolex* (with 18), and *Megascolex* (with 36 species), are represented outside this faunal area.

Of *Megascolex*, as many as 17 species have been recorded from Ceylon, two species occur in the Indian peninsula, and one species—*M. mauritii* (Kinb.)—is very widespread, as has already been stated. Finally, a doubtfully-distinct species has been obtained from the Marquesas (*M. albidus*), which, in all probability, has been accidentally imported, and, according to Michaelsen, may be identical with Fletcher's *M. tenax*, from New South Wales.

Thus, of the 55 well-established species of the genus *Megascolex*, more than 65 per cent. occur in Australia, and 30 per cent. occur in Ceylon.

Now, it is a remarkable fact that not only is *Megascolex* found in Ceylon, and practically confined to this island and Australia, but also *Notoscolex* shares in this distribution.

In Ceylon it is represented by seven species, and is at present almost unknown elsewhere, one species, *N. americanus* (Smith), being recorded from America.

Of *Plutellus*, we have only two species in Ceylon, and four species (occurring in the United States of America) are included by Michaelsen and by Beddard in the same genus.

EXTRA-AUSTRALIAN DISTRIBUTION OF CHARACTERISTIC AUSTRALIAN GENERA.

	Austral.	Ceylon.	India.	U.S.A.	C. Amey.	N.Z.	Total.
Plutellus	39	2	...	4	1	...	46
Notoscolex	18	7	...	1	...	...	26
Megascolex	36	17	2	...	...	...	55
Diporochœta	33	..	1	...	...	2	36

I will emphasise this very important fact, that two, out of the three genera, are, to all intents and purposes, divided between Australia and Ceylon. The latter island contains, altogether, seven genera of earthworms, with 34 species, excluding three genera with widely-spread species, which are probably introduced. It is a remarkable fact that 26 out of the 34, *i.e.*, 75 per cent., are referable to the three characteristic Australian genera, the remaining species belonging to Oriental genera.

I have referred to the fact that both in Ceylon and Australia there occur species of a genus (*Pheretima*), or, as we have been accustomed to call it, *Perichœta*. This genus is by far the largest genus of earthworms, containing at least 113 species, of which about 70 occur in the Malay Archipelago and the Moluccas; and numerous species occur also in the Philippines, in Burmah, Southern China, and Japan.

It is, indeed, quite characteristic of the Oriental region, especially of the Indo-Malayan sub-region. A few stragglers have wandered thence to some of the islands of Melanesia and Polynesia, through New Guinea, while two species have gone south towards Australia. One of these occurs in Darnley Island, Torres Straits—*P. darnleiensis*—(Fltchr.); the other has entered this continent, and appears to be peculiar—*Ph. queenslandica* (Fltchr).

Deductions from the above Facts.

This rather tedious survey teaches us three important facts:—

(1) That New Zealand has no resemblance to Australia in respect of its earthworm fauna;

(2) That, on the other hand, New Zealand has very close affinity to the southern extremity of Africa on the one hand, and to South America on the other; while

(3) Australia presents a remarkable similarity to Ceylon, but differs entirely from the intervening Indo-Malayan sub-region, and the rest of the Oriental region.

Dr. Wallace, in his "Island Life" (p. 74), says, in speaking of the distribution of mammals:—"Whenever we find a considerable number of mammals of two countries exhibiting distinct marks of relationship, we may be sure that an actual land-connection, or, at all events, an approach within a few miles of one another, has at one time existed." Now, this statement applies still more forcefully to earthworms, and, indeed, we must delete the qualifying clause as to a mere "approach," for, as we have seen, earthworms cannot cross even a narrow arm of the sea; consequently, we must have direct continuity of land-surface to explain the facts. This statement of Wallace's necessarily implies considerable changes in the disposition of land and sea, which involves an upheaval of the ocean-bed to form dry land. So long as the idea of a permanency of ocean basins was considered an article of faith by geologists, this continuity of land could only be permitted by supposing movements of the sea-floor through a few fathoms round the coasts of continents, bringing islands into junction with the neighbouring continental area, or converting an archipelago into a continent; but within recent years several classes of evidence have led geologists and biologists to contemplate more extensive movements in an upward and downward direction, and great continents have been evolved "from the vasty deep."

Let me make another quotation, this time from Sir John Murray's "Summary" of the *Challenger* Reports (p. 1461):—"It is abundantly evident (he says) that the land of continents has been most unstable, and can in no way be regarded as permanent during the course of geological history." He goes on to point out that "most probably the ocean basins in Palæozoic times were not so deep as they are now; that numerous islands existed in them, and, possibly, these former land-masses now form the bases of the groups of oceanic islands, wholly consisting, as far as we can see, of erupted rocks." In the gradual evolution of the surface-features of the planet, he thinks that "Continental land appears, on the whole, to have become more compact, more circumscribed, and higher, while the ocean basins have become more shut off from each other, and deeper." But, although the outlines and extent of the continental lands may not be permanent, yet there is reason to believe, he remarks, "That the areas within which the present continents are situated are areas within which continents have been torn down and built up again since the dawn of geological history; while similar revolutions have not taken place in the abysmal or pelagic area of the ocean basins to anything like the same extent." The faunal and floral resemblances between the three southern lands has been noted, as you are aware, by all naturalists who have studied the subject; and a large number of authors have called to their aid, by way of explaining the facts, a greater extension of these lands in a southerly direction, accompanied by a more extensive land-surface across the Antarctic region, at a period probably as late as the Mesozoic, when the climate was considerably milder than at present.

The flood of biological evidence in favour of an Antarctic continent has become extremely strong since it was first mooted by Hooker, to explain the present flora of Tasmania and its resemblance to these southern lands. It has been supported by Rutimeyer, and later by Captain Hutton, who was the first to attempt to correlate biological and geological evidence in its favour, although in recent years he has seen reason to considerably modify his views on the matter. The continent has received support from Blandford, on geographical and distributional grounds; from Forbes, in order to explain the distribution of certain birds in the Chathams and Madagascar (he was the earliest to attempt to map the outlines of the continent); from Hedley, who, moreover, refuses to believe in so extensive a continent; from Spencer, as an outcome of the study of the Australian fauna; from Ameghino and Ortmann, as a result of their researches on the vertebrate and invertebrate fossils in Patagonia; from Moreno, owing to the discovery of a fossil

Chelonian in South America of the same genus (*Miolania*) as occurs in Lord Howe Island and in Queensland; further, Osborne, from the general study of the evolution of mammalia; Beddard, as an outcome of the study of earthworms; Spencer Moore, from a study of South African flora; Von Graff, who finds, amongst the Planarians, certain genera practically divided between Australasian and Neotropical regions—all give in their adherence to the existence of such a continent, as well as do several other botanists and geologists; while it also appears that geographers, from their own special studies, have reason to believe in the existence of an Antarctica; and some little evidence from the geological side, at any rate, seems to confirm the view of a land continuity between Victoria and Wilkes Land, which presents evidence of being "continental geologically, if not geographically at the present time."

It is quite needless for me to detail the evidence brought forward by so many able authorities in favour of this continent. All I wish to put before you is the evidence afforded by the earthworms, and this is, I think, as strong as any other, of some land connection between New Zealand, South Africa, and South America, and, but doubtfully, with Australia. I will now attempt to trace out the migration of these genera.

The phylogeny of the chief genera of earthworms with which we are concerned has been worked out pretty fully by Michaelsen; and most lumbricologists are agreed that the Acanthodrilids, Cryptodrilids, Megascolex, and Pheretima, are genetically related in the order named. Most of us consider *Notiodrilus* or some similar form as the most archaic of the series, and as being close to the base of the whole series of earthworms. This conclusion was arrived at, on anatomical grounds, by one who did not consider an Antarctic continent necessary to explain the facts of distribution.

It is true that Beddard reverses the order, and regards *Pheretima* as the most archaic—a view founded principally on facts of distribution—but this involves a great number of anatomical difficulties, while it is entirely opposed to the little we know of the embryology of earthworms.

The facts derived from the study of anatomy, and those derived from the consideration of the distribution of the earthworms, seem to confirm the view as to the former existence of an Antarctica.

We find the most archaic earthworms down in the extreme south. It is true that this may be explained by imagining the ancestral forms to have been more or less cosmopolitan, or, at any rate, distributed in a band round the earth, north of the Equator, whence they were driven southwards into each of the chief continents—driven down either by climatic or physical changes, and as a result of competition with the more northern, more modern, and more sturdy *Lumbricidæ* of the Palæarctic region. But if this were the case, surely it is a most astonishing fact that the same genera, regarded as archaic anatomically, with very closely allied species, persist in the extreme southern ends of the land-tracts. It seems strange, indeed, that during their journey from north to south, in spite of the struggle for existence with physical and organic nature, varying in each of the continents, as it must have done, the same genera should persist in Patagonia, Cape Colony, and New Zealand, while, except on the American continent, not a single representative should have survived the struggle north of the Equator, across which they must have been driven.

Again, on this supposition, how can we explain the absence of species of *Notiodrilus* on such islands as St. Helena, and other long-isolated islands in the different oceans, together with the presence on such Antarctic islands as have been visited and explored of closely-allied species; identical species on Kerguelen and Marion, closely allied to which are other species in South Georgia, Fuegia, Auckland Islands, and Macquarie Island. These last facts seem to me to form a very convincing piece of evidence in favour of Antarctica; and it is even suggestive of an Antarctic origin of the genus. Blandford says:—"It is highly probable that many forms of terrestrial life originated in the Southern Hemisphere, and . . . it is far from improbable that the Antarctic continent was an original area of development."

Again, Lydekker, in his book on geographical distribution of mammals, writes:—"The *Spheniscidæ* (penguins), which present a relation to other birds, somewhat analogous to that exhibited by Edentates to other mammals, having no apparent affinity with the group, may prove an exception to the rule of northern origin of most of the existing types of terrestrial vertebrates, since they are quite unknown in the north, and occur fossil both in New Zealand and in Patagonia." But, however this may be, whether the Acanthodrilids, evolving, as they probably did from fresh-water Oligochœta, originated in Antarctica, or in Archiplata, of Von Jhering (*i.e.*, Chili and Patagonia), or in Antipodea of Forbes—as I think more probable—they must have spread from one land to the other by an Antarctic bridge, and, on reaching each of these continents, have passed into it, and given origin to other genera, which have wandered still further northwards and peopled the land, meeting as they proceeded members of other families which have developed in the Northern Hemisphere and migrated southwards.

We have at present little evidence of the age, or length of duration, of this Antarctica. We may look forward to interesting discoveries by the various expeditions exploring those regions now or in the immediate future, which may give us some clue to the solution of the problem. It is, by most authorities, believed to have been in existence, at any rate during the Mesozoic period, and to have shrunk away from the northern connections during some part of the Tertiary period; but at what particular time this shrinkage took place, whether late or early, we cannot speak with certainty, for, as you are aware, the matter is still under dispute. For our present purpose, the exact date matters nothing; but, from the small amount of geological evidence available, the rocks seem to be of very great age. I quote from Professor Gregory's article in "Nature" (April, 1901):—"The specimens of rocks collected by Wilkes, and the boulders dredged by the *Challenger* or *Valdivia*, include Archæan and Sedimentary rocks, similar to those in Southern Australia; while rocks collected by the staff of the *Southern Cross* are practically identical with some of the Lower Palæozoic rocks of Victoria."

At some part of the period at which this Antarctic continent existed, the land in the region now occupied by New Zealand and the outlying islands was at a much higher level than at present, so that most of these islands were continuous with the mainland. To this great island Hedley gave the name "Melanesian Plateau," to which reference has been already made.

At one period the "Melanesian Plateau" was connected with the Papuan Land, represented by New Guinea. The various land connections here were probably not synchronous.

It was in the more limited Antipodea that the Acanthodrilids seem to have originated, or, at any rate, this area was a centre of migration.

From this Antipodea the Acanthodrilids appear to have passed northward into Papua Land; and, after this, in Cretaceous times, Antipodea became cut off from it. It then became united with the Antarctic continent, and the Acanthodrilids, wandering across it, gained access to South Africa and to South America. I am aware that Captain Hutton has expressed the opinion that "New Zealand was always separated from Antarctica by a deep, broad channel south of the Macquaries," but I must throw in my vote with those who, like Forbes, Spencer, Hedley, and others, believe in a direct land connection, either in very early Tertiary, or, perhaps, in pre-Tertiary times.

At or about this period the South American continent of the time (Archiplata, of Von Jhering) represented by what we know as Chili and Patagonia, was connected by the elevation of Fuegia, Falkland Island, and the various islands between it and Graham's Land, with Antarctica. About this continuity little doubt is expressed, but the junction of the Antarctic continent with South Africa, or, as formulated by Forbes, with Madagascar, has met with a good deal of scepticism.

In order to effect this continuity, an elevation of the sea-bottom through a height of about 2000 fathoms, *i.e.*, 12,000 feet, appears to be necessary. It is true that the *Challenger* made but few soundings hereabouts, and I have not had an opportunity of studying those of the *Valdivia*, though Mr. Louis Bernacchi, in his book on the *Southern Cross* Expedition to the Antarctic region, gives a map, indicating apparently the soundings obtained by this ship; but whether the demand is exorbitant or not, it appears to be necessary to make it, in order to explain the presence in Madagascar of *Notiodrilus*, and, in South Africa, of two Patagonian genera of earthworms—*Notiodrilus* and *Chilota*.

The absence of *Chilota* in New Zealand seems to indicate that Antipodea had been cut off from Antarctica before the South African connection had terminated.

The Acanthodrilids, having entered South America, soon wandered northwards, peopling "Archiplata" with characteristic Acanthodrilid descendants, amongst which *Yagansia* and *Microscolex* may be mentioned. And at a later period, in the middle Tertiary, when the Southern and Northern continents became continuous, these descendants passed as far north as Mexico, and the Acanthodrilid stock gave rise to several other genera now characteristic of the Nearctic region. But I may mention that both Brazil and Central America, as well as Mexico, are inhabited by members of quite a distinct family of earthworms. So, in Africa, the offspring of the ancestral *Notiodrilus*, wandering into warmer climates, have given rise to *Benhamia* and other allied genera, both on the east and on the west coast, and have ultimately peopled the continent with a set of worms characteristic of the Ethiopian region. In both these continents, the southern forms met the northern immigrants, so that both these regions present a peculiar admixture of forms. But, be it noted that, both in South America and South Africa, the more archaic genera persisted in the extreme southern area.

In New Zealand, the Acanthodrilids have met with no competition from Northern forms; the original inhabitants have been fairly prolific in giving rise to a number of genera, but they are all very closely allied. This indicates an early and persistent isolation, such as we have learnt to consider as an established fact from geological and biological researches.

The earthworm fauna of New Zealand is not only a very homogeneous fauna, but it is very ancient—far older than that of Australia; indeed, in its entirety, the oldest in the world.

Let us now consider Australia, for it presents us with several rather perplexing problems. The Acanthodrilids appear to have entered the continent, and may have spread over practically the entire land at a time when conditions permitted, which must have been, according to Spencer and others, not later than mid-Tertiary times, before the central region, at any rate, was as dry as at present.

It will be remembered that the only earthworm found by the naturalists of the Horn Expedition was a species of *Notiodrilus*, specimens of which were found on three mountain ranges—George Gill, McDonnell, and James Ranges—separated by desert. Spencer pointed out that probably this worm—" the sole survivor of the old earthworm fauna, which almost disappeared when in post-Pliocene, the climate changed "—was a member of an ancient genus, which had once been widely spread over the continent; and he suggested that it had entered from New Zealand by the northeast connection, as far back as the lower Cretaceous.

The absence of any Acanthodrilid in Papuan Land, and in the northern islands of the " Melanesian Plateau," seems at first sight to negative this northern entry of Acanthodrilids. It is, however, a curious fact that the three other Australian species of *Notiodrilus* occur in the northern portion of the continent—two of which are in Queensland—whereas, in South Africa and South America, the ancestral and original settlers persist in the south, and their offspring have migrated northwards. In other words, in those two continents the more archaic worms persist near the point of entry; and we may, then, regard the point of entry into Australia as in the north-east.

The sparseness of the Acanthodrilids in this great continent of Australia may indicate a very brief connection with their home, but more probably it is a result of their replacement by more highly-developed northern genera; while their absence in the south seems to indicate the absence of a connection with Antarctica during the existence of these worms on that land. This is further emphasised by the total absence of Cryptodrilids from South America and South Africa.

I am not denying the probability of a continuity of land-connection between Tasmania and Antarctica at some period—this appears to be required to explain various distributional facts—but the earthworms indicate that this connection was an early one—earlier, even, than that of New Zealand and the Southern continent.

As I have remarked above, the Cryptodrilids, *i.e.*, *Plutellus*, *Notoscolex*, and *Megascolides*, appear to be descendants of the Acanthodrilids; and, from the evidence available, we are led to look upon the Oriental region as the probable centre of distribution of this group.

This evolution must have taken place at a time when the present islands of Malay Archipelago and Melanesia were in more direct continuity—not necessarily a continuous land-surface, but forming an area sufficiently large to permit the development of Cryptodrilids, and from them the genus *Megascolex*. These genera must have spread westward over the southern portion of the Oriental region, and at an earlier period migrated southward into Australia.

It would take too long to discuss fully the approximate period of the westward migration, and the various land-changes that necessarily took place; but we have evidence from the peculiar distribution of Placental mammals in these islands that they have undergone various upheavals and depressions, thereby producing a variety of inter-communications. It appears probable that the entry of Cryptodrilids and *Megascolex* into Australia coincided with the entry of marsupials, in late Mesozoic or the early Tertiary. Here they over-ran the continent, each genus giving rise to one or several allied genera, and thus ousting the original Acanthodrilids, which perhaps never reached very far to the south.

It is difficult to account for the absence of Cryptodrilids in the mainland of the Oriental region, but it may be that further search for them will be repaid. Nevertheless, there is, as Wallace and Blandford have shown, several striking faunal resemblances between Ceylon and the Southern Deccan on the one hand, and the Malay islands on the other, and marked differences between Ceylon and the northern part of the Indian peninsula. It was even suggested by Wallace, and at one time by Blandford, that a direct land bridge connected Ceylon and Malayia; but Blandford has, more recently, shown this to be unnecessary.

It appears that Ceylon must have become isolated from the more easterly portions of the Oriental region at a comparatively early date, and thus served as a harbour of refuge for the Cryptodrilids, just as Australia did in the south. The two lands are the terminals of two lines of migration. At a subsequent period, in this Oriental region, *Megascolex* gave rise to *Pheretima*, which spread over the southern portion of Asia, and made its way northwards into China and Japan, and peopled the Malay Archipelago. But this evolution of *Pheretima* must have occurred after the formation of Torres Straits, otherwise we should find representatives of the genus in, at any rate, Queensland. The genus *Pheretima* appears to have originated contemporaneously with the Placental mammals.

Summary.

Let me briefly summarise the conclusions to which we have arrived.

In the first place, the earthworms, as a group, are not by any means so ancient as their anatomy seems to indicate. From the fact that, at the present time, they are found to be constantly associated with angiospermous plants, we may estimate their origin from what we know of the geological history of these. The earliest fossils, possibly attributable to angiosperms, occur in the middle of the Mesozoic, but we do not meet with undoubted or relatively abundant remains of angiosperms till the Cretaceous period.

It seems to be impossible for earthworms, as we know them now, to exist without a fair amount of nutritious vegetable soil; they appear to have developed *pari passu* with the higher plants; and we may place the ancestral earthworm somewhere in the late Jurassic period.

This ancestral form was an Acanthodrilid, possibly somewhat like *Notiodrilus*, which is, anyhow, one of the most archaic genera existing. *Notiodrilus* persists in the southernmost regions of the world, and there is reason to believe that the centre of distribution, if not of origin, was in the "Melanesian Plateau."

Antipodea, which separated early from the northern portion of this Plateau (and subsequently broke up into New Zealand and its associated islands), possesses the most ancient earthworm fauna known, its characteristic worms being all closely allied to *Notiodrilus*. This fauna appears to date from the lower Cretaceous period.

From this area the primitive Acanthodrilid spread in two chief directions, firstly northwards, through Papua Land, to enter the Austro-Malayan area, subsequently passing into Australia from New Guinea; secondly, and later than this northerly migration, was a southern migration, into the Mesozoic Antarctica, by way of which South America and South Africa were reached; but the connection with the latter must have been after the shrinkage of Antipodea. Yet it is clear that this African union was very early, otherwise mammals would have passed between South America and Africa.

As the Antarctic continent shrank in its dimensions, it left behind it Marion and Kerguelen Islands, in which some of the early Notiodrilids persisted. And, while Antipodea shrank in the early Tertiaries, representatives of the same genus were left behind in the Macquarie and Auckland Islands.

Australia appears to have lost contact with Antarctica previous to the entrance of earthworms thereinto, and to have received its Acanthodrilids from the north-east.

The Cryptodrilids, and from them *Megascolex*, took their origin from Acanthodrilids in the south-eastern portion of the Oriental region in very early Tertiary times; and appear to have entered Australia with the marsupials, and to have driven out the Acanthodrilids.

These investigations into the distribution of earthworms, and the attempt—for, after all, it is nothing more than an attempt—to trace the migration of successive groups in the Australasian regions, have opened up certain lines of thought with regard to the proposed "South Pacific Continent" put forward by Hutton to explain the stocking of South America with marsupials and early Placentals. His opinion, I will remind you, is that these early mammals did not pass through Australia and the Antarctic continent to reach South America, but travelled along a land-bridge stretching from about New Guinea to Chili.

There is a certain suggestiveness about the absence of Cryptodrilids in South America, and the apparent loss of the Australio-Antarctic connection which this seems to imply. There is also the fact that in New Zealand we find *Microscolex* and *Rhododrilus*—two closely-allied genera, while on the West Coast of America, especially in Chili, we find *Microscolex* and *Yagansia*, also closely allied (these are all immediate descendants of Acanthodrilids); but, although these facts are of considerable interest, my time will not permit me to enlarge on the Palæogeographic conditions which they may suggest. Moreover, as I have already remarked, we must be very cautious in using the distributional facts derived from a study of earthworms, except as confirmatory of, or supplemental to, such facts derived from groups of animals that have the advantage of leaving fossilised remains.

I have intentionally avoided any reference to a large body of facts accumulated by specialists in other groups of animals, in illustration of my remarks, for I have already occupied sufficient time in dealing with my own group.

ON EUCALYPTUS CORDATA, Labill., AND ITS COGNATE SPECIES.

By R. T. Baker, F.L.S., Curator and Economic Botanist, Technological Museum, Sydney, New South Wales.

The species which form the subject of this paper are—

(1) *E. cordata*, Labill., Tasmania,
(2) *E. pulverulenta*, Sims, New South Wales.
(3) *E. cinerea*, F.v.M., New South Wales.
(4) *E. Stuartiana* var. *cordata*, R.T.B. *et* H.G.S., Victoria, described in 1806, 1819, 1860-1, 1898, respectively.

Bentham, working on type specimens, classifies the first three as distinct species in his "Flora Australiensis," but Müeller later, in his Census and "Eucalyptographia" suppresses his own species *E. cinerea* under *E. pulverulenta* (a synonymy with which Bentham states he did not agree, B. Fl. iii. p. 239), a procedure which I think is to be regretted, as it has caused much confusion in regard to these species.

A research on the Eucalypts, that has recently been completed by myself and colleague, H. G. Smith, caused us to give these particular species some attention, in order that the origin of the chemical results should be rightly placed.

I.—*Eucalyptus cordata, Labill.*

These investigations show conclusively that the first species, *E. cordata*, is distinctly a Tasmanian tree, and does not occur on the mainland of Australia, a determination in agreement with Bentham and Müeller (B. Fl. iii., p. 234, and Müeller's "Eucalyptographia").

In herbarium material alone it can be easily shown to be quite distinct from—

(*a*) Sims' *E. pulverulenta* (described and figured in Bot. Mag., under t. 2087).

(*b*) *E. cinerea* (F.v.M., B. Fl. iii., p. 239)—

the differences being particularised under each species in this paper. In field characters all three are still further specifically removed. Deane and Maiden (Proc. Linn. Soc. N.S.W., 1901, p. 126), have, however, recorded this species as occurring in New South Wales at Cow Flat, near Bathurst, a tree which my field observations, in conjunction with the plate and description (*loc. cit.*) show to be identical with Sims' *E. pulverulenta*, and quite distinct from *E. cordata*, which is a medium-sized tree, with leaves, fruits, and buds quite distinct from the New South Wales Eucalyptus. The two could never be confounded in the field.

E. cordata has not the "weak, green stem, hardly able to support itself" of Sims' plant, neither has it the nodal appearance of the branches caused by the scars left by the fallen leaves at their former place of attachment.

The differences in the dried herbarium material of the two are also well marked, and on such grounds, as well as chemical evidence, I consider them quite distinct.

Sir Joseph Dallon Hooker has recently (May, 1902) described and figured this species as distinct from the other two in the "Botanical Magazine."

II.—*Eucalyptus pulverulenta* (Sims', Bot. Mag., t. 2087).

The description of this species was first published in 1819 (Bot. Mag., t. 2087), by Sims, from a cultivated specimen obtained from the Northampton Nursery, its habitat being given (*loc. cit.*) as a native of New Holland. Its present known habitat in New South Wales is Cow Flat, near Bathurst, and beyond the Blue Mountains, which range was not crossed by the early explorers until after 1813, so that the opinion is held by some that there could scarcely have been time for the seed to have been collected in New South Wales and then to have been imported into England, and for shrubs to have grown to the size stated by Sims, in 1819. It has therefore been supposed that the seeds from which these trees were raised in England must have come from Tasmania. It is quite possible that seeds may have been sent from Tasmania; in which case, of course, the species occurred in that island; but it is doubtful, as no material has ever been recorded from there that could be placed as Sims' *E. pulverulenta*. But there is also no reason why it may not also have *occurred in the early days of New South Wales much nearer Sydney than is at present the case*, and seeds of indigenous plants were probably sent from Sydney by almost every boat returning to England immediately after the foundation of the Colony in 1788. The locality "New Holland" is significant in 1819, as Bass had already discovered 20 years before, that Tasmania was an island, and seeds coming from either New Holland or Van Diemen's Land would no doubt be so labelled, and I therefore think that the locality being given as "New Holland" strengthens the case that the seeds were sent from Sydney. Sims was familiar with Labillardier's specimen of *E. cordata* from Van Dieman's Land, and was emphatic that his tree was distinct from that of the French botanist's. It will also be noted that he disputes its being ranked as a synonym of *E. cordata;* and that, too, after discussing the matter personally with Robert Brown (*loc. cit.*).

I have seen *E. cordata* growing in Tasmania, and in my opinion the evidence is quite sufficient to warrant its being regarded as quite a distinct tree from Sims' *E. pulverulenta;* and Baron Müeller must also have held this view, for his plate of *E. cordata* illustrates quite a different tree from Sims' *E. pulverulenta* of the Bot. Mag., and the same remarks also apply to Labillardiere in his plate of *E. cordata* (Pl. Nov. Holl., t. 152).

Since A. Cunningham recorded this tree from Cox's River in 1825 (Field's, N.S.W.), it appears never to have been again collected till January, 1900, when Mr. R. H. Cambage, L.S., was fortunate enough to have found a few trees of it at Cow Flat, near Bathurst, thus showing what a rare species it is. I have recently (1901) visited this locality, and thoroughly examined these trees, and consider Sims' description and plate (*loc. cit.*) most faithfully depict this particular Eucalyptus, and not the "Argyle Apple," *E. cinerea*, a tree I had known in the field since 1888, neither is it *E. cordata* of Tasmania, as shown above.

The confusion has probably been caused, in a measure, perhaps, by Müeller suppressing his *E. cinerea*, the "Argyle Apple," under Sims' *E. pulverulenta* (a classification from which Bentham dissented, B. Fl. iii, p. 239), and then figuring it as *E. pulverulenta* in his "Eucalyptographia."

Morphologically there may be some slight resemblance in herbarium material of these two trees, but in the field their differences cannot be questioned. The flowers of this species are larger than those of the "Argyle Apple," *E. cinerea*, F.v.M. I now regard Müeller's *E. cinerea*, "Argyle Apple," as distinct from Sims' *E. pulverulenta*, and my researches confirm Bentham's classification of these two species (B. Fl. iii., pp. 224, 239).

Those who are familiar with this Eucalyptus in the field will at once recognise how faithfully it has been depicted and described by Sims, in the Botanical Magazine, and that although closely connected, yet is quite distinct from *E. cordata*, Labill., of Tasmania.

"ARGYLE APPLE."

III.—*Eucalyptus cinerea*, F.v.M., (B. Fl. iii. p. 239).

Before the re-discovery of Sims' species, by Mr. R. H. Cambage, I had always considered this Eucalyptus—the "Argyle Apple,"—as *E. pulverulenta*, being probably led to this conclusion by Baron von Müeller, who, in his "Eucalyptographia," as previously stated, figures it as Sims' *E. pulverulenta*, but now I think it is only under a much restricted classification that such a synonymy would hold, for when seen in their native habitat no two trees could be more unlike each other than are these two. Bentham, however, agrees with the original authors, Labillardiere, Sims, and Müeller, and separates the three species (B. Fl. iii., pp. 224, 239), and my investigations confirm this determination.

It is unfortunate for recent botanical workers that Müeller figures this particular species (*E. cinerea*) when illustrating *E. pulverulenta* (*loc. cit.*), and no doubt this has led to so much confusion of the two trees.

In Müeller's numerous references to *E. pulverulenta* in his "Eucalyptographia" it is undoubtedly *E. cinerea* that is meant, as it is that tree—the "Argyle Apple"—which has "a reddish, stringy bark and a reddish-coloured timber" similar to *E. Stuartiana*, the "Apple" of Victoria, and Müeller often states that he was inclined to consider these two latter identical. Sims' *E. pulverulenta* has no such timber and bark.

Müeller obtained his original specimens of the "Argyle Apple" from near Lake George, N.S.W., a locality where it occurs to-day, and this further strengthens the case of it being his *E. cinerea*, as Sims' *E. pulverulenta* has never been found so far south. Bentham's remarks in B. Fl. iii., p. 239, under this species, are worth re-producing in this connection:—"F. Müeller unites this with *E. pulverulenta*, of which it may be a variety; but as far as the specimens go, the differences in the leaf, in the size of the flower, and in the shape of the fruit, appear to be constant."

My botanical material is quite in agreement with these remarks, and my field observations fully endorse them, especially in regard to the bark and timber of the two being quite distinct.

Under *E. pulverulenta*, Bentham (B. Fl. iii., p. 225) gives almost similar remarks to show that that species is different from *E. cinerea*.

Unfortunately, most of the Eucalyptus vernacular names are misleading, one name being applied to several distinct species, but *E. cinerea* is an example in which one common name is applied to the one species and not to several others, so that in this instance there can be no mistaking the tree locally, however much the botany may be in doubt.

W. H. Howitt's *E. pulverulenta* var. *lanceolata*, of Victoria, should now be *E. Stuartiana*, var. *cordata*, R.T.B. *et* H.G.S. The leaves of this variety resemble somewhat the lanceolate ones of those of *E. cinerea*, but the trees also differ in inflorescence, as Howitt's tree has constantly from five to seven flowers in the umbel, and a slightly more conically shaped fruit. Probably Bentham (B. Fl. iii., p. 239) had specimens of this tree before him when describing *E. cinerea*, F.v.M., as he records (*loc. cit.*) the number of flowers in that species as three to seven. It is quite a distinct tree from the N.S.W. *E. cinerea*, which only occasionally has lanceolate leaves, and under these circumstances I think Howitt's variety should stand.

In conclusion, I can only add that my investigations fully confirm Bentham's classification (*founded on type specimens*) of these species.

The record of *E. cordata* as occurring in N.S.W. cannot stand, as it is the true *E. pulverulenta* of Sims that should be enumerated for this State, whilst *E. cinerea*, although closely connected with both, has yet such marked specific characters as to warrant its ranking as a species as determined by Bentham.

I think, also, that science, as well as systematic and economic botany, will be better served by such a classification, as it quite removes any debatable synonymy.

RANGE OF SPECIES.

TASMANIA.—*E. cordata*, Labill.—South-eastern littoral region of Tasmania:—D'Entrecasteaux's Channel, F.v.M.; Huon River, J. D. Hooker; Recherche Bay, Labillardiere.

VICTORIA.—*E. Stuartiana*, var. *cordata*, R.T.B. *et* H.G.S.—Moa, Victoria, A. W. Howitt.

NEW SOUTH WALES.—*E. cinerea*, F.v.M.—Counties of Argyle and Camden (more particularly), F.v.M., Woolls and others.

E. pulverulenta, Sims.—Cox's River, A. Cunningham; Cow Flat, near Bathurst, R.H.C.

Salient Differences in the Species.

	Timber.	Bark.	Leaves.	Calyx.	Operculum.	Flowers.	Fruit.
E. cordata	Small, hard, dark coloured.	Persistent, spotted, slightly wrinkled	*Crenate*, cordate, sessile, bluish coloured	Rounded at the base, broadly campanulate	Depressed hemisperical, shortly acuminate, much shorter than the calyx tube	3 in the umbel	Globular, truncate, 6 lines in diameter, contracted at the orifice, rim thick, valves slightly protruding
E. pulverulenta	Small, pale-coloured, very hard, close-grained	Persistent, or decorticating in flakes	*Entire*, cordate, sessile, coriaceous, orbicular, or broadly-ovate obtuse.	Tapering at the base, petiolate	Conical, about equal to the calyx in length	3 in the umbel	Bell-shaped, 4 lines in diameter, rim thick or countersunk, valves exserted
E. cinerea	Reddish-coloured, poor quality, worthless	Red-coloured, stringy	Cordate sessile or lanceolate petiolate glaucous	Rounded at the base, petiolate	Hemispherical, shortly acuminate, shorter than calyx tube	3 in the umbel	Not sessile, subglobose to conical, 2 to 3 lines in diameter, rim thick, valves protruding
E. stuartiana var. *cordata*	Reddish-coloured, poor quality, worthless	Red-coloured, stringy	Lanceolate petiolate or sessile cordateglaucous	Rounded at the base, petiolate	Conical, acute, same length as calyx	7 in the umbel	Hemisnherical, 3 lines in diameter, rim thick, valves protruding

THE COMMON EUCALYPTUS FLORA OF TASMANIA AND NEW SOUTH WALES.

By J. H. Maiden, Government Botanist and Director, Botanic Gardens, Sydney.

Introductory.

In my "Second Contribution towards a Flora of Mount Kosciusko" (*Agric. Gaz. N.S.W.*, October, 1899), I have adduced evidence (supplementing that of Mueller), of a striking character, showing the remarkable similarity of the vegetation of that mountain to that of Tasmania. If the matter be further enquired into, it will be found that this similarity by no means alone refers to the mountain in question, but extends to many others parts of New South Wales. In both States Eucalyptus trees are the prevailing and most characteristic vegetation over enormous areas, and I think it will be a profitable field for enquiry to compare the species of this genus in Tasmania and New South Wales. To this end I have carefully examined the types; some of them, of course, originating in Tasmania, and some of them in New South Wales. It is a matter of great importance to trace a species over as extended an area as possible, for there is some danger of looking upon a species only from the points of view of its occurrence in a particular State. The Eucalypts know no political divisions between States, although those divisions are convenient for records as to range. The study of types in such a large and widely distributed genus as Eucalyptus is of such importance that it should be frequently insisted upon, in order that we may not make our comparisons or deductions with false standards.

I would point out that there is still much room for field-work in regard to the Tasmanian Eucalypts, and I trust that local botanists and collectors will support Mr. Rodway in the efforts he is making to throw light upon the many forms which Tasmania possesses. The other States have to face similar problems.

A complete series of specimens of a Eucalypt includes, besides the ordinary mature foliage and buds, flowers and ripe fruits, young suckers (these are very important), and the more these young leaves differ from the mature ones, the more important it is to gather them. Then, again, we require characteristic specimens of the bark, and also specimens of the wood, other than the sap-wood. Small axe-cut specimens answer all requirements.

The Tasmanian Eucalypts are of special interest, in that many of them were among the earliest of the genus to be described, *E. obliqua*, L'Heritier, being the first species, *i.e.*, in 1788, although the identity of the plant was overlooked for many years.

There are but four species peculiar to Tasmania, viz.:—

E. Risdoni, Hook. f.
E. coccifera, Hook. f.
E. urnigera, Hook. f.
E. vernicosa, Hook. f.

A continuance of the activity in regard to the genus that has taken place during the last few years may reduce the list still further; perhaps Tasmanian botanists will endeavour to increase it, and also the general list of Tasmanian species.

The following table shows the list of Tasmanian Eucalypts recognised by Hooker, Spicer, Mueller, and myself, arranged for comparison.

Hooker. (Fl. Tas.)	Spicer. (Handbook of Tasmanian Plants.)	Mueller. (2nd Census.)	Maiden. (Present paper.)
coriacea	coriacea	pauciflora	coriacea
—	—	hæmastoma	amygdalina
—	—	regnans	regnans
amygdalina	amygdalina	amygdalina	amygdalina
radiata	amygdalina var.	amygdalina var.	amygdalina var.
nitida	amygdalina var.	amygdalina var.	amygdalina var.
Risdoni	Risdoni	amygdalina var.	Risdoni
—	—	amygdalina var.	linearis
coccifera	coccifera	coccifera	coccifera
gigantea	obliqua	obliqua	obliqua
—	—	Sieberiana	Sieberiana
—	—	obliqua var.	virgata var. (?)
globulus	globulus	globulus	globulus
—	—	—	Maideni
cordata	cordata	cordata	cordata
urnigera	urnigera	urnigera	urnigera
vernicosa	vernicosa	vernicosa	vernicosa
Gunnii	Gunnii	Gunnii	Gunnii
acervula	Stuartiana	Stuartiana	Gunnii var.
viminalis	viminalis	viminalis	viminalis

Hooker, therefore, recognised 14 species, of which 3 have been suppressed, leaving 11; Spicer recognised 12 species, of which 1 has been suppressed, leaving 11; Müeller recognised 14 species, of which 2 have been suppressed, leaving 12; and in the present paper I submit that the Tasmanian Eucalyptus flora contains 16 species, including 3 (viz., *linearis*, *virgata* (?), *Maideni*) which are in no former list.

E. hæmastoma, Sm., has not been proved to exist in Tasmania so far.

The following species have, however, at various times, been looked upon as *hæmastoma* in Tasmania:—

1. *E. obliqua*, L'Hérit. (*See* "Gum-topped Stringybark," p. 366).
2. *E. amygdalina*, Labill. (*See* p. 356).

Some Deal Island specimens are interesting, and I hope we may have perfect material some day.

Although nearer to Victoria than to Tasmania, it is a moot point as to whether the flora cannot be claimed by Tasmania. In any case, the above plant about to be referred to should be looked for in islands undoubtedly Tasmanian, and on the mainland of Tasmania itself. Deal Island, Kent Group, is 50 miles S.E. of Wilson's Promontory, and much nearer Australia than Tasmania. (*Vict. Nat.*, vii., 121.)

Müeller determined the Deal Island Eucalypt as *E. amygdalina*, Labill. (*op. cit.*, 138).

The specimen is a strict form, with rather small, stiff, leaves.

Later on in the herbarium, Mueller marked these specimens *E. hæmastoma*, Sm. I am not, however, satisfied that this plant is not nearer to *E. amygdalina*, Labill. (as at first determined by Mueller), than to *E. hæmastoma*. It presents a good deal of resemblance to R. Gunn's No. 808 (*E. amygdalina*, Labill., var. *nitida*, Benth.). The borderland between several of the Renantheræ is so ill-defined that I hesitate to follow Mueller in his *E. hæmastoma* determination, and in adding a species to the flora of Tasmania. It is to be hoped that these Bass' Straits islands may be further explored by botanists.

E. stellulata, Sieb., is a species one would expect to find in Tasmania. It grows in bleak mountain regions, and, in Southern New South Wales, associated with a number of plants, common to Tasmania and New South Wales.

E. alpina, Lindl., a Victorian species, frequenting a few mountain-tops, and allied to *E. globulus*, Labill., according to most authors, although I think its true affinity is rather with *E. capitellata*, Sm., should be looked for in Tasmania.

In Tasmania we miss the Stringy-barks, which are so abundant in New South Wales, viz.—

E. eugenoides, Sieb.,
E. capitellata, Sm.,

and particularly *E. macrorrhyncha*, F.v.M., which is so abundant also in Victoria.

Another tree with fibrous bark is *E. pulverulenta*, Sims, which I have lately shown (Proc. Linn. Soc., N.S.W., 1901, 553) to have an extended range, and to include one of the Victorian trees which has passed under the name of *E. Stuartiana*, F.v.M. It is found near Melbourne, and it seems to me a likely species to occur in Tasmania also.

There is no true Ironbark in Tasmania, *i.e.*, *E. paniculata*, Sm.; *E. siderophloia*, Benth.; *E. crebra*, F.v.M.; *E. sideroxylon*, A. Cunn. The so-called White Ironbark of Tasmania is *E. Sieberiana*, F.v.M., the "Mountain Ash," and I have occasionally heard the name "White Ironbark" applied to it in New South Wales, though in error.

There appears to be no true Box in Tasmania, nor, indeed, any of the Porantheræ.

None of several species known as Mahogany on the mainland appear to be found in Tasmania.

The Mallees seem also to be absent, but as they are denizens of dry continental tracts, not as a rule approaching the sea-coast, this is hardly a matter for surprise.

It seems somewhat strange that no member of the Parallelantheræ from *rostrata* to the end of the list has yet been found in Tasmania, not even the widely-diffused *tereticornis* nor the coast-loving *corymbosa*.

Critical Examination of Tasmanian Species.

A.—*E. coriacea*, A. Cunn. (Syn. *E. pauciflora*, Sieb.).

I have examined the following classical Tasmanian specimens:—

(*a*) Gunn's Nos. 684, 684?, 1107, and 1108 (R. Gunn, 1844, and noted in Hooker's, *Fl. Tas.*), in Herb. Kew. They are typical *E. coriacea*, A. Cunn., and are *E. piperita*, Sm., var. *pauciflora*, D.C., Prod. iii., 219, as pointed out by Hooker in Fl. Tas., i., 136.

(*b*) Col. Paterson ex. herb. Lambert in herb. Cant.

I have also—Richmond Road, near Risdon—L. Rodway's No. 266, of Oct. 1892.

Some of Gunn's specimens in European herbaria labelled "*Eucalyptus radiata*" with glaucous buds really belong to *E. coriacea.* Some of them are labelled "Very common about Hobart Town," and "Weeping Gum of Norfolk Plains." The true *E. radiata,* Sieb., is much less likely to be confused with *E. coriacea,* A. Cunn., than the forms (*E. radiata,* Hook. f., non. Sieb.) that Hooker took to be *E. radiata* See p. 356.

Synonyms—

1. *E. submultiplinervis,* Miq.
   E. submultiplinervis, Miq., var. *minor,* Miq.
   (*E. silvicultrix,* F.v.M., Herb.).
   See Ned. Kruidk. Arch. iv. 138 (1856).

Miquel's *E. submultiplinervis* was founded on Charles Stuart's Nos. 10, 13, 14, 15, from Tasmania. Specimen No. 34 (species number in Miquel's paper), "*Eucalyptus silvicultrix,* Ferd. Müeller, Tasmania" (in Müeller-s hand writing), and "*E. submultiplinervis* forma *minor,*" in that of Miquel, have buds, and are undoubtedly *coriacea,* as so marked by Bentham on the specimen. I fail to see that Miquel's "forma *minor*" is really smaller than the other specimens.

2. Following is copy of a label in Herb., Melb.:—"*Euc. sylvicultrix,* F.v.M., Syn., *E. coriacea,* A. Cunn., var. *silvicultrix,* F.v.M., Syn., *E. multiplinervis, Miq.* (a slip of the pen for *submultiplinervis*). No. 765, near Woodhall, March, Stuart."

The above type material is in twigs bearing leaves, very young buds, and flowers. The material, as far as it goes, in the venation of the leaves and their hooked apices, their length and breadth, in the very young buds, in the calyces and flowers, absolutely match much of the *E. coriacea* from New South Wales. Bentham (B. Fl. iii. 201), speaks of *E. submultiplinervis,* Miq., *E. sylvicultrix,* F.v.M.), as a narrow, straight-leaved variety, with the flowers of the ordinary size. Looking over a large series of *E. coriacea* and three or four specimens of *E. submultiplinervis,* I see nothing abnormal in the latter.

3. *E. phlebophylla,* F.v.M., is also interesting to the Tasmanian botanist, from the circumstance that Miquel (Ned. Kruidk. Arch. iv. 140, 1856), who described the species on behalf of Mueller, gave Stuart's Tasmanian specimens as co-types.

> I have examined Stuart's specimen, and it bears, in Miquel's handwriting, the words "*E. phlebophylla*, M." (Mueller), with the words "*E. submultiplinervis*, affinis," cancelled. (Herb., Melb.).

It seems to me that the alpine forms of *E. coriacea* are very close to *E. coccifera*, Hook., f., and this word of caution may be useful to the student.

E. coriacea is very widely distributed in New South Wales; it is not found in the western plains, nor the warmer coast districts. In cold table lands and mountainous districts, it prefers damp, bleak localities. In a stunted form, it forms the "tree-line" at Mount Kosciusko. I have not seen a Tasmanian form that does not also occur in New South Wales.

B.—*E. regnans*, F.v.M.

I am of opinion that *E. regnans*, F.v.M., is a good species, although latterly Mueller suppressed it, including it under *E. amygdalina*. Space will not permit me to go into the matter fully at this place, but I think its broadish suckers alone remove it from *E. amygdalina*.

It was Mr. F. Abbott who first drew attention to the fact that the tree called *regnans* in Victoria grows in Tasmania, as the following passage in the "Eucalyptographia," (under *E. amygdalina*) bears witness.

"Huge stems, quite smooth and almost white . . . . . . passes one of the White Gum trees . . . . according to Mr. F. Abbott it is this form, which constitutes the 'Swamp Gum-tree' in Tasmania, where already Sir William Dension placed early its huge dimensions on record."

Some specimens of "Swamp Gum" from Mr. Abbott are typical, or nearly typical, for *E. amygdalina* var. *nitida*.

Most of the leaves (probably taken from a top branch) are smaller than those of *E. regnans* usually are, but some precisely match those of *E. regnans*, particularly the thicker-leaved forms of the latter. This is but an additional instance of the intimate relations of *E. regnans* and *E. amygdalina*. But Mr. Abbott probably saw typical *E. regnans* in addition, and specimens collected by Mr. L. Rodway, leave no room for doubt that the species occurs in Tasmania.

Mr. Rodway says:—"Tree 70-80 ft.; bark smooth, except at extreme base, where it is ribbony." His specimens are of nearly typical *regnans*. The fruits are not quite ripe; they are pyriform.

I do not think that typical *regnans* (a White Gum) has been collected in New South Wales. But I shall take an early opportunity of showing that the species is very variable in regard to its bark, including all stages of rough bark. In New South Wales (as also in parts of Victoria) we have the rough-barked forms.

C.—*E. amygdalina*, Labill.

Tasmania is of course the home of the type. Labillardière figured his plant, and this should be borne in mind when we consider the extensive range and the variability of the species.

As compared with New South Wales forms, the Tasmanian specimens have often more domed fruits, and the rim thicker and more conspicuous.

I will now proceed to take notice of some synonyms of the species, founded on Tasmanian forms.

1. A plant in early bud from Tasmania, labelled "*Eucalyptus salicifolia*" in Fraser's* handwriting is in Herb. Oxon., and is identical with No. 25, Gunn. It is *E. amygdalina*.

2. *E. tenuiramis*, Miq., is described in Ned. Kruidk. Arch., iv., 128 (1856), from Tasmanian specimens ("Stuart, No. 11, p. 16," *sic*).

I have examined the type specimen ("unicum" in Miquel's handwriting) in Herb. Melb., *E. tenuiramis*, Miq., "Van Diemen's Land, C. Stuart." It has broadish leaves, with thickened margins, is in flower, without buds or fruit. It precisely matches the specimens of "Swamp Gum" (F. Abbott), referred to at p. 355, as regards the leaves.

I cannot see any difference between this specimen and R. Gunn's No. 1112 (see Fl. Tas.).

3. *Euc. radiata*, Hook. f., non. Sieb. (Fl. Tas. i. 137).

Hooker's observations afford an excellent example of the difficulties (especially great in the case of the older workers) in dealing with plants of the *amygdalina* group. In making up duplicate sets for distribution, the so-called varieties were either mixed a little, or, what is more probable, the

* Charles Fraser was first Superintendent of the Botanic Gardens, Sydney, and died in 1831.

specimens vary somewhat amongst themselves, adding to the difficulty of determining some of them.

None of the specimens are true *E. radiata*, Sieb., which is found in New South Wales and Victoria; I have not seen it yet from Tasmania.

Hooker (*loc. cit.*) attempted to define, and distributed, five varieties of "*E. radiata*, Sieb.," from Tasmania. I have examined a number of specimens from various herbaria, and report as follows upon them.

Var. 1.—1073, Gunn. Twig taken from a young tree or young growth, the leaves not ceasing to be opposite; later on they will lengthen and narrow. From Herb. Benth. (Kew.) in Herb. Syd. It is *E. amygdalina*, Labill.

Var. 2.—Herb. Calcutta, ex Herb. Hook. (Kew.). There are two specimens on one sheet, both Coll. R. Gunn.

(*a*) One is labellel "*Eucalyptus radiata*, Sieb., var. 2."

(*b*) Is labelled "*Eucalyptus radiata*, Sieb., var. *nitida*."

(*a*) is in fruit only, and (*b*) is in bud only. (*a*) is *E. Risdoni*, Hook. f., var. *elata*, and (*b*) is not to be distinguished from the dull-leaved form referred to under var. 5, and is therefore *E. amygdalina*, Labill., var. *nitida*. 1112 R. Gunn is also typical of var. 2. It is entirely identical with *E. tenuiramis*, Miq. It is non-glaucous, and may be referred to *E. Risdoni*, var. *elata*, or may be looked upon as a form of *E. amygdalina*, near to var. *nitida*, at the option of botanists; for, indeed, while close to the former, it partakes of the character of the latter, more particularly in regard to the leaves.

Other specimens of var. 2, from Herb. Cant. and elsewhere, differ slightly from some of the specimens already referred to. I find that I cannot always separate vars. 2 and 5, and therefore label them (including 1112 Gunn)—"*E. amygdalina*, Labill., tending to *E. Risdoni*, var. *elata*." One of Gunn's 1112 is identical with *E. tenuiramis*, Miq.

Var. 3.—The only absolutely authentic specimen of this variety I have seen is ex. Herb. Hook., in Herb. Calcutta, and bears the usual litho. label, "Hab. Tasmania, Coll. R. C. Gunn," and the writing "*Eucalyptus radiata*, Sieb., var. 3" It is in very young bud, but comparison with a large series of specimens enables me to make the following statement. It is near var. 1, but more glaucous. It belongs to that series connecting *E. amygdalina*, Labill., var. *alpina*, and *E. Risdoni*, var. *elata*, and different Eucalyptologists would put in one or the other, or both.

Var. 4.—No. 1110, Gunn. Has very glaucous buds in most specimens. All the authentic specimens I have seen, marked "1110 Gunn," or "*E. radiata*, var. 4, ex. Herb. Hook.," are in bud or flower, but a specimen in Herb. Benth. (Kew.) ex Herb. Webb., collected by Labillardière, has a single fruit.

I label it *Euc. amygdalina*, Labill., with the note that it shows transit to *E. Risdoni*, var. *elata*.

Var. 5.—I have examined at least four authentic specimens:—

(*a*) Herb. Hook. (Kew.), bearing the following in Gunn's handwriting, "808 (?) Eucalyptus ('*radiata*, var. 5,' in Hook. f's. handwriting):—
"I think this is the same as my original 808. At Currie's River it formed low bushes about 5 feet high, but occasionally a few feet higher. It grew in the poor sandy land near the sea." Another label of Gunn's reads, "Currie's River, east of George Town, 24. 10. 43."

(*b*) A duplicate of (*a*) in Herb. Hook. In (*a*) and (*b*) the foliage is somewhat shining; the fruits are pale-brown, very shining, with dark rims, and are borne in profusion.

(*c*) A specimen in Herb. Calcutta, ex. Herb. Hook., with label "*E. radiata*, Sieb., var. 5, R. C. Gunn." Two specimens on sheet: one in bud, the other in fruit. The foliage quite dull, and mostly narrow, but the fruits precisely those of (*a*) and (*b*).

(*d*) A specimen in Herb. Oxon. bearing the same label as (*c*), but in bud only. Matches (*a*) and (*b*), as far as it goes.

As regards var. 5, Hook. f. (Fl. Tas. i. 137) says, "Arbor elata, ad *E. nitidam* tendens."

Gunn's specimens of 808 (?) are shrubby, doubtless owing to the situation, but *E. amygdalina* flowers and fruits when small. I think var. 5 is very close to typical *E. amygdalina*, var. *nitida*, taken from the description and Hooker's figure. The shape and length of the leaves in the figure is that of the Herb. Calcutta specimen (*c*) alluded to.

4. *E. nitida*, Hook. f. (Fl. Tas. i. 137 t. 29).

Has very small sessile fruits, and very shining coriaceous leaves. Hooker's *E. nitida* is founded on Gunn's No. 808.

The specimens of Gunn labelled 808 (?) doubtless belong to that form also. See my remarks on "*E. radiata*, Sieb." (Hooker's var. 5). A specimen in Herb. Kew. is labelled "*E. nitida*, Hook. f. A large dense tree, near the sea, at Port Arthur." Fruit bright or shiny. The rim is slightly raised, broadish, and very red. It bears a strong superficial resemblance to *E. hæmastoma.*

When reducing it to a form of *E. amygdalina*, Bentham has a note, "Leaves broader and more rigid. Peduncles and pedicels shorter. Flowers rather longer. *E. ambigua*, DC. Prod. iii. 219 (?), from the idagnosis taken from Labillardière's specimen. *E. nitida*, Hook. f. In the dried specimens this variety appears to pass into the variety *elata* of *E. Risdoni*" (B. Fl. iii. 203).

E. amygdalina passes imperceptibly into var. *nitida*, which has thicker, broader leaves, hemispherical operculum, broad, domed red rim, fruits in heads; but all these points are variable.

I have specimens from Jenolan Caves, N.S.W., which closely resemble Hooker's *E. nitida*, as figured in Fl. Tas. This is the nearest approach I have yet seen in New South Wales to the Tasmanian variety; it appears to connect this form with that form of *E. regnans* which Mr. Baker has named *vitrea.*

5. *E. amygdalina*, var. *alpina*, Rodway, Herb.

A stunted tree, glaucous in all its parts, strongly reminding one of *E. coriacea*, A. Cunn., var *alpina*, from which it can be chiefly distinguished by its prominent midrib, and perhaps more spreading veins. This form, found on Ironstone Mt., and in other high situations, requires a fuller knowledge of Tasmanian Eucalypts in the field than I at present possess to determine its position absolutely. It is one of the forms intermediate between *E. coccifera* and *E. amygdalina.* It is very near to, and perhaps identical with, one or more forms of *E. radiata*, Hook. f., non. Sieb. (vars. 2 and 3). At present one cannot do harm by adopting Mr. Rodway's provisional name, and when the Eucalypts of Tasmania are more fully examined, I would suggest to my co-worker, Mr. Rodway, to issue numbered sets of the *amygdalina-Risdoni* series, in order that we may secure as much definiteness as possible in referring to these intermediate forms.

D.—*E. Risdoni*, Hook. f. (Hooker's Lond. Journ. Bot. vi. 477, 1847. Fl. Tas. i. 133. t. 24).

I have examined the following types:—

(*a*) R. Gunn's No. 1278, from Herb. Kew.—"Small tree growing in clusters on the side of a hill near Risdon, 10-20 ft. high, branched from the base, Oct. 1840. R. Gunn."

(*b*) 1072, R. Gunn. Risdon, Hobart, 10.10.40.

E. perfoliata, R. Br. (B. Fl. iii. 253), is a Northern Territory shrub. There is, however, *E. perfoliata*, R. Br., in Herb. Kew., which is *E. Risdoni*, Hook. f. The name *perfoliata* was loosely employed in regard to Eucalypts by the early botanists. (See Proc. Linn. Soc. N.S.W. 1901, 550.)

E. connata, J. Schauer, from Tasmania, in Herb. Vienna, is *E. Risdoni*. If this species was described it would perhaps take priority of Hooker's name. *E. perfoliata*, Tausch, in the same herbarium ex Herb. Ferd. Bauer, is also *E. Risdoni*.

The affinity of *E. amygdalina* to *E. Risdoni* is undoubtedly close, the relationship being closest through the var. *elata* of the latter. *E. Risdoni* has broad sucker leaves, and on this character alone I would retain it as a species distinct from *E. amygdalina*. At the same time, it passes into *E. amygdalina* by innumerable gradations.

If *E. Risdoni* be abandoned, then *E. dives* must be abandoned, a strong species in my opinion.

The bark of *E. Risdoni* is smooth; that of *E. amygdalina* is always fibrous* on the butt; this is an important character.

In these days the determinations of Eucalypts by the older botanists are carefully criticised, in view of the extensive field knowledge of the genus we now possess, and which is becoming increasingly accurate, but the following remarks by Bentham (B. Fl. iii. 203) seem to be quite accurate:—

"F. Mueller also unites *E. Risdoni* altogether with *E. amygdalina*. J. D. Hooker and Oldfield, both of them from observations made on the spot, have assured me that the two are quite distinct, in habit as well as in the bark. The

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* Mr. Rodway writes to me, "Many forms of undoubted *E. amygdalina* are smooth-barked from the butt." Nevertheless, in view of the uncertain position of *E. linearis*, I prefer to leave my remarks on the bark to stand for the present.

sessile opposite leaves occupy frequently the flowering branches of *E. Risdoni*, and are only on the saplings and adventitious flowerless branches of *E. amygdalina*; they are, moreover, broad, frequently connate, and usually glaucous or nearly white in the former, always, as far as known, narrow-ovate or oblong-lanceolate in *E. amygdalina*. When the leaves are alternate, they appear to be broader in *E. Risdoni* than in *E. amygdalina*, the pedicels thicker and more angular, the flowers and fruits larger, differences, however, of degree only, to which our dried specimens do not admit of our fixing any precise limits, and in that state it is sometimes scarcely possible to decide to which species they should be referred.

"Var. *elata*.—A beautiful tree of the largest size, the bark of the trunk grey and deciduous, that of the extremities of the branches purplish red or reddish brown (Gum). Leaves broadly lanceolate-falcate, 2 to 4 in. long, rather thick, sometimes almost as in *E. obliqua*. Flowers of *E. Risdoni*. Fruit pear-shaped, 4 lines diameter, with a broad convex rim.—Lake St. Clair (Gunn). This variety in the dried specimens appears to connect *E. amygdalina* with *E. obliqua*, but without doubt belongs to *E. Risdoni* as observed by Oldfield, although the dried specimens were included by J. D. Hooker among the varieties of *E. radiata*, Sieb., now united to *E. amygdalina*." (B. Fl. iii. 203.)

Var. *elata* is a drooping broad-leaved glaucous form, with broadish sucker-leaves, common (Mr. Rodway states) in mudstone country, in Tasmania, and one of the intervening forms between *E. amygdalina* and *E. Risdoni*. Has large domed fruits and coriaceous leaves, which are often glaucous along the edges, giving them an unusal hoar-frost appearance. They may be looked upon as having affinity on the one hand with *E. amygdalina*, var. *nitida*, and on the other with var. *alpina*.

The variety *elata* also closely approximates to *E. coccifera*.

Lanceolate leaves are common on the tops of branches of *E. Risdoni*, it being not an uncommon occurrence to find the sessile, almost cordate leaves, and the lanceolate leaves on the same branch. I believe Mr. F. Abbott first made this observation, and he directed my attention to the trees. Mr. Deane and I made a similar observation in regard to *E. pulverulenta*, leaves of the two shapes being found on the same twig. (See Proc. Linn. Soc. N.S.W. 1900, p. 110.)

The following notes refer to *E. hypericifolia*, R. Br., which belongs, in my opinion, to *E. Risdoni*, Hook. f.

E. hypericifolia, R. Br., which is in *Index Kewensis* referred to as "ex Benth., B. Fl. iii. 203."

The reference is as follows:—

"*E. amygdalina*, var. (?) *hypericifolia*, Benth.—Leaves of the fruiting branches all opposite, oblong-lanceolate, rounded or cordate at the base, and sessile or nearly so. Risdon Cove, R. Brown. *E. hypericifolia*, R. Br. Herb.—The specimens are larger and good, but in fruit only. To this form may belong also some of the garden plants described from the foliage under the same name." (B. Fl. iii. 203).

In a letter to me Mr. Rodway speaks thus of var. *hypericifolia*:—"Fruit rather smaller than in var. *nitida* These, with *E. Risdoni* and *E. Risdoni*, var. *elata*, form a quite uninterrupted series."

This is another form intermediate between *E. amygdalina* and *Risdoni*. Its affinity to *E. Risdoni*, var. *elata*, is obvious and close.

The *E. hypericifolia*, Dumont, described as follows, from leaf specimens only, is "very doubtful." (B. Fl. iii. 200.)

It may be convenient to draw attention to Dumont's imperfect descriptions at this place, especially as he says his plant is the *E. hypericifolia* of English gardens. With the aid of Kew, I have been successful in obtaining Dumont's original description, which is instructive, as showing how Eucalypts were described in the early days. I have not been able to see the type:—

"*Eucalyptus hypericifolia*, Dum.-Cours., Bot. Cult. ed. 2, vii.

"E. à feuilles de millepertuis, *E. hypericifolia*, Hort. angl.

"Cette espèce ne me semble former qu' un arbrisseau. Ses rameaux sont très menus et n'ont guère, surtout vers leur sommet, que la grosseur d'un fil. Feuilles opposées, lancéolées, oblongues, pointues, très-entières, glabres, d'un beau vert en-dessus, un peu glauques en-dessous, de 4 centimètres de longueur, et de 4 à 5 millimètres de largeur. Lieu. id. [La nouvelle-Hollande]. Toujours vert."

Then comes Link's briefer description:—

"*B. Folia juniora opposita adultiora.*

"228, *E. hypericifolia.* Dumont-Cours., Botan. Cult., 7212, Hab. in Australia, Fol. pet. 6″, l. lam. 6′, lga. 1′ 6″, lata, nervis lateralibus parallelis ante marginem connexis." (Link's "Enumeratio," p. 31.)

Sweet's reference is very brief:—

"56. *hypericifolia,* (White), N.S.W., 1804. Greenhouse-shrub." (Sweet. Hort. Brit. Ed. 2, p. 209.)

I submit the following diagram as exhibiting the relations of *E. amygdalina* and *E. Risdoni,* as far as we know them at present. But I repeat that much field work still requires to be done in regard to aberrant forms.

amygdalina | *Risdoni*
Var. *alpina* ———————— Var. *elata*

E.—*E. linearis,* Dehnh.

Following is the original description, obtained from Kew. It has not been previously published in Australia, so far as I know. It is from *Catalogus plantarum horti Camuldensis,* Ed. ii. 1832, p. 20:—

"*Eucalyptus linearis,* Dehnh.—E. ramosissima. Ramulis viminalibus teretibusque lævibus; foliis alternis linearibus subfalcatis subcrenulatis rugosiusculis in petiolo decurrentibus apice uncinatis; cortice laevi punctato. Ramulis debilibus paniculatis. Folia uncias 3-4 longa, lineam 1 lata. Species haec differt ab illis quae descriptae sunt in Catalogo Horti Parisiensis; phrases quibus utitur cl. Desfontaines ejus Catalogi Auctor hic transcribo. *Eucalyptus rubricaulis. Ramis asperis; ramulis filiformibus: foliis alternis, angusto-lanceolatis acutis petiolatis.*

"*Folia-uncias 2-3 longa, lineas 3 lata.*

"*Eucalyptus pulchella. Ramulis filiformibus; foliis alternis lineari-subulatis.*

"Ramulis filiformibus paniculatis. Folia uncias 2 longa, lineam 1 late."

The original descriptions of *E. rubricaulis,* Desf., and *E. pulchella,* Desf., have been inserted for convenience of reference. It will be observed that all three species have been described from leaf only. Walpers (Rep. Bot. Syst. ii. 164), gives the following:—

"*E. linearis,* Dehnhardt (*Rivista Napolitana,* 1-3, p. 173).—Operculo conico glandulifero, umbellis lateralib, 5-8 floris parvulis albidis; ramulis viminalib. teretibq. lateribq., foll.

alternis linearib. angustissimis subfalcatis rugosiusculis subcrenulatis, in petiolum decurrentib., apice uncinatis, cortice laevi punctato. Crescit in Nova Hollandia."

Bentham says that *E. linearis* is far too imperfectly described to render identification possible (B. Fl. iii. 200.)

I have not seen a type specimen,* but I understand that the specimens about to be referred to are authentic.

A smooth-barked species, and, in my opinion, in spite of the fact that there are connecting links between it and *E. amygdalina*, it will be convenient to retain it as a species, at all events for the present. It seems a more strongly-marked form than the other varieties of *amygdalina*, but we must look to Tasmanian botanists for a full investigation of it with reference to other forms.

E. linearis, as seen by me on Mount Wellington, is a large White Gum, with stripy bark. The leaves are strict, and inclined to be succulent. They seem to have an odour of oil of geranium when crushed.

Herb. Cant. contains a very narrow-leaved form of the narrow-leaved 1079 Gunn, which bears the label, "*E. linearis*, Cunn., environs of Hobart Town: is one of Lhotsky's *amygdalina* vars."

I cannot find that Cunningham ever published a species of that name; the plant is, however, identical with what goes under the name of *E. linearis*, Dehnh. A Kew label has "*E. linearis*, Hobart Town, 85/1819, A. Cunn."

Another specimen of Gunn's 1079, labelled "Peppermint Gum," is taken as typical of *E. amygdalina* by Hooker, (Fl. Tas.)

Backhouse calls it the "Mountain Peppermint" of Oyster Bay.

I have received cultivated specimens of it from California, under the name *E. amygdalina*, var. *angustifolia*, Link., a variety name I am unable to trace. There is, however, in Link's "Enumeratio," ii. 30, "No. 227, *E. angustifolia*, Desfont. Par. Fol. subsessilia, 2′ 6″, lga. 2″, lata acutata attenuata," which may be *E. linearis*, Dehnh.

Specimens labelled *E. angustifolia*, Desf., in Herb. Berol., 1900, are *E. viminalis*, Labill. I observe that Don (Gen. Syst. ii. 819) refers *E. angustifolia*, Desf., to *E. saligna*, while Bentham (B. Fl. iii. 200) says it is very doubtful.

I may mention that *E. angustifolia*, Desf., has also been quoted as *E. angustifolia*, Spreng. et Candolle, and *E. angustifolia*, Link. Enum. ex Spreng.

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* Since this was written I have seen the type, and have written a paper on the subject (See *Proc. Roy. Soc. Tas.* 1902.)

F.—*E. coccifera*, Hook. f. (Lond. Journ. Bot. vi. 477, 1847. Journ. Hort. Soc. vi. 222. Bot. Mag. 78, 4637.)

This received its specific name because its foliage was infested with a *Coccus*, a condition by no means peculiar to this species; debilitated Eucalypts of perhaps any species may become thus infested.

"This species has much the same aspect of some thick-leaved forms of *E. amygdalina*, but is readily known by the depressed operculum and longer calyx." (B. Fl. iii. 204.)

The affinity of *E. coccifera* with *E. coriacea*, var. *alpina*, is so pronounced as to be apparent to the most superficial observer, but is distinguished from that species in the more prominent and more spreading veins, showing its closer relationship to *E. amygdalina*.

The affinity of this species to the alpine Tasmanian forms of *E. amygdalina* is undoubtedly great. The leaves of both species are very similar as regards the venation, &c. Further observations are required to absolutely settle their relations, though I believe that *E. coccifera* is quite a distinct species; the seedling-leaves settle this. Following are some specimens examined:—

(*a*) *E. coccifera*, Hook. f.—Tree, 120 ft., Mount Wellington, Tasmania. Oldfield. (Herb. Barbey-Boissier.)

(*b*) 1076, R. Gunn, 1844. (Herb. Kew.)

(*c*) 411, R. Gunn, var. *parviflora*, Benth.—"Flowers much smaller, the peduncles exceedingly short." (B. Fl. iii. 204.)

I have not seen Gunn's specimens of this form, and would recommend that they be compared with *E. amygdalina*, var. *alpina*.

Synonyms—

1. *E. alpina*, R. Br. MS.—Top of Table Mountain, Tas. (Herbs. Kew. and Brit. Mus.)
2. *E. daphnoides*, Miq. (Ned. Kruidk. Arch. iv. 133, 1856).—The type specimen is Stuart's No. 9.
   There is a specimen in Herb. Kew. marked "*E. amygdalina nitida* var."
3. In Herb. Barbey-Boissier is a specimen of *E. coccifera* labelled *Eucalyptus citryandra*. Verrières près Paris, 27 April, 1891. Cult. Vilmorin, gélè, 1890-1891.

G.—*E. obliqua*, L'Herit.

This is the first species of Eucalyptus described, it having been originally collected by David Nelson, "Assistant Botanist," on Cook's Third Voyage (1776-9), and described by L'Heritier in 1788. At the time of its collection, and for long afterwards, Tasmania was looked upon as part of Australia; moreover, it was poorly described and figured, and the specimens themselves were imperfect, and not easily accessible. The result was that it was not recognised until the sixties that *E. obliqua* was the common Tasmanian Stringybark. Hooker, "Flora of Tasmania," was not aware of its identity, and consequently in that classical work it is not mentioned, but a new species, *E. gigantea*, Hook. f., takes it place.

Following is the original description of *Eucalyptus obliqua* by L'Heritier:—

"*Eucalyptus.*—Perianthium: Operculum superum, integerrimum, truncatum. Petalum: Calyptra obverse hemisphærica, margini calycis imposita, ante anthesin discedens Filamenta numerosissima, calyci inserta. Germen inferum turbinatum. Stylus unicus. Capsula subquadrilocularis, apice duntaxat dehiscens. Semina plurima, angulata.

"*Eucalyptus obliqua.* Tab. 20. Habitat in Nova Cambria. Nelson, Guil. Anderson." (L'Herit. *Sert. Angl.*, p. 18.)

Following is Hoffmansegg's brief reference to the species, which is given here because of the rarity of the work:—

"(430) *Eucalyptus obliqua.* Male in Willd. foliorum nulla mentio, id quod in Link. 'Enum.' probe emendatum." (Hoffmg. verz. Pfl. Nachtr. 2, p. 114.)

The fruits of *E. obliqua* sometimes have great similarity to those of *E. coriacea.*

Following are reports by Mr. Allen Ransome of London, on two Tasmanian samples of *E. obliqua* timber (see "Kew. Bulletin," May, 1889):— . . . . ."a very strong, tough wood, with a straight grain, in appearance somewhat resembling American Ash. From its great strength and toughness it is well adapted for carriage, cart, and waggon building, wheelwork, and agricultural machinery, as well as for the framing of railway carriages and trucks. It is also a valuable wood for the stronger description of building constructions, and would make excellent railway-sleepers. From the peculiar strength of the fibre of the grain it will not maintain a good surface, as even when perfectly dry, the grain rises, so as to render it impossible to polish it successfully."

"Stringybark can be obtained in patches all over Tasmania, but is most abundant in the south; like the Blue Gum, it can be got of any reasonable length or size. It is of quicker growth than the gum, and is of a lighter and milder nature generally. The timber is much used in Tasmania, and in the adjacent Colonies, for house-building, &c. To ensure durability the wood requires fair seasoning. The different varieties are Gum-top Stringybark,* Brown and White Stringybark (the Brown being the older growth). The White Stringybark makes good palings and shingles."

An official report says:—

"*Eucalyptus obliqua* (Stringybark) is our most valuable wood. It differs from, and is better than, the Stringybark of Australia. The timber is light-coloured, and varies considerably, from a brown wood resembling oak to a much lighter-coloured wood resembling ash; and because of the great variety of its uses, and its abundance, is more valuable economically than Blue Gum. The bark might be made a source of income, as it is suitable for the manufacture of paper."

The timber appears to be more valuable in Tasmania than on the mainland; its utilisation as a paper-making material is not likely to have any commercial importance.

Although chiefly a Tasmanian and Victorian tree, it has during the last four years been found to extend over very large areas in New South Wales, though its precise limit is a matter for further investigation. It is abundant in many places along the top of the eastern slope of the coast range from Mittagong south. Thence there is a gap in our localities until the Upper Williams River and Eastern New England is reached. We do not know the connecting links between the southern and northern localities; it doubtless will be found in various spurs of the Great Dividing Range. It extends to South Australia.

Synonyms—

1. *E. gigantea*, Hook. f. (Lond. Journ. Bot. vi. 479 (1847). Fl. Tas. i. 136. t. xxviii.)

   As already pointed out, *E. obliqua*, L'Herit., was not known to Hooker at the time he wrote "Fl. Tas.," nor clearly to Mueller in "Fragm.," i. 44, 45, where the supposed differences between *E. obliqua*, L'Herit., and *E. gigantea*, Hook. f., are discussed. (See also "Fragm." ii. 171, 172.) I am not quite clear as to the

* See p. 370.

date when the identity of L'Heritier's species was placed beyond doubt.

2. *E. elatus,* Hook. f., Herb. Kew. Gunn's specimen 1284 in Herb. Kew. bears the MS. name, in Hooker f.'s handwriting, "*Eucalyptus elatus,* H. f." "Trunk erect, branching at top only, 140 feet high. 3000 ft. alt. Dee tier. Very large trees; many dead."

   The fruits are not ripe, but the plant is *E. obliqua,* L'Her., as so noted in Herb Kew.

   Another of Gunn's specimens ("Kangaroo Bottom, 9/25, 1840") also bears the provisional name "*Eucalyptus elatus,* J. D. H.," in Hook. f.'s handwriting.

3. *E. fissilis,* F.v.M. (See p. 216, Official Record. Intercol. Exhib. Australia (Melb., 1866-7), and other documents).

4. *E. heterophylla,* Miq., is described in Ned. Kruidk. Arch. iv. 141 (1856), briefly, as follows:—"45, *Eucalyptus heterophylla,* Miq., n. sp.: foliis subopposits et oppositis, alternisve, longiuscule petiolatis, elliptico vel ovato-oblongis, sursum attenuatis, basi aequali vel inequali acutis vel obtusis, coriaceis, 4-9½ poll. longis, 1½-3 latis, floribus. . . . . Van Diemen's Land (Stuart, n. 2)."

   Bentham, while pointing out that it was "described from barren leafy branches," says that it "appears to be one of the forms assumed by the saplings, or by the adventitious shoots of *E. obliqua*" (B. Fl. iii. 205).

   Müeller, however ("Eucalyptographia," under *E. globulus*), thinks that it may be *E. globulus.*

   Stuart's No. 2 is not at Kew.

   The matter is not of the first importance, but I am making an endeavour to trace every described species of Eucalyptus.

5. *Eucalyptus procera,* Dehnh.

   "E. foliis late-ovatis longissimis obliquis coriaceis parallele venosis marginatisve subcrenulatis utrinque glanduliferis apice uncinatis, petiolis muricatis coloratis, ramulis teretibus glanduliferis rubicundis. Cortice laevi aestivo tempore in squamas secedente."

   Nov. Holl. (Dehnh. Cat. Pl. Hort. Camald. Ed. 2., p. 20).

I have seen some excellent specimens, in bud, flower and ripe fruit, communicated by Dehnhardt himself to the Vienna Herbarium (Herb. Mus. Cæs. Palat. Vindob.), which show that the species is *Euc. obliqua*, L'Herit. The label states that the tree (Hort. Camaldul.) was raised from "unknown seed," and that the tree (? that from which the original seed was taken) was 70 ft. high. The seed probably came from Tasmania. Bentham says the species is far too imperfectly described to render identification possible. Mueller, "Eucalyptographia," quoting Walpers' (Repert.) wording of the description, refers it to *pauciflora* (*coriacea*), but the specimens set the matter at rest.

Following is copy of a label in Herb. Melb.:—

"*Euc. hœmastoma*, Sm.—Gum-topped Stringybark of Lake Sorell, Tasmania (T. Stephens). Lower part of stem exactly like common stringybark, but, if anything, rather less furrowed, the bark being quite loosely fibrous, and easily rubbed into what bushmen call 'bulls' wool.'"

A second label is—

"*Euc. Sieberiana*, F.v.M.—Gum-topped Stringybark, East Mt. Field. 1000-1500 ft. 1869." (Also a Tasmanian locality.)

Reference to my paper "On the occurrence of *Eucalyptus dives*, Schauer, in Victoria" (*Victorian Naturalist*, xviii., p. 127), shows, I submitted, that these specimens belong to *E. dives*. I have in that paper dealt with the matter so fully that I do not intend to repeat myself on the present occasion. I shall be glad to receive information as to the extent of its distribution in Tasmania.

In New South Wales this form occurs in the highest parts of the southern mountain ranges, and in similar situations in northern Victoria.

There is another "Gum-top Stringybark" that I have doubtfully referred, *infra*, p. 371, to *E. virgata*, Sieb., var. *altior*. I have at that place stated a case in regard to the amount of the relationship between the two "Gum-top Stringybarks."*

* *Note added, May*, 1903. I have given further consideration to this form, and now consider it to be a form of *E. obliqua*, L'Herit. It seems to be the alpine form of that species in all the three States in which it occurs, and therefore I suggest the name of *E. obliqua*, var. *alpina*, for it. Its affinity to *E. dives*, Schauer, is undoubted, and that species frequently occurs in Victoria. I have not yet found indubitable *E. dives* in Tasmania, though it should be looked for.

H.—*Eucalyptus virgata,* Sieb., var. *altior,* Deane and Maiden. (Proc. Linn. Soc. N.S.W. 1901, p. 124; also Syn. *E. oreades,* R. T. Baker, ib. 1900, p. 596.)

This is a "Gum-topped Stringybark" of Tasmania which has been included under several species by different botanists. In "Notes on a Species of Eucalyptus (*E. hæmastoma*) not hitherto recorded in Tasmania," by T. Stephens (Proc. R.S. Tas., 1881, p. 24), he refers to it as "Gum-topped Stringybark," and speaks of it as follows:—

"The chief peculiarity of this tree is that, while the lower part of the butt is clothed with a thick fibrous bark, closely resembling that of the common Stringybark (*E. obliqua*), the upper part, and the smaller limbs and branches, are quite smooth, whence its popular name. The timber is highly prized by splitters, and for general purposes it is described by many competent authorities as second only to the Blue Gum, though opinions seem to differ as to its durability. It is found in most parts of the State, and appears to grow as freely on table-land of the interior, reaching an altitude of not less than 3000 ft. above the sea, as along the coast-line."

It seems to be the same as the following timbers referred to in a Tasmanian Official Catalogue:—

"Gum-topped Stringybark (*Eu. hæhastoma* ?)—

"Stringybark Gum (*Eu. obliqua*)—

No. 30B, T.G.R.—Two planks, 6 feet by 9½ inches by 6 inches, Scottsdale Line.

"Stringybark Gum (*Eu. obliqua*)—

No. 30C, T.G.R.—Two planks, 6 feet 6 inches by 9 inches by 5 inches, Scottsdale Line."

"*Eucalyptus hæmastoma* (Gum-topped Stringybark) is a builder's tree for inside-work or cart-bodies. So far no determination has been made as to its strength and weight, though it is used extensively where it grows. It is not known, however, as a distinct timber in the market."

I believe it is the same as the following timber sent to the Colonial and Indian Exhibition of 1886:—

"'Stringygum.'—This wood bears a strong resemblance in general appearance and texture to the Stringybark last described, but the grain is crossed diagonally with long spots of a lighter shade, which would show a good figure if the wood could be polished. Stringygum, however, is open to the same objections as Stringybark, but in a still more marked degree, for not only does the grain rise after the board is planed, but unless it is absolutely dry, fibres of the wood become detached from the surface, which renders this wood quite unfit for any but rough work." (Allen Ransome, in "Kew. Bulletin," May, 1899.)

I believe it is the same as the following, collected by Mr. Rodway:—

"Sucker-leaves (glaucous when fresh) from base of stem of typical *E. regnans*, 120 feet high, bark fibrous, but not thick, for about 40 ft. Mount Wellington, 1500 ft."

It will be observed that there are two "Gum-topped Stringybarks" in Tasmania, and that I put them under two species, viz::—*E. obliqua*, L'Herit, and *E. virgata*, Sieb., var. *altior*. The question is, to what extent are they related? The matter requires very careful consideration, and as I have not the necessary field knowledge of Eucalypts in Tasmania, I trust that the careful attention of local botanists will b egiven to the matter.*

Even at the cost of some repetition, I venture to state the case, just as a solicitor would for counsel's opinion.

1. See "Notes on a Species of Eucalyptus (*E. hæmastoma*) not hither recorded from Tasmania," by T. Stephens. (Proc. R.S. Tas., 1881, p. 24.)
2. Mr. Stephens' surmise that the species might not be *E. hæmastoma* has been justified. We have specimens collected by Mr. Stephens from Lake Sorell.
3. I am of opinion (as already stated) that it is a variety of *E. obliqua*, L'Hérit.
4. Is this identical with the non-glaucous, non- (or scarcely) aromatic "Gum-topped Stringybark," common at lower elevations in Tasmania? (See 5.)
5. "Gum-topped Stringybark" or "Stringy-gum."—"Tree 150 ft. Lower 20 ft. of fibrous bark, but not thick and coarse; above that bark smooth." (Rodway.)
6. Mr. Rodway's specimens are from the Waterworks and Huon Road. I do not know of other specific localities, but there must be many. I have referred this form to *E. virgata*, Sieb., var. *altior*.
7. Gunn's 1100, collected by J. D. Hooker, Marlborough, Tas., 17th October, 1840, and referred by Hooker (Fl. Tas. i. 137), to *E. radiata*, var. 4,

* Since the above was written I have answered some of these questions in my "Critical Revision of the genus Eucalyptus." Part 2 (*E. obliqua*). I am of opinion that most of the "Gum-top Stringybarks," are forms of *E. obliqua*. As regards the determination of a Tasmanian plant as *E virgata* var. *altior*, I prefer it to be considered doubtful until I get ampler material. (Note added, May 1903.)

seems to me a "Gum-topped Stringybark," and should be enquired into by local botanists.

J.—*E. Sieberiana*, F.v.M.

"Ironbark," of Tasmania. The common "Mountain Ash" of New South Wales.

I give the following Tasmanian localities for this species, so far as I have examined authentic specimens.

"Ironbark," George's Bay, Aug. 1878, Augustus Simson, (comm. W. W. Spicer). With shiny fruits. First labelled *E. virgata*, Sieb., and then *E. Sieberiana*, F.v.M., by Mueller.

These specimens are undoubtedly identical with the Mountain Ash (*E. Sieberiana*), which is so abundant in the mountain ranges of New South Wales. The species was long confused with *E. virgata*, Sieb., really a shrubby species (as its specific name denotes), from the vicinity of Port Jackson.

"Ironbark" (Tasmania). This timber grows principally on the north-east coast of Tasmania, and is equal in quality to the Ironbark* found on the Australian Continent, and does not grow so tall or so large as the gum, but has a small heart, and is very durable in or out of the ground. It makes splendid piles or medium-sized timber. The principal place for shipment would be from George's Bay, this being the most central place for it." (John Bradley.)

The timber is called "Ironbark, *Eu. Sieberiana*," in the following Tasmanian exhibits:—

No. 41, T.G.R.—Three sleepers, cut 1894.
No. 42, T.G.R.—Two pieces, planed, 8½ inches by 4½ inches.
No. 43, T.G.R.—Bark.
No. 44, T.G.R.—Leaves, flower, and fruit.
No. 45, T.G.R.—Three sleepers, cut 1894.

I may mention that the same species is sometimes, though erroneously, known as "White Ironbark" in New South Wales, *e.g.*, near Braidwood.

K.—*E. globulus*, Labill. (Voy. i. 153. t. 13. Nov. Holl. Pl. ii. 123.)

I suppose this Eucalypt has been oftener figured, and has a more extensive literature, than any other. I have there-

* This is undoubtedly exaggerated.

fore no intention of offering general remarks concerning it.

Synonyms—

1. *E. cordata*, Miq. non. Labill., in Ned. Kruidk. Arch. iv. 141 (1856).
2. *E. diversifolia*, Miq. non. Bonpl., ib. 141.
3. *E. glauca*, DC. Prod. iii. 221. Mueller refers these three plants to *E. globulus*, Labill.
4. *E. perfoliata*, Desf. Cat. Hort. Par. Ed. iii. 408. This by Bentham (B. Fl. iii. 200) is doubtfully referred to *E. globulus*.
5. *E. pulverulenta*, Link. Enum. Hort. Berol. ii. 31.
6. *E. pulverulenta*, Hort. Monacensis. The specimen in question was referred to me from Munich, and bears the label as above, also "*Eucalyptus glauca*, Dec. (?), and *E. pulverulenta*, Link (?) non Sims." It consists of seedling foliage, and was grown in the garden in 1849.
7. *E. gigantea*, Dehnh. "E. operculo subconico medio constricto obtuso calycem subaequante, fruct. 4-gono turbinato magno tuberculatoque pulverulento, pedunculis brevissimis ancipitibus, floribus solitariis axillaribus maximis, foliis alternis ovato-lanceolatis longissimis coriaceis obliquis falcatis marginatisve parallele venosis apice rostratis, petiolis contortis basi ampliatis, ramulis angulatis patentibus rubicundo-virentibus.

   Laevem corticem exuit Septembri Nov. Holl. Flor. Oct. Nov.

   Obs. Planta est in juventute omnino pulverulenta, et tam caulis quam ramuli sunt quadrangulares. Folia sunt ovata et oblonga in basi cordata opposita et sessilia. Qui caracteres 5-6 annos permanent. Totius arboris et praesertim foliorum odor paene similis terebinthino." Dehnhardt (*Cat. Pl. Hort. Camald.* Ed. 2, p. 20).

In my paper "On *Eucalyptus pulverulenta*, Sims" (Proc. Linn. Soc., N.S.W., 1901), I have a note in regard to the confusion of *E. pulverulenta* with *E. globulus*. Typical *E. globulus* is confined to limited areas in New South Wales, its principal localities being:—The Snowy Mountains, Germanton to Tumberumba, Adelong, and other southern localities; Nulla Mountain, Rylstone, and Parish of Derale, County of Phillip, near Mudgee, both western localities; and Stony Creek, County of Vernon, New England, a northern locality. Most of our New South Wales trees have fruits smaller than the Tasmanian ones.

L.—*E. Maideni*, F.v.M.

I have been favoured with an excellent series of specimens from Mr. Rodway, and they match *E. Maideni*, F.v.M., from a type locality (Colombo, Lyttleton, N.S.W.) exactly. Whether *E. Maideni* is an extreme form of *E. globulus* or not is worthy of further examination, and Mr. Rodway's specimens and observations (*infra*) are worthy of note in connection with any experiments to reproduce certain species from cultivation of existing forms.

My present view is that *E. Maideni* is as near midway as can be between *E. globulus* and *E. goniocalyx*, and therefore I am unable to reduce it to a form of either.

If my determination is correct, and I have no doubt about it in my own mind, then another species is added to the flora of Tasmania.

Mr. Rodway is, however, of opinion, that his specimens belong to *E. viminalis*, and he proposes to call the variety *macrocarpa*, and the remarks of such an experienced observer require the most careful attention. I am of opinion that the sucker-leaves are of *E. Maideni*, rather than of *E. viminalis*. The locality is Domain, Hobart, and Mount Nelson Range, and the plant is worthy of further enquiry.

"Habit and leaves as in typical *viminalis* to rather more erect, and leaves slightly larger. Mature bud 1:5 cm. long by 8 mm. Operculum sub-hemispheric to conical, smooth. Fruit of the type only 1·2 cm. diameter, often obscurely 2-ribbed.

"This form I have only found in plantations of *E. viminalis* growing with *E. globulus*. I take it to be a hybrid. Of six seedlings grown from seeds of the same tree, four were closely approximating *E. viminalis*, one *E. globulus*, and the sixth intermediate."

M.—*E. cordata*, Labill.

Up till quite recently this species was believed to be endemic to Tasmania, but Deane and Maiden (Proc. Linn. Soc. N.S.W., 1901) have shown that it also occurs in New South Wales. It is, in fact, the *E. pulvigera* of A. Cunn.'s Journal, referred to *E. pulverulenta*, Sims, in B. Fl. iii.,

224. In my paper on *E. pulverulenta*, Sims (Proc. Linn. Soc. N.S.W., 1901, 551). I have shown the differences between *E. cordata* and *E. pulverulenta*, which are frequently not obvious when herbarium material is alone relied upon. The former is a gum and the latter a stringybark.

I have examined the following Tasmanian specimens:—

1. Specimens collected by Labillardière (Herb. Webbianum), in Herb. Kew., in Herb. Cant. ex Herb. Lindl., and in Herb. Barbey-Boissier, not only do not show the margins of the leaves so crenulate as Labillardière's figure (by Rédouté), but even less crenulate than Mueller's figure in the "Eucalyptographia."

   Some of the leaves are even lanceolate, showing transit to *E. pulverulenta.*

2. R. Gunn's 1071, from Huon River, 1842, quoted by Hook. f., (Fl. Tas.).

   Neither the crenulation of the leaf-margins nor the rim of the fruit is as well marked, in many cases, as shown in Mueller plate in the "Eucalyptographia."

There is a note on the distribution of *E. cordata*, Labill., in Tasmania, in Papers and Proc. R. S. Tas., 1888, p. xxxiii., and at the same place a note on the resemblance of this species to *E. Risdoni.* While alluding to this I may mention that there is in Herb. Oxon. a specimen of *E. Risdoni* labelled by Fraser "*Eucalyptus cordata.*"

Specimens gathered by Mr. R. H. Cambage and myself on Mount Wellington have the fruits in threes, though they are sometimes so crowded as to appear like fives or sixes.

N.—*E. urnigera*, Hook. f. (Lond. Journ. Bot. vi. 477, 1847).

"The typical form is well described in Hooker's Fl. Tas. Bark is smooth, green, clothed with chocolate red." (Rodway, *in litt.*)

I have examined Gunn's No. 1074, from Mount Wellington, also Lake Crescent (T. Stephens.)

In Herb. Brit. Mus., Kew., Edinburgh, and other European herbaria, specimens of this species bear Robert Brown's label "*E. constricta*, R. Br., Table Mountain, V.D.L.," a species which, however, was never published.

Following is a form of this species, for which Mr. Rodway proposes the variety name "*elongata*."

"Leaves long, narrow, 4-8 in. $\frac{1}{2}$ — $\frac{3}{4}$in. Operculum umbonate-conical, nearly as long as the calyx. Calyx slightly constricted below the rim. Fruit broadly ovate, very slightly constricted at, but not below the rim, 1 cm. long, 7-8 mm. broad, capsule slightly sunk. Bark smooth, white.

"This approaches very closely small fruited forms of *E. longifolia*, Link., except that the lateral veins are not so conspicuous, nor so regularly parallel." (Mr. Rodway in letter to me.)

I quite agree that this is a form of *urnigera*, and it is worthy of further investigation. From the specimens I have seen, however, I imagine that it shows transit to *E. goniocalyx*, F.v.M., rather than *E. longifolia*, Link. Examination of the timber would at once settle the affinity as regards these two species, assuming that it has affinity to either.

O.—*E. vernicosa*, Hook. f. (Lond. Journ. Bot. vi. 478, 1847).

There is a note on this species by Rodway, in Proc. R.S. Tas., 1898-9, p. 104.

I have examined specimens from Mount La Perouse, in Herb. Barbey-Boissier, collected by Oldfield, also from Mount Sorell, Macquarie Harbour, in Herb. Cant., collected by Milligan (No. 716).

E. Muelleri, T. B. Moore, Trans. R.S. Tas., 1886. The valves often do not protrude.

We have a note by Rodway (ib. 1898-9, p. 104), who states that at Mount Geikie (west coast), while very similar in appearance to *E. vernicosa*, it still maintains its distinctness in its crenulated leaves, with less oblique venation and flattened operculum. Mueller, by excluding it from the 2nd edition of his "Census," was not satisfied as to its specific difference from *E. vernicosa*, and the specimens seen by me cause me to recommend that it be further investigated. I recommend that its specific rank be not recognised until that is done:

P.—*E. Gunnii*, Hook. f.

This is a species originally described from Tasmania. I have written a paper "On *Eucalyptus Gunnii*, Hook. f.," which is being published by the Linnean Society of New

South Wales. It contains much that is based on Tasmanian specimens, and I beg to invite the attention of my readers to it.

I propose to give a few brief notes in regard to what I may term the Tasmanian portion of the paper. Some critical observations in regard to type specimens are given, and some Tasmanian and New South Wales localities are enumerated.

E. Gunnii, F.v.M., var. *glauca*, D. and M., is suppressed and shown to be typical, or nearly so.

E. Perriniana, Herb. Perrin., non F.v.M. (these Proceedings, xxvi. 135), is placed under *E. Gunnii*.

A variety *acervula*, D. and M., is established, and the following is given:—

E. Patersoni, R. Br. Herb.
E. persicifolia, Lodd. (Bot. Cab. t. 501).
E. persicifolia, Miq. (Ned. Kruidk. Arch. iv. 137).
E. Baueriana, Miq. non Schauer (ib. iv. 137).
E. citrifolia, F.v.M., Herb. (ib. iv. 137).
E. ligustrina, Miq. non. D.C. (ib. iv. 134).
E. acervula, Miq. (ib. iv. 137).
E. acervula, Hook. f., non. Sieb. (Fl. Tas. i. 135).
E. Stuartiana, F.v.M. (Miq. in Ned. Kruidk. Arch. iv. 131).
E. Gunnii, F.v.M. (Fragm. ii. 62).
E. viminalis, Benth. (B. Fl. iii. 240) non. Labill., *partim*.
E. paludosa, R. T. Baker (Proc. Linn. Soc. N.S.W. xxiii. 167; xxvi. 136).
E. undulata, Oldfield, is written, in Oldfield's handwriting, on a Tasmanian specimen collected by himself. Herb. Vienna. I do not know if the species was described.
E. Patersoni, was collected by Col. Paterson, at Port Dalrymple (Launceston).
E. persicifolia, Lodd., may have been raised from Tasmanian seed.
E. persicifolia, Miq., was based on Stuart's No. 12 (Tasmania), and was thought by Miquel to be identical with Loddiges' plant.
E. Baueriana, Miq., non. Schauer, and *E. citrifolia*, F.v.M., were based on the same specimen of Stuart (Tasmania borealis).
E. ligustrina, Miq., was based on one of Stuart's Tasmanian specimens.

A full account is given of *E. acervula*, Miq., non. Sieb., also of *E. acervula*, Hook. f., non. Sieb. (Fl. Tas. i. 135), as *E. acervula*, Sieb., and critical observations are given in regard to a number of type specimens.

The position of *E. Stuartiana*, F.v.M., is discussed, and also of the *E. Gunnii*, F.v.M.

Then we come to var. *ovata*, D. and M., which is full of interest to Tasmanian botanists. Syn. *E. ovata*, Labill., (Nov. Holl. Pl. ii. 13. t. 153).

E. androsmœfolia, Hoffmg. (Verz. Pfl. Nachtr. ii. 113).
E. mucronata, Link. (Enum. Hort. Berol. ii. 30).
E. camphora, R. T. Baker (Proc. Linn. Soc. N.S.W. xxiv. 298).

It is not possible to usefully abstract this paper, as far as variety *ovata* is concerned, any more than as regards variety *acervula*. The paper contains much research, some of it the result of my recent visits to the principal European herbaria, and examination of material since entrusted to my care.

Mr. Deane and I established two other varieties viz.:—Var. *rubida* (*E. rubida*, D. and M., &c.), and var. *maculosa* (*E. maculosa*, R. T. B.).

These varieties are of less interest to Tasmanian botanists, but is is quite possible that both forms may be found to exist in Tasmania, and therefore, I would suggest that my original paper be consulted.

I have attached a list of species and synonyms referred to in this paper, which will, I think be of practical utility.

Q.—*E. Viminalis*, Labill.

This like *E. Gunnii*, is a species which was first described from Tasmanian specimens, and afterwards found to be extensively distributed on the mainland.

Mr. Deane and I have critically examined the species in Proc. Linn. Soc. N.S.W. [2] 1901, to which paper I beg to refer my readers.

Following are some classical specimens I have examined—

1. Robert Brown, Tasmania, 1802-5. No. 4740. River Derwent.
   Ditto, No. 42.
2. No. 685, R. Gunn. Collected at Hobart, 29/2/'40. The truncate appearance of unripe fruits, referred to under *Gunnii*, is also observable in *E. viminalis* around Hobart. In various herbaria, incl. Herb. Syd.

The leaves vary a good deal in width in Tasmania itself. Operculum sometimes *very pointed*, precisely similar to Victorian specimens from—

3. 1085, R. Gunn, Hobart. In flower and early fruit.
4. 1090, R. Gunn, Circular Head, V.D.L. In plump bud, flower or early fruit. In various herbaria including herb. Syd. Flowering profusely.
5. 1092, R. Gunn, Grass-tree Hill, V.D.L., Herb. Cant. ex herb. Lindl. In bud only.

   A number of Gunn's specimens (and probably Hook. f's., as well) were distributed from the Hookerian herbarium under the name *E. viminea*, Lab. A slip of the pen for *E. viminalis*.
6. A specimen ex herb. Paris in herb. Barbey-Boissier, bearing the No. 127, collected in 1844, (probably by Verreaux, has the rather narrow leaves, and is similar in every other respect to Labillardière's figure of the type. This species is somewhat variable in the width of the leaves.

I have also examined No. 286, Oldfield, Hills, Frogmore, near Richmond, Tas. Herb. Barbey-Boissier, and Cant.

While the flowers of *E. viminalis* are normally in threes, it is a mistake to suppose that it may not have a larger number. The subject is dealt with at length by Mr. Deane and myself, Proc. Linn. Soc. N.S.W. 1901, p. 138.

Specimens from Mount Ardell, T. Stephens, are mostly in 3's, but also in 4's.

Those from Swanport, Dr. Story, have very pointed buds.

I have received some interesting specimens from Mr. Rodway, from near Hobart. The tree, tall, erect, smooth barked. In absence of sucker-leaves, one would at once pronounce the plant to be *E. viminalis*. But Mr. Rodway's sucker-leaves are broadish, blunt and cordate at the base. They are glabrous. These sucker-leaves are the broadest I have ever seen on *E. viminalis*.

If they are *viminalis*, as I think they must be, then it amounts to this, that it is possible for *E. viminalis* to have broadish suckers.

An easier way would be to look upon these specimens as *E. Gunnii*, and it is possible that they may be referable to that species. It is not desirable, perhaps, to draw further conclusions in regard to these specimens. We know that the sucker-leaves of *E. viminalis* have a tendency to become broader in some localities, and, bearing that in mind, we require to more fully investigate broad suckered forms in Tasmania and elsewhere.

Mr. Rodway points out that "The sucker-leaves of his specimen closely approach those of *E. urnigera* and *E. Muelleri*, Moore."

The fruits are more hemispherical than usual. They precisely match those from Frederica Falls, Lawson, N.S.W., collected by Baker. Miquel, (Ned. Kruidk. Arch. iv. 125) quotes *E. saccharifera*, F.v.M., mss. and *E. crucivalvis*, F.v.M., as synonyms of *E. viminalis*, Labill., and one of his specimens was from Tasmania. (Stuart, No. 7).

SPECIES AND SYNONYMS REFERRED TO.

THE PROPOSED BIOLOGICAL STATION AND MARINE FISH HATCHERY NEAR DUNEDIN, NEW ZEALAND.

By Geo. M. Thomson, F.L.S.

In the paper on the above subject, read before the meeting of the Association in Melbourne, in January, 1900, I narrated the steps which had been taken to bring about the construction of the proposed station, and again expressed the hope that it would soon be an accomplished fact. This hope has not been realised, not on account of any lack of effort on the part of those interested, but solely from the difficulty of moving the Government to take definite action. There has been no opposition, but the pressure which the promoters have hitherto been able to bring to bear has not proved sufficient to overcome the *vis inertia* encountered. The Government are, however, in favour of carrying out the scheme, and it rests with those interested to put forth greater effort to secure this result.

During the early part of 1900, as the outcome of a closer examination of the proposed site at Purakanui by Professor Benham and Mr. Ayson, Inspector of Fisheries, it was considered that the risks of contamination of the tanks and ponds by fresh water were too great, and it was resolved to look out for a more suitable locality. Such a spot was found on Quarry Point, Portobello, immediately opposite Quarantine Island, in the lower harbour, and nearly opposite Port Chalmers. Careful examinations and surveys of the ground were made, analyses of the water were secured, with satisfactory results, and negotiations for obtaining the requisite land have been carried out. It only remains now to sign the lease. Meanwhile, a plan of the required buildings and tanks was submitted to the Marine Department, and Mr. Ussher, head of the Public Works Department in Dunedin, was instructed to report on it. This he has done recently, but his estimate of cost, amounting to some £3000, is so far in excess of the sum available that the scheme has temporarily come to a stop. The members of the local committee which has hitherto pushed the matter forward are of opinion that the estimate is an excessive one, and that the work of construction could be accomplished at a much lower cost. They also consider that the Government might utilise prison labour for the necessary cutting down and filling in of the ground which is required.

The reason of the great increase in cost of the Portobello site, as compared with that at Purakanui, is that at the latter place no cutting down nor filling in would be required, and there is a dwelling-house which would be available for a caretaker, and which could probably be secured at a small cost. But, for convenience of access, for suitability of water transport of fish, ova, &c., for abundance of good water, and adequate shelter in all weathers, the new site is an ideal one, and, once established, it would probably justify its existence in a very short time.

In closing this brief narration of the steps taken by our local committee, I have to recommend that the General Council of this Association be asked to communicate with the Government of this Colony, through the General Secretary, and to urge respectfully that the construction of the station should be proceeded with as a matter of colonial importance.

NOTE ON A NEGLECTED TASMANIAN EARTHWORM.

By Professor BENHAM, D.Sc.

IN a work published in 1861, entitled "Neue Wirbellöse Thiere," Schmarda gives pictures and brief diagrams of a great number of worms belonging to various classes, and collected in various parts of the world. Amongst these is an earthworm which he called *Hypogœon orthostichon*, whose habitat he gives as "New Zealand, Mt. Wellington."

This worm—all too imperfectly described by Schmarda—was re-examined by Mr. Beddard in 1892 (Ann. Mag. Nat. Hist.), who was permitted to open one of the specimens collected by Schmarda, then preserved in the Vienna Museum.

As a result of his investigations, he was able to show that this worm does not belong to the genus *Hypogœon* at all, but is a member of a genus which till recently was termed *Megascolides*; and in Beddard's monograph (1895) it appears as *Megascolides orthostichon*, (Schmarda).

Still more recently Michaelsen (in 1900) has limited the genus *Megascolides* to worms of the type of *M. australis*, and retains Fletcher's genus *Notoscolex* for the majority of the species attributed by Spencer and Beddard to *Megascolides*.

Schmarda's worm, then, is *Notoscolex orthostichon*.

Now, *Notoscolex* and *Megascolides* are characteristically Australian worms, and in recent collections no species has been found in New Zealand; so that Beddard and Michaelsen, while attributing *N. orthostichon* to New Zealand, have noted this exceptional distribution. But this apparent exception is due to a geographical error committed by Schmarda, who no doubt collected the worm, as he says he did, on "Mount Wellington," but attributed that mountain to New Zealand, confusing it with Wellington, the town.

Captain Hutton, as long ago as 1879, in a footnote to his "Catalogue of New Zealand Worms" (Trans. N.Z. Instit. xi., p. 317), pointed out that Mount Wellington was in Tasmania, and that this worm should be included in the fauna of that island, and not in that of New Zealand; yet, this rectification has been entirely overlooked; and Spencer, when dealing with the Tasmanian earthworms, did not seem to be aware of the fact; while Michaelsen, in the most recent memoir on the class, still gives "New Zealand" as the habitat of this species. Now, in New Zealand the sub-family to which *Notoscolex* belongs is unrepresented, except for two species of *Diporochœta*, and it is extremely improbable that the only earthworm collected by Schmarda in New Zealand should have belonged to this sub-family.

DESCRIPTIONS OF SOME NEW SPECIES OF AUSTRALIAN AND TASMANIAN CHRYSOMELIDÆ.

By Arthur M. Lea.

The Australian and Tasmanian *Chrysomelidæ* have (in comparison with other families of Coleoptera) been well worked out; but that I am able to describe as new 74 species of the sub-families *Chrysomelides* and *Cryptocephalides* alone, will serve to show how little is known of these beautiful and often very destructive insects. For permission to describe the new *Chrysomelides* of the Macleay Museum collection I am indebted to Mr. George Masters, the Curator of that Institution.

Chalcolampra consimilis, n.sp.

Elliptic-ovate. Bronzy-black; antennæ and legs black or piceous-black.

Head with sparse punctures, becoming denser behind, and in front of eyes; clypeus finely punctate, its suture distinct, each side bounded by an angular impression; antennæ stout, third joint not much longer than fourth. *Prothorax* with minute punctures, with larger punctures scattered about, and moderately dense on each side at base, but very sparse on basal portion of disc. *Elytra* with series of not very large punctures, becoming small towards apex; interstices almost impunctate, and almost invisibly wrinkled in places. *Under-surface* almost impunctate along middle, but with moderately large punctures on sides and on antepectus. Basal joint of *tarsi* but little wider than third. Length $6\frac{2}{3}$, width $3\frac{1}{3}$; variation in length, 6-8mm.

Hab.—W.A.: Bridgetown, Swan River, Pinjarrah.

Close to *repens*, but the groove dividing the clypeus from the face more distinct, and not sexually variable; the elytral punctures are considerably larger, and the colour is constant.

Chalcolampra adelioides, n.sp.

Almost parallel-sided. Colour as in the preceding species.

Head, *prothorax*, and *elytra*, as in the preceding species, except that the punctures of the elytra are larger, and the outline is much more parallel. *Under-surface* with small but distinct punctures, each of which bears a small hair; antepectus with a few large punctures. Basal joint of *tarsi* no wider than third. Length $7\frac{1}{4}$, width $3\frac{1}{2}$mm.

Hab.—N.S.W.: Tamworth.

Allied to the preceding species, but almost parallel-sided, and less convex; from *Hursti* it is distinguished by the antennæ being darker, with the third joint but little longer than the fourth; apparently, also, it is close to *acervata*, but the prothorax is not coarsely punctate in the middle. It has a strong general resemblance to a number of species of *Adelium* (*e.g.*, *regulare*, *neophyta*, and *inconspicuum*).

Chalcolampra arthritica, n.sp.

Elliptic-ovate. Bronzy-black; head and prothorax sometimes with a greenish gloss; antennæ, legs, and apical segment of abdomen of a rather obscure red.

Head densely and irregularly punctate; clypeus indistinctly separated from the face, but with a small fovea on each side. Antennæ with the third joint almost twice the length of the fourth. *Prothorax* with moderately dense minute punctures, and with large punctures not very irregularly distributed, but becoming considerably larger at sides, especially about base. *Elytra* with series of comparatively large punctures, becoming larger at sides, and not much smaller towards apex; the interstices with rather dense minute punctures. Intercoxal process of *prosternum* carinate on each side; an oblique carina from each coxa to apex. *Abdomen* rather densely and very distinctly punctate. Basal joint of *tarsi* large. Length 5, width $2\frac{3}{4}$ mm.; variation in length, $4\frac{1}{2}$-$5\frac{1}{2}$mm.

Hab.—W.A.: Darling Ranges, Karridale, Bridgetown (Lea), King George's Sound (Macleay Museum).

Close to *simillima*, but the prothorax almost regularly punctate, and the interstices not impunctate, but with fine and moderately dense punctures.

Chalcolampra impar, n.sp.

Parallel-sided. Bronzy-black; legs and antennæ red; under-surface obscure reddish-brown.

Head moderately densely, but irregularly punctate; clypeus depressed, indistinctly separated from the face, but each side with a shallow fovea. Antennæ with the third joint about once and one-half the length of fourth; terminal joint elongate. *Prothorax* with dense small punctures, the sides with scattered larger punctures, becoming larger towards base. *Elytral punctures* and *prosternum* as in the preceding species. *Abdominal segments* with moderately dense punctures at base, but sparse elsewhere. Basal joint of *tarsi* large. Length 5, width $2\frac{1}{2}$mm.

Hab.—W.A.: Geraldton, Darling Ranges.

Close to the preceding species, but the form more elongate and parallel-sided; the prothorax entirely without larger punctures on the disc, and the abdomen less densely and more irregularly punctate.

Chalcolampra soror, n.sp.

Oblong elliptic. Bronzy-black; legs and antennæ red.

Head with irregular and rather indistinct punctures, a shallow fovea marking each side of the clypeal suture. Antennæ with the third joint about once and one-half the length of the second. *Prothorax* with rather dense small punctures; the sides with sparsely-distributed and larger punctures. *Elytra* with series of punctures, becoming smaller (but still distinct) to apex; the interstices not visibly punctate. *Antepectus* indistinctly punctate. *Abdomen* irregularly and not densely punctate; sides feebly wrinkled. Basal joint of *tarsi* moderately inflated. Length $4\frac{1}{2}$, width $2\frac{1}{3}$mm.

Hab.—W.A.: Darling Ranges, Donnybrook.

In shape and general appearance close to *arthritica*, but at once distinguished by the absence of punctures on the elytral interstices.

Chalcolampra atropha, n.sp.

Parallel-sided. Bronzy; legs and antennæ red.

Head with four or five distinct punctures on each side; clypeus indistinctly separated from the face, with punctures as on head, but more numerous, each side marked by a shallow fovea. Antennæ with the third joint considerably longer than the fourth. *Prothorax* without minute punctures, but with moderately numerous distinct punctures irregularly distributed, but denser at sides, and almost absent on basal part of disc. *Elytra* with series of comparatively distant punctures, becoming closer together and considerably smaller towards apex; interstices impunctate.

Antepectus rather densely punctate; intercoxal process scarcely ridged. *Abdomen* with very sparse, scattered, minute punctures. Basal joint of *tarsi* moderately inflated, as long as the two following combined. Length $4\frac{1}{2}$, width $2\frac{1}{2}$mm.

Hab.—Australia.

The specimen described is from the late Mr. A. Sidney Olliff's collection (without locality), and bears a label—"*Chalcolampra parallela*, Germ." It is, however, not that species, from which it differs in being consideraby narrower, more convex, more decidedly bronzy, and head less densely punctate, but in particular by the punctures of the under-surface.

CHALCOLAMPRA OBLONGA, n.sp.

Oblong, comparatively wide. Bronzy-black; legs and antennæ red; under-surface obscure reddish-brown.

Head with medium-sized irregular punctures; clypeal suture distinct; each side with a shallow impression. Antennæ with the third joint considerably longer than fourth. *Prothorax* with small dense punctures, and with larger (but not very large) punctures, becoming crowded at the sides, but sparse in the middle. *Elytra* with series of almost approximate punctures, distinct to, and but little smaller at, apex; interstices with dense small punctures. *Antepectus* densely punctate. *Metasternum* and abdomen with small but moderately dense punctures. Basal joint of *tarsi* much less inflated than usual. Length $4\frac{1}{2}$, width 3mm.

Hab.—N.S.W.: Forest Reefs, Queanbeyan, Braidwood.

A short oblong species, having the metasternum as densely punctate as the abdomen; the punctures at the sides of the prothorax, and on the elytral interstices, are more crowded than usual. I have but one specimen from each locality named.

CHALCOLAMPRA XANTHORRHŒÆ, n.sp.

Oblong-ovate. Head and prothorax dark metallic blackish green, and subopaque; elytra bronzy; legs and antennæ red.

Head and *prothorax* very densely punctate, the punctures ranging in size from almost microscopic to moderately large, and denser on prothorax than on head; clypeal suture not very distinct, each side with a shallow impression. Antennæ with the third joint almost twice the length of the fourth.

Elytra with series of punctures, which are not much smaller on apical than on basal portion; interstices with small and moderately dense punctures. *Antepectus* slightly rugulose. *Metasternum* and abdomen with small and rather sparse punctures, the sides slightly rugulose. Basal joint of *tarsi* moderately inflated. Length 5½, width 3mm.

Hab.—W.A.: Pinjarrah (on *Xanthorrhœa*).

A very distinct species, owing to the punctures on the head and prothorax; these are so dense on the latter that, under a Coddington lens, absolutely no space can be picked out that is not densely punctate; the surface, in consequence, is rendered subopaque.

Chalcolampra podagrosa, n.sp.

Ovate. Bronzy-black; head and prothorax with a greenish gloss; legs and antennæ brownish-red; apical joints of the latter reddish-brown.

Head indistinctly punctate; each side of clypeal suture (which is very indistinct) with a shallow impression. Antennæ with the third joint considerably longer than the fourth. *Prothorax* with minute and comparatively sparse punctures, and with larger (but still small) ones scattered about on the sides, and becoming larger at the extreme base. *Elytra* with series of comparatively large punctures, becoming small towards apex; interstices with very sparse minute punctures. *Prosternum* with scattered punctures; the sides rugulose. Metasternum and abdomen with minute scattered punctures. Basal joint of all the *tarsi* considerably wider than third, and as long as second and third combined. Length 6½, width 3¼mm.

Hab.—Mount Kosciusko (Mr. W. E. Raymond).

The basal joint of the *tarsi* is much more strongly inflated than in any other species with which I am acquainted.

Chalcolampra gyrata, n.sp.

Oblong-ovate, rather wide, and strongly convex. Bronzy-black; the elytra bronzy; antennæ pale red; legs reddish-brown—the tarsi paler.

Head with three or four punctures of moderate size, but otherwise indistinctly punctate; clypeus moderately densely punctate, its suture moderately distinct, and subfoveate at the sides. Antennæ with the basal joint much stouter than usual, the third joint fully twice as long as fourth. *Prothorax* with small and rather sparse punctures, and with larger punctures moderately densely distributed (except on basal portion of disc), and becoming larger at sides. *Elytra* with series of punctures, becoming smaller and rather closer together posteriorly; interstices (except posteriorly) scarcely visibly punctate. *Pro-* and *metasternum* almost impunctate; epipleuræ of the latter with distinct irregular punctures. Abdomen with minute scattered punctures. Basal joint of *tarsi* scarcely inflated. Length 5, width 3mm.

Hab.—N.S.W.: Galston.

A distinct species, having a more rounded outline than usual.

CHALCOLAMPRA PUNCTIFRONS, n.sp.

Oblong-ovate, strongly convex. Head obscure blackish-brown; prothorax black with a greenish gloss; elytra bronzy; basal joints of antennæ (the apical infuscate) and legs obscure testaceous—under-surface somewhat darker.

Head minutely punctate in front, with coarse punctures; vertex deeply longitudinally impressed; clypeus densely punctate, its suture indistinct in middle, subfoveate at sides, an oblique line continued hindward to each eye. Antennæ with the second, third, and fourth joints equal in length, or almost so. *Prothorax* with minute punctures, the sides with large and almost regular punctures, disc with only the small punctures at base, but with a few of moderate size apically. *Elytra* with a series of comparatively large and subapproximate punctures, but little smaller near apex than base; the interstices impunctate, and just perceptibly separately convex. *Abdomen* not minutely punctate, but the punctures rather sparse. Basal joint of *tarsi* moderately inflated. Length 4½, width 3mm.

Hab.—N.S.W.: Forest Reefs.

A strongly convex and well-marked species, rendered very distinct by the sculpture of the head and comparative length of the second joint of the antennæ.

CHALCOLAMPRA SIMILLIMA, Baly.

This species (which I have from Geraldton, Mount Barker, and Beverley) is narrower and more convex than *parallela*, and with punctures in the elytral series rather larger. I believe it to be distinct from *parallela*, although, for purposes of tabulation, I have not been able to specify any distinguishing features.

CHALCOLAMPRA REPENS, Germ.

I have little doubt but that I know this species (some of my specimens agree exactly with both Germar's and Baly's descriptions). It has been recorded from Adelaide and Melbourne by Baly; my own specimens are from New South Wales (Windsor, Hillgrove, Forest Reefs, Tamworth, Queanbeyan, Bindogundra, and Cootamundra), and vary in length from 6 to 8½mm. Many of them are brassy; others are brassy, brown, purplish-brown, bluish, bluish-purple, or brassy-green; in some, the elytra have a purplish gloss which is absent or scarcely traceable on the prothorax. In a large specimen the elytra are distinctly (but finely) wrinkled, especially on the apical third; in a few others feeble wrinkles (starting from the punctures) can be traced, but the majority are without them. The clypeus in one sex (†female?) is separated from the face by a distinct groove, but in the other sex the groove is scarcely traceable; in both, however, there is a very distinct angular impression on each side.

CHALCOLAMPRA THORACICA, Baly.

I have numerous specimens from Tasmania, which agree exactly with Mr. Baly's description and figure of this species. The species, however, is variable in size (7-10mm.), in comparative width, and, to a certain extent, in markings. The paler border of the prothorax* is sometimes very obscure, with its spot sometimes isolated (as in the type), but often joined to the base, or base and middle.

C. RUFIPES, Jacoby.

Hab.—Clarence River.

C. PARALLELA, Germ.

Hab.—N.S.W.: Whitton.

C. HURSTI, Blackb.

Hab.—N.S.W.: Braidwood, Queanbeyan.

C. 18-GUTTATA, Fabr.

Hab.—Moreton Bay, Brisbane.

* Much more distinct in living than in dead specimens.

Margins of prothorax not concolourous with disc ... *thoracica*, Baly.

Prothorax uniform in colour.
- Head red ... ... *rufipes*, Jacoby.
- Head dark.
  - Antennæ with the 2nd joint fully as long as 3rd. ... ... *punctifrons*, n.sp.
  - Antennæ with the 2nd joint much shorter than 3rd.*
    - Antennæ black, legs black or blackish.
      - Body almost parallel-sided ... ... *adelioides*, n.sp.
      - Body more or less elliptic-ovate.
        - Clypeal suture sexually variable ... *repens*, Germ.
        - Clypeal suture constant ... ... *consimilis*, n.sp.
    - Antennæ red, legs red or reddish.
      - Prothorax subopaque and extremely densely punctate ... ... *xanthorrhoeæ*, n.sp.
      - Prothorax polished and less densely punctate.
        - Body comparatively short.
          - Basal joint of all the tarsi greatly inflated ... ... *podagrosa*, n.sp.
          - Basal joint not much inflated.
            - Elytral interstices densely and very distinctly punctate ... ... *oblonga*, n.sp.
            - Elytral interstices scarcely visibly punctate ... ... *gyrata*, n.sp.
        - Body more or less elongate, often almost parallel-sided.
          - Elytral interstices densely and distinctly punctate.
            - Body almost perfectly parallel-sided ... ... *impar*, n.sp.
            - Body elliptic-ovate ... ... *arthritica*, n.sp.
          - Elytral interstices not at all or scarcely visibly punctate.
            - Head with an impressed median line visible from the sides ... *Hursti*, Blackb.
            - Head without median line.
              - Head (except clypeus) sparsely punctate ... ... *atropha*, n.sp.
              - Head densely punctate.
                - Prothorax with moderately large and with dense minute punctures ... ... *soror*, n.sp.
                - Prothorax with moderately large punctures only ... { *parallela*, Germ. / *simillima*, Baly.

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* I would have liked to have made use of the lengths of the 3rd and 4th joints, but though these are different in many of the following species, the 3rd joint is invariably longer than the 4th; sometimes it is almost twice as long; in others, just perceptibly longer.

ACACICOLA, n.g.

Antennæ subfiliform, half the length of the body. *Palpi* clavate, apical joint wide and truncate. Basal joint of all the *tarsi* inflated, the second joint very small; claws dentate. *Body* shortly ovate, moderately convex.

Abundantly distinct from any previously described genus. The shape is not unlike *Platyparopsis* (and possibly *Micromela*), which genus it is probably allied to, but at once distinguished from by the dentate claws; the basal piece of each claw is large, but not very deeply divided. In Dr. Baly's tabulation* it would fall beside *Eulina* and *Australica* (*Calomela*), but it is very different to those genera, or to any of the sub-genera partitioned off from the latter.

ACACICOLA TRISTIS, n.sp.

Testaceous-brown, prothorax pale flavous; its base in middle infuscate; under-surface (middle of metasternum and of abdomen slightly infuscate); antennæ (apical joints infuscate) and legs (claws infuscate) pale testaceous.

Head flat, wide, punctures not very sparse or small; clypeus minute; antennæ thin. second to tenth joints subequal in length, the third to eighth feebly increasing in width. the eleventh about once and one-half the length of the tenth. *Prothorax* with minute punctures in middle, larger and crowded at sides, base rounded, sides rounded; anterior angles obtusely rounded, and extending to middle of eyes. *Elytra* not much wider than and with an outline continuous with that of prothorax, with not very regular series of rather small punctures (larger at apex), becoming dense and irregular on sides; interstices impunctate, not separately convex; epipleuræ inwardly obliquely concave. Basal segment of *abdomen* shorter than metasternum, the three intermediate segments equal in size. *Femora* stout; tibiæ compressed, apex oblique; basal joint of all the tarsi large and wide, narrowest in the posterior; second joint small, less than half the width of third, and not as long. Length 4, width 3mm.

Hab.—N.S.W.: Forest Reefs.

Another specimen differs in being entirely of a dingy sooty-brown, except for a very narrow testaceous border of the prothorax, the muzzle, basal joints of antennæ, palpi, tarsi, and anterior tibiæ. The species occurs on *Acacia decurrens.*

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* T.E.S., 1854, p. 170.

LAMPROLINA MICANS, n.sp.

Of a brilliant metallic-green, with a coppery gloss; antennæ pale yellow, the two terminal joints black. Under-surface and legs with thin yellowish pubescence.

Head with scattered minute punctures; clypeus separated from the face by a deep semi-circular impression, from the middle of which an impressed line extends backwards to the base, and from the sides an oblique line extends to each eye. Antennæ simple. *Prothorax* almost twice as wide as long, base bisinuate, sides very feebly sinuous; disc minutely punctate, each side of extreme base and the sides with a few small punctures; extreme margin with a small fovea in middle, each side with two rather deep foveæ, of which the posterior is the larger and more irregular. *Elytra* with minute scattered punctures, traceable in very feeble series, about middle of suture, each with seven foveæ; one within shoulder, four (three of which are double) forming a transverse series at basal third, and two (the inner one double) just beyond the middle. Length 9, width $4\frac{1}{2}$mm.

Hab.—Cairns (type in Macleay Museum).

A remarkably handsome species, the brilliant colour and foveæ of which are suggestive of *Diphyllocera*, but the antennæ are composed of cylindrical and perfectly simple joints.

LAMPROLINA BINOTATA, n.sp.

Head testaceous, the base infuscate; prothorax and scutellum testaceous, the former with two distinct infuscate spots in middle, occasionally conjoined, and rarely with an additional small spot on each side; elytra obscure purplish-blue, or steel-blue, or bronzy, or coppery-bronze; under-surface (except prosternum, which is testaceous) obscure testaceous-blue; legs testaceous, the tarsi blackish-brown; antennæ black, the three basal joints more or less testaceous.

Head coarsely and irregularly punctate; clypeal suture deep on each side, but not continuous to middle, an impressed median line not continuous to vertex, an oblique line on each side to eye. *Prothorax* with comparatively small punctures on disc, becoming larger and variolose on sides. *Elytra* with series of moderately small punctures, becoming minute towards apex, and with scattered very minute ones; the interstices (except at base, sides, and near suture) with punctures almost as large as those in the series, so that these become confused; behind shoulders scarcely visibly impressed, but with larger punctures than elsewhere. Length $7\frac{2}{3}$, width $4\frac{1}{3}$; variation in length, 7-9mm.

Hab.—N.S.W.: Inverell.

Dr. Baly records a variety of *puncticollis* having black spots on the prothorax. I have not seen such a variety, but the species above described differs from the typical form of that species in being wider and more depressed, with the elytral and prothoracic punctures considerably smaller. I have also never seen a specimen with coppery-green elytra, nor of *puncticollis* without such. At the same time, it is possible (although far from likely) that they represent an extreme variety of that species. Numerous specimens were beaten from *Bursaria spinosa*, as have been all the species of the genus with which I am acquainted.

LAMPROLINA PERPLEXA, Baly.

I cannot regard this other than as a feeble variety of *œneipennis.*

L. ŒNEIPENNIS, Boi.

Hab.—N.S.W.: Dalmorton, Richmond River, Armidale, Galston.

L. SIMILLIMA, Baly.

Hab.—Sydney, Cairns.

L. PUNCTICOLLIS, Baly.

Hab.—Clarence River.

L. JANSONI, Baly.

Hab.—Rockhampton.

PLAGIODERA LOUNII, Baly.

I have a specimen of this species from the Clarence River, and there is another in the Macleay Museum from Ash Island (Hunter River). It belongs to the Rev. T. Blackburn's new genus *Pseudoparopsis*, and has the features mentioned by him as distinguishing it from *nitidipennis.*

CYCLONODA PILULA, Clark.

Hab.—W.A.: Darling Ranges, Bridgetown.

C. SUBPUNCTATA, Clark.

Hab.—W.A.: Mount Barker.

ÆSERNOIDES NIGROFASCIATUS, Jac.

Hab.—Richmond River.

PLATYMELA STICTICOLLIS, Baly.

Hab.—Cape York.

Chalcomela cupreosplendens, n.sp.

Head (including clypeus), prothorax (the basal third at sides, and fourth in middle, and the apex narrowly, purplish-blue), base sides, and epipleuræ of elytra, prosternum, metasternum (except margins), middle of basal segment of abdomen, and part of femora, of a fiery copper; elsewhere purple; the antennæ blackish, with the basal joints partly diluted with red.

Head with a few minute punctures; clypeus finely punctate, separated from the face by a deep groove, from the middle of which a feebly impressed line extends backwards to the base. *Prothorax* minutely punctate, the sides with moderately large but not very dense punctures. *Elytra* with regular series of not very small punctures, becoming small towards apex; the interstices feebly separately convex in places, and with sparse minute punctures. Length $5\frac{2}{3}$, width 4mm.

Hab.—Thursday Island (Macleay Museum).

The shape is that of *eximia* and *insignis*, but the elytra are almost entirely purple; the coppery part commences on each side of the scutellum, and is continued irregularly round the sides to apex, being widest on, and narrowest on each side of, the shoulders.

Chalcomela viridimicans, n.sp.

Upper and under surface of a brilliant green, with a slight coppery gloss, and in certain lights appearing purplish; legs, antennæ, and muzzle reddish.

Head with irregular and fine punctures, becoming denser and larger at base; clypeus with distinct punctures, its suture not deeply impressed but distinct; from its middle a feebly impressed line extends backwards to the base. *Prothorax* with small and almost regularly distributed punctures; a few larger ones at extreme base, but not at sides. *Elytra* with series of small punctures, becoming very indistinct towards apex. *Under-surface* with a semi-circular row of large punctures behind each of the four posterior coxæ. Length 8, width $6\frac{1}{4}$mm.

Hab.—N.Q.: Cairns (Macleay Museum).

The shape is that of *illudens.* Of two specimens under examination, one has a shallow fovea on each side of the prothorax, whilst the other has two small foveæ on each side, the outer one of which is more distant from the side than in the other, so that they are probably all accidental.

Both this and the following species being green, no doubt somewhat resemble *sulcata*, but the antennæ and legs are red, the head is without a distinct fovea on vertex, and the elytra are not sulcate-striate in either.

CHALCOMELA TRICOLOR, n.sp.

Upper-surface metallic-green. with a coppery gloss; under-surface (including elytral epipleuræ) deep glossy black; legs, antennæ, and palpi reddish-testaceous.

Head with minute punctures, but with a few of moderate size in middle, a triangular depression (invisible from most directions) on each side, with its base on the eye; clypeus densely punctate, its suture moderately distinct. *Prothorax* with small and not very dense punctures (smaller on disc than elsewhere), becoming subvariolose on sides anteriorly. *Elytra* with series of rather small punctures, becoming smaller, to, but still distinct on, apex, the outer row of punctures large, an extreme marginal row of minute punctures; interstices with sparse minute punctures. *Metasternum* with two transverse rows of large punctures; a semi-circular row of large punctures behind each of the posterior coxæ. Length 7, width 6mm.

Hab.—N.Q.: Barron Falls (Mr. A. Koebele), Cairns (Macleay Museum).

C. EXIMIA, Baly.

Hab.—Q.: Somerset, Port Denison.

C. INSIGNIS, Baly.

Hab.—Somerset. Port Denison.

C. ORNATISSIMA, Baly.

Hab.—N.S.W.: Richmond River; Q.: Brisbane.

C. ILLUDENS, Baly.

Hab.—N.S.W.: Richmond River; Q.: Moreton Bay.

CYCLOMELA NITIDA, Baly.

Hab.—Tweed and Richmond Rivers.

CLIDONOTUS GIBBOSUS, Baly.

Hab.—Richmond River.

STRUMATOPHYMA UNDULATIPENNIS, Clark.

Hab.—Swan River.

PHYLLOCHARIS IANTHINIPENNIS, n.sp.

Head (an obscure semi-circular greenish macula at the base), prothorax (feebly maculate or not in the middle of the base), sterna (except mesosternal episterna and sutures of metasternal episterna), and coxæ red; elytral epipleuræ paler; elsewhere violet-blue, the elytra almost pure violet.

Head smooth and impunctate, or with a few scattered punctures; clypeus depressed, triangular, from its apex a shallow oblique depression extends almost to base along the eyes, a very distinct groove extends almost to vertex, and terminates in a shallow fovea. Antennæ stout; the first five joints sparingly, the next two densely, the others very densely punctate. *Prothorax* almost twice as wide as long, very finely margined, base feebly bisinuate, sides almost straight, apical angles rounded and produced, basal rectangular; a few moderately large punctures on each side of base, elsewhere microscopically punctate. *Elytra* elongate, wider than prothorax, widest at about apical third, shoulders rounded and prominent, seriate-punctate, punctures rather small, becoming very small and distinct posteriorly, each with about ten rows, but not very distinct, and separated at unequal distances, between some of the rows a feeble row of distinct punctures. Length 8, width 4mm.

Hab.—Cape York (types in Macleay Museum).

Allied to *ficus*, but considerably larger; elytra unicolourous, and of a deeper violet. In one malformed specimen the apical segment of the abdomen, the apex, and sides of the penultimate, and the extreme sides of the other segments, are red; it has the elytra subopaque, transversely rugulose, the series of punctures not traceable, and with several raised spaces.

PHYLLOCHARIS HILARIS, n.sp.

Clear pale yellow; scutellum, two elytral fasciæ, two basal segments of abdomen (except at sides), legs, and antennæ deep blackish purple.

Head smooth and impunctate, nowhere distinctly impressed, but with a very feeble median, and two lateral depressions traceable in certain lights; clypeus depressed and triangular. Antennæ stout, the four basal joints sparsely, the others densely punctate. *Prothorax* of the same shape, and with the same punctures as in the preceding species. *Elytra* shaped much as in the preceding species, but rather wider, more convex, and with the shoulders less prominent; seriate-punctate, the series more or less easily traceable on the dark portions, but becoming very confused (owing to more or less numerous punctures subseriately arranged) on the paler portions; interstices not raised, with scattered minute punctures. Length 9¼, width 4½mm.

Hab.—Cairns (types in Macleay Museum).

A remarkably handsome species. Each of the two specimens under examination has a fascia occupying nearly one-third of the base of the elytra; the second fascia commences beyond the middle, and is triangularly dilated along the suture to one-fourth from the apex. In one of the specimens this fascia is complete, being at the sides half the width of the basal fascia; in the other specimen a large triangular space is completely isolated from a small spot on each side.

PHYLLOCHARIS MARMORATA, n.sp.

Head and prothorax bronzy-black, mottled with red; basal two-thirds of elytra somewhat similar, but the darker markings plum-coloured, shoulders and apical third clear testaceous; under surface reddish-testaceous, the apical segment of abdomen paler; legs violet-brown; antennæ black, the four apical joints almost white.

Head with a few scattered punctures; clypeus depressed and triangular, from its apex a depression extending on each side to behind the eyes, but close to the eyes sending out a short deep furrow. Antennæ stout, five basal joints sparsely, the others densely punctate. *Prothorax* about once and one-half as wide as long, base feebly bisinuate, sides slightly sinuous; apical angles rounded and slightly produced, posterior feebly acute, with irregular and moderately large punctures forming an irregular semi-circle, the sides of which rest on the posterior angles, those at the base variolose. *Elytra* much wider than prothorax, widest at base, shoulders rounded, the greater part of the surface impunctate or with microscopic punctures, across basal third punctures subseriately arranged, two very feeble sutural rows traceable almost to apex; an irregular depression behind shoulders. Length 6, width 3⅓mm.

Hab.—Richmond River (type in Macleay Museum).

A short robust species, allied to *melanospila* and *acroleuca*; the former has one, the latter two, whilst the present species has four of the terminal joints of the antennæ white.

PHYLLOCHARIS BICEPS, n.sp.

Pale testaceous; three spots on head (a transverse one between antennæ and a small roundish one close to each eye), with a narrow U (the convex side towards base) on forehead, two moderately wide stripes on prothorax (continuous from apex to base), scutellum, a small oblique spot within each shoulder, a curved fascia at basal third of elytra (not quite continuous to extreme sides), three large spots beyond the middle (of which the median one is transversely suboblong), and two large subapical ones chocolate-brown. Under surface black, middle of sterna, sides of prosternum, two apical segments of abdomen, and three obscure spots on third testaceous; legs blackish, the claws red; six basal joints of antennæ red at base, dark at apex; the others infuscate, apical third of the terminal joint whitish.

Head with scattered minute punctures; clypeus truncate at apex, from each side a groove extending backwards to the eye, and close to each eye, surrounding a dark eye-like space. Antennæ stout, the seven basal joints more or less sparsely, the others densely punctate. *Prothorax* more than twice as wide as long, sides slightly sinuous, base feebly bisinuate, anterior angles rounded and produced, posterior rectangular; each side at extreme base with elongate shallow punctures of foveæ, elsewhere with very minute punctures and with small but deep scattered punctures almost absent on the sides. *Elytra* at extreme base no wider than prothorax, and very little wider elsewhere; each with about ten seriate rows of small punctures, not traceable towards base or apex; interstices not at all or scarcely visibly punctate. Length $7\frac{1}{3}$, width 4mm.

Hab.—Brisbane (types in Macleay Museum).

A remarkable species, which I have hesitated to regard as belonging to *Phyllocharis*; but the claws are dentate, antennæ moniliform and palpi ovate. The grooves on the head, with the truncate apex of the clypeus, and the dark isolated spaces at the sides, cause an appearance as if the head of a small *Dytiscus* or *Cybister* had been carved out, the resemblance being not traceable with difficulty, but absolutely perfect, and is as distinct in the variety (noticed below) as in the typical specimens. The wide prothorax and white termination of the antennæ are also very distinctive features. The two brown stripes on the prothorax cause three testaceous stripes to appear, of which the median one is the narrowest; in conjunction with the scutellum, and the two basal spots of the elytra, they cause a W to appear when viewed from in front, or an M from behind. The basal fascia of the elytra may be considered as six closely conjoined spots. In one specimen the legs (except for the brownish femora) are testaceous, and the six basal joints of the antennæ are entirely red.

Var. ALTERNATA.

A variety in the Macleay Museum from Brisbane differs in having the markings deep black, and occupying a much greater portion of the surface. The head, except for four spots, is black; the prothorax has four stripes, of which the two median are wider than the others (these are at the extreme sides, and wider than any of the pale stripes); the elytra are black, except for three narrow fasciæ, a very small medio-lateral spot, and a small subapical spot on each side; of the fasciæ, the basal one is curved, so as almost to resemble the figure 5 on each side; the second is just before the middle, and is interrupted, and not continuous to sides or suture; the third is curved, one-third from apex, and not continuous to sides or suture. The abdomen is almost entirely black, the tibiæ are pale; the antennæ are coloured as the type.

PHYLLOCHARIS 10-MACULATA, n.sp.

Head, prothorax, legs, and antennæ (the seven terminal joints infuscate) red; under-surface (except prosternum) black; scutellum black; elytra black, but with ten pale sharply-defined spots; of these, six are almost round, two (scutellar) are elongate suboval, and two (subapical) are lunulate; four form a transverse series near the base, four just before the middle, and two at less than one-third from apex, the series being equidistant from each other.

Head impunctate, or nearly so; clypeus semi-circular, from each side an oblique groove extends backwards to beyond the eye, but near the eye sends out a short internal groove. Antennæ stout, the pale joints feebly, the others densely punctate. *Prothorax* almost twice as wide as long, base feebly bisinuate, sides straight (except for a slight diminution near apex), anterior angles produced and moderately acute, posterior rectangular; impunctate. *Elytra* subovate, at base wider than prothorax, widest at about apical third, with series of small punctures, between which are irregular series of still smaller punctures, so that the whole becomes somewhat confused. Length 4, width $2\frac{1}{6}$mm.

Hab.—Wide Bay (types in Macleay Museum).

The smallest of the genus with which I am acquainted. In shape it approaches *flexuosa*, except that the prothorax is proportionately wider and more parallel-sided. The eyes are coarsely faceted, a character strongly at variance with the other known species, but scarcely sufficient to warrant generic separation.

Var. IMMACULATA.

Elytra entirely black.

Specimens from Moreton Bay present the above difference from 10-*maculata*. I am unable to state, however, which is the species and which the variety, although I have placed the immaculate specimens as the variety. Each is represented by two specimens in the Macleay Museum.

PHYLLOCHARIS FICUS, n.sp.

Head, prothorax, and apical fourth of elytra (triangularly encreached upon along suture), and prosternum clear testaceous; scutellum and elytra deep blue, the blue sometimes encroaching on middle of base of prothorax; sterna, basal segments of abdomen, and legs obscure piceous-blue; antennæ entirely black, but with a slight bluish gloss.

Head impunctate, a fine depressed line on each side between eyes; clypeus widely triangular, finely punctate. Antennæ stout, extending to posterior coxæ. *Prothorax* transversely impressed at base, impunctate except for a few of moderate size at sides of base. *Elytra* with series of small punctures, becoming very small posteriorly. Length 5⅔, width 3mm.

Hab.—N.S.W.: Dalmorton (on *Ficus* sp.), Richmond River; Q.: Moreton Bay (Macleay Museum).

One of the smallest and prettiest species of the genus, and strongly resembling *Lamprolina grandis* in miniature.

PHYLLOCHARIS HIEROGLYPHICA, n.sp.

Metallic blue, with a slight greenish gloss; base of head, sides of prothorax (a small bluish spot on each side), three bands or patches on elytra, prosternum, middle of metasternum, and three apical and sides of basal segments of abdomen testaceous; legs bluish; antennæ bluish-black.

Head impunctate on vertex, sparsely and irregularly elsewhere; clypeal suture distinct, each side oblique, from middle a groove extending backwards, but not to vertex, from each side an oblique impression continued to eye. *Prothorax* with microscopic punctures, and with small punctures scattered about, and becoming subvariolose at base and at sides towards base. *Elytra* with irregular series of distinct and not very small but deep punctures, larger behind shoulders than elsewhere, and becoming smaller (but still distinct) towards apex. Length 6½, width 3½mm.

Hab.—N.Q.: Somerset (Mr. C. French), Cairns (Macleay Museum).

The pale markings on the elytra consist of an irregular semi-circle on each side, commencing at the scutellum and meeting on suture at one-third from base, a transverse fascia beyond middle interrupted by suture, but continued along sides to extreme base, and a narrow stripe close to suture on apical third, and extending to extreme apex. The species is moderately close to *ornata*, but the markings are very different, and the elytral punctures are larger, denser, and differently arranged; apparently, also, it is allied to *eximia*, but the size is very much smaller, and the markings of the elytra different, the prothorax with a small spot on each side, &c.

PHYLLOCHARIS CYANICORNIS, Fabr.

In addition to the varieties of this species noticed by Dr. Baly, I have—

Var. D. Prothorax with basal and without lateral spots; elytra with four blue spots and large apical cross.

Var. E. Prothorax with three spots; elytra with eight spots, the four apical forming a large cross, but not continued across suture.

Var. F. Head immaculate; prothorax with an oblong blue patch from base to apex; elytra blue; the shoulders, a slightly oblique post median transverse spot, and a sub-apical transverse spot, yellow.

This variety might perhaps be regarded as belonging to *cyanipes*.

PHYLLOCHARIS FLEXUOSA, Baly.

I have specimens from New South Wales (Wilcannia, Armidale, and Forest Reefs), varying in length from 7 to 11mm.

P. MELANOCEPHALA, Baly.

Hab.—Tweed River.

P. ORNATA, Baly.

Hab.—Near Jenolan Caves.

P. ACROLEUCA, Baly.

Hab.—Tweed River.

P. JANSONI, Baly. (Var. B. of Jacoby).

Hab.—N.Q.: Somerset.

ATERATOCERUS INTRICATUS, Blackb.

Hab.—Richmond River.

DIPHYLLOCERA GEMELLATA, Westw.

Hab.—Richmond River.

ÆSERNIA AUSTRALICA, Jac.

Hab.—Q.: Endeavour River.

Eyes coarsely faceted.
  Elytra with 10 spots ... ... 10 *maculata*, n.sp.
  Elytra immaculate ... ... *immaculata*, n.var.
Eyes finely faceted.
  Head with head-like impressed figure.
    Prothorax with two dark stripes ... ... *biceps*, n.sp.
    Prothorax with four dark stripes ... ... *alternata*, n.var.
  Head without head-like figure.
    Part of antennæ white.
      Four terminal joints white ... ... *marmorata*, n.sp.
      Two ... ... *acroleuca*, Baly.
      One ... ... *melanospila*, Baly.
    Terminal joints not white.
      Elytra entirely dark ... ... *ianthinipennis*, n.sp.
      Elytra dark with pallid markings, or *vice versâ*.
        Prothorax immaculate.
          Apex of elytra pallid ... ... *ficus*, n.sp.
          Apex and shoulders pallid ... ... *cyanipes*, Fabr.
          With two dark fasciæ ... ... *hilaris*, n.sp.
        Prothorax with two dark patches.
          Elytra coarsely punctate ... *Jansoni*, var. B. of Jacoby.
          Elytra finely punctate ... ... *flexuosa*, Baly.
        Prothorax with one or three dark patches.
          Elytral suture pallid for part of its length *cyanicornis*, Fabr. *
          Suture entirely dark.
            Not one of the pale elytral markings isolated ... ... *ornata*, Baly.
            Some of them isolated.
              Head entirely pallid ... ... *cyanicornis*, var. F.
              Head partly dark ... ... *hieroglyphica*, n.sp.

Calomela nigra, n.sp.

Black, with a decided coppery or coppery-green gloss; under-surface and the greater portion of femora metallic-green, legs elsewhere, episterna and the elytral epipleuræ dull red or piceous-red; antennæ and palpi paler, terminal joints of the former very feebly infuscate.

Head irregularly punctate, vertex almost impunctate, the largest between eyes; clypeal suture bisinuate. *Prothorax* with large variolose punctures or foveæ on sides, becoming sparser and smaller on disc. *Elytra* with ten rows of rather distant punctures (becoming much smaller and closer together posteriorly), those about and behind the shoulders very much larger than elsewhere, being almost as large (but not so dense) as those at sides of prothorax; interstices minutely punctate. Length 7, width 4mm.

Hab.—Q.: Rockhampton (types in Macleay Museum).

A very distinct species, in build approaching *ioptera*, but very differently coloured; the elytral punctures are unusually widely separated.

* And some of its varieties.

Calomela cœlestis, n.sp.

Bright violet-blue, the scutellum with a slight greenish tinge; legs, antennæ (the five terminal joints infuscate), and palpi bright reddish-testaceous.

Head rather densely and irregularly punctate; median line feebly impressed; clypeal suture semi-circular, and more or less interrupted by punctures. *Prothorax* with large subvariolose punctures at sides, becoming smaller to and almost absent on middle of disc; with very minute punctures scattered about. *Elytra* with numerous rows of rather small punctures, larger behind shoulders than elsewhere, towards suture becoming so arranged as almost to form geminate striæ; interstices in places very feebly raised, and with very minute scattered punctures. Length 6, width 3mm.

Hab.—Port Denison (types in Macleay Museum).

The entirely blue colour (except for the appendages) will readily distinguish this from all previously described species. It is a narrow species, in build resembling *amethystina*, but narrower, and with a proportionately wider head.

Calomela nigripennis, n.sp.

Head, prothorax (the extreme margins with a coppery gloss), legs, antennæ (the apical joints infuscate), and palpi red; scutellum and elytra bronzy-black; under-surface (including elytral epipleuræ) dull red, with a greenish or coppery gloss.

Head moderately densely but not coarsely punctate, punctures denser between eyes than elsewhere; clypeus punctate, its suture angular, from its middle a scarcely impressed but impunctate line extending backwards almost to the base. *Prothorax* moderately densely punctate, punctures deep but not very large, larger at sides than in middle, and everywhere manifesting a tendency to form in feeble clusters; minute punctures scattered about. *Elytra* irregularly impressed behind the shoulders, with ten feebly geminate rows of small punctures, no smaller towards apex than elsewhere, but more crowded and irregular; interstices not raised, impunctate. Length $6\frac{1}{2}$, width $4\frac{1}{3}$mm.

Hab.—Rockhampton (types in Macleay Museum).

In build, punctures, &c., closely resembling *ruficeps*, but readily distinguished from that species by its red prothorax.

Calomela punctifrons, n.sp.

Of a burnished coppery-violet; in places (on head, apex, and base of prothorax, base suture, sides, and transversely at basal third of elytra), a brilliant metallic green or blue; under-surface dark chocolate brown, with a slight metallic gloss; legs red (the four posterior femora darker), antennæ (the apical joints not at all infuscate) and palpi paler.

Head with a few small punctures at base, and scattered about, and some larger ones in front; clypeus widely triangular, coarsely but not irregularly punctate; its suture deep, from the middle a feeble line traceable to base. *Prothorax* with moderately large punctures in middle, becoming larger and subvariolose on sides, microscopic punctures scattered about. *Elytra* impressed behind the shoulders, each with ten rows of distinct punctures, becoming smaller (but still very distinct) posteriorly; interstices sparsely and minutely but (in certain lights) distinctly punctate. Length 7½, width 4½mm.

Hab.—Rockhampton (types in Macleay Museum).

The elytral suture is very narrowly purple, then shades off through various degrees of metallic blue, green, and copper to the general tone; the transverse sub-basal markings are indistinct from some directions, but very distinct from others.

Calomela fugitiva, n.sp.

Of a metallic blue, green, coppery-green, and purple; under-surface and legs chocolate-brown, and with a metallic greenish gloss, sides and claw-joints obscure red; basal joints of antennæ (the rest infuscate) and the palpi red.

Head (including clypeus) with sparse and minute punctures; median line not traceable. *Prothorax* with sparse, small, and irregularly distributed punctures, not much denser or larger at sides than elsewhere. *Elytra* impressed below shoulders, each with ten rows of distinct punctures, becoming very small posteriorly; interstices with sparse minute punctures. Length 6, width 4⅙mm.

Hab.—Wide Bay (type in Macleay Museum).

Close to the preceding species, but more compact in build, the colour more metallic or violet, the prothoracic punctures sparser in middle, the elytral interstices scarely visibly punctate, clypeus sparsely and finely punctate, legs almost unicolourous, and antennæ with the apical two-thirds infuscate. The colour varies so much from different directions that it is almost impossible to define it; a beautiful purple colour can, however, be usually seen on the base of the head, apex, and base (more or less narrowly) of prothorax, on scutellum, suture, base, and epipleuræ of elytra, and from some directions on disc. Any part of the elytra, however, can be made to appear purple, and almost any part a coppery-green; the middle of the prothorax is of a more or less fiery copper or coppery rose colour, toning off into various shades of green and blue.

A specimen from Wide Bay, in the Macleay Museum, is possibly a variety of this species; its colour appears to be the same, but it is slightly less compact in build, and with stronger punctures on clypeus and sides of the prothorax. The punctures are finer and sparser (very much sparser in middle of prothorax), the colour (noticeably that of the antennæ and legs) is different, and the whole insect is more compact than *punctifrons*. It might, however, be regarded as a variety of either species, or as representing an as yet undescribed one. I can by no means regard *fugitiva* as a variety of *punctifrons*.

Calomela monochromatea, n.sp.

Bright brownish-red; antennæ (except basal joints) infuscate; each seriate puncture on the elytra surrounded by a watery ring.

Head with fine irregular punctures; clypeus separated from the face by a fine, semi-circular, slightly irregular punctured line. *Prothorax* more than twice as wide as long; with rather sparse minute punctures, disc and extreme base with scattered moderately large punctures. *Elytra* slightly wider than prothorax, feebly incurved behind shoulders; with ten rows of small punctures, becoming very minute on apical third; interstices with sparse and minute but fairly distinct punctures. Length $6\frac{1}{2}$, width $3\frac{1}{4}$mm.

Hab.—Q: Barron Falls (Mr. A. Koebele).

The shape is much the same as that of *flavescens*, but the colour is very much darker, the prothorax is more irregularly punctate, and the elytra are slightly sinuous behind the shoulders. The watery rings around the seriate punctures on the elytra are invisible from most directions.

Calomela intemerata, n.sp.

Entirely (except for the eyes) pale lemon-yellow.

Head rather densely and coarsely punctate, punctures finer on vertex than elsewhere; clypeus distinctly separated from the face, and impunctate. *Prothorax* with moderately fine punctures on disc, becoming larger and subvariolose (but not much denser) on sides. *Elytra* slightly wider than prothorax, with ten rows of not very large punctures (moderately large at sides), becoming much smaller on apical portion; interstices scarcely visibly punctate. Length $7\frac{1}{2}$, width 4mm.

Hab.—Q.: Somerset (Mr. C. French).

Moderately close to *flavescens*, but the antennæ are entirely pallid, the head less coarsely punctate, and the prothorax with smaller punctures at sides, and denser on disc.

Calomela cephalotes, n.sp.

Pale testaceous, apical half of antennæ and claws infuscate; each seriate puncture on the elytra surrounded by a watery ring.

Head wider than usual, being almost the width of prothorax, feebly punctate, the punctures more distinct (but very small) in front than elsewhere; clypeus separated from the face by a curved line, from the middle of which a short line is directed backwards, but does not extend to the vertex. *Prothorax* densely and rather finely punctate, punctures becoming larger (but not very large or variolose) at sides. *Elytra* not much wider than prothorax, with ten rows of small punctures less distant from each other than usual, but becoming obsolete posteriorly; interstices gently (but distinctly) convex, and with small punctures. Length 8, width $3\frac{3}{4}$mm.

Hab.—N.W.A.: Upper Ord River (Mr. R. Helms).

Of the shape and size of *flavescens*, but with the head larger and more finely punctate, the anterior margin of the prothorax less sinuous, with the sides more coarsely punctate, and the elytral punctures decidedly closer together; from *pallida* it is at once distinguished by the punctures of the head, besides its narrower form.

Calomela amethystina, n.sp.

Head (basal portion, except for a narrow median line, bright metallic green), antennæ (apical half infuscate), prothorax (extreme apex and base infuscate, and extreme sides green), and legs clear testaceous; scutellum and elytra bright metallic blue or purplish-blue, sometimes with a greenish gloss; under-surface testaceous, but (except apical segment of abdomen and prosternum) with a very decided bluish (or greenish) gloss.

Head with coarse and not very dense but irregular punctures, smaller and sparser in middle of vertex than elsewhere; clypeus rather densely punctate, and distinctly separated from the face. *Prothorax* with sparse, indistinct punctures in middle, at sides becoming rather large and variolose. *Scutellum* strongly transverse. *Elytra* with more than ten irregular rows (sometimes appearing feebly geminate) of rather small punctures, becoming smaller (but still very distinct) on apical portion, towards the sides feebly rugulose. Length $5\frac{2}{3}$, width $2\frac{2}{3}$mm.

Hab.—W.A.: Geraldton.

A very distinct species, in appearance resembling to a certain extent some of the small and highly coloured varieties of *ioptera*, but the punctures utterly different to those of that species.

Calomela viridipennis, n.sp.

Testaceous, extreme margins of prothorax infuscate; elytra bright pale metallic green; scutellum and metasternum, with or without a metallic green gloss.

Shape and punctures as in the preceding species. Length $5\frac{2}{3}$, width $2\frac{2}{3}$mm.

Hab.—N.W. Australia (Macleay Museum).

Very close to (perhaps only a variety of) the preceding species, but the head and antennæ entirely pallid; the elytra of a pale green (although from some directions appearing purple), and not quite so densely punctured, and the punctures smaller towards the apex.

Calomela nigricornis, n.sp.

Pale testaceous; base of head, antennæ (except lower half of two basal joints), apical joint of palpi, scutellum, the suture (very narrowly), apex of femora and of tibiæ, and the tarsi black or brown; prothorax occasionally with a narrow infuscate line, but usually with a minute blackish spot at base; each elytron with a wide metallic green (the margins purplish) stripe conjoined at apex. Flanks of meso and metasternum with distinct silvery pubescence.

Head moderately densely but irregularly punctate, punctures smaller and sparse towards and disappearing in middle of vertex; clypeus punctate, depressed, and very distinctly separated from the face, behind it in middle a narrow impressed line scarcely extending to the vertex. *Prothorax* with the sides more irregular, and the anterior angles more distinctly produced than usual; disc with a few distinct punctures, sides with dense variolose punctures. *Scutellum* considerably longer than wide, apex obtusely rounded. *Elytra* noticeably wider than prothorax at base, with ten rows of punctures, those beneath the green stripes very large and crowded together, posteriorly becoming more crowded, and losing their (more or less) regular arrangement; interstices almost impunctate, the sutural and lateral wider than the others. Length 7, width $3\frac{1}{2}$; variation in length, 6-8mm.

Hab.—N.S.W.: Forest Reefs.

A rather large and very beautiful species; the punctures beneath the stripes are larger, more crowded and quadrate than in *vittata*, whilst those outside the stripes (especially beyond the middle) are very much smaller; the colour, to a certain extent, resembles some of the green-striped varieties of *Curtisi*, but the two species have little else in common. The dark portion of the head varies in extent, and sometimes has an indistinct bluish or purplish gloss. When seen from the sides, the stripes on the elytra lose their bright metallic green appearance, and become a decided purple. The clothing of the sterna is a very distinctive feature; in several other species the flanks of the sterna are feebly clothed, but in this species the pubescence is silvery, and very distinct.

Calomela juncta, n.sp.

Clear pale testaceous (almost flavous); antennæ (under-surface of two basal joints excepted), palpi, and tarsi infuscate; each elytron with a narrow metallic-green (slightly curved) stripe, commencing on shoulder and conjoined at apex; extreme apex of femora and of tibiæ feebly infuscate. Shape and punctures as in the preceding species, except that on the elytra the green stripes only cover three rows of large, crowded punctures; the punctures between the stripes and sides are as large as (or even larger than) those beneath the stripes, but they are not crowded, and are almost regular. Length $7\frac{1}{3}$, width $3\frac{3}{4}$; variation in length, $6\frac{1}{2}$-8mm.

Hab.—N.S.W.: Tamworth, Armidale, Braidwood.

Decidedly close to the preceding species, but the under-surface, head, and scutellum entirely pale; the green stripe of each elytron covering only three coarse series of punctures (instead of at least six), and without silvery pectoral clothing; like that species, however, the green stripes appear purplish from the sides.

Calomela parilis, n.sp.

Testaceous; antennæ (basal joints excepted), apical joint of palpi, and the tarsi black or infuscate; each elytron with a wide metallic-green stripe (narrowly conjoined at apex), appearing decidedly purple when viewed from the sides.

Head densely and irregularly punctate, a feeble impunctate median line traceable; clypeus punctate, indistinctly (except from in front) separated from the face. *Prothorax* moderately densely punctate, punctures not very small on disc, becoming larger and variolose at sides. *Scutellum* longer than wide. *Elytra* with ten rows of punctures, the rows distinctly traceable only on the paler parts, the punctures on the green stripes being much more crowded and irregular; interstices scarcely visibly punctate. Length 6, width 3½mm.

Hab.—N.S.W.: Galston (Mr. W. Dumbrell), Bungendore, Armidale (Lea).

In appearance strongly resembles *Curtisi*, but the under-surface and legs (except tarsi) pallid, and the elytral punctures (especially beneath the green stripes) very much larger; in all the specimens (seven) under examination the prothorax is immaculate. The punctures of the elytra are almost as large at apex as they are at base.

CALOMELA GLORIOSA, n.sp., or var.

Head black, the muzzle and basal joints of antennæ obscure testaceous; prothorax black, the base and apex narrowly obscure testaceous, a median line and a small spot on each side blue; scutellum black, with a bluish gloss; elytra with two interstices on each side of suture, and the lateral interstice (but not the epipleuræ, which are of a more or less dingy brown) black; the space between metallic-blue or green or purple. Under-surface (except flanks of prosternum, which are obscure testaceous) black, with a bluish gloss; legs deep black. Under-surface with scattered, whitish pubescence, becoming more condensed on apex of abdomen.

Shape and punctures as in *Curtisi*. Length 5⅔, width 3⅓mm.

Hab.—Sydney.

The specimen described probably represents an extreme variety of *Curtisi*; the colour, however, is so entirely different that, even as a variety, it deserves a name. The blue markings of the prothorax are invisible from some directions, although very distinct from others; the elytral suture, for the width of two interstices on each side throughout (except for a slight interruption near apex), and three at base, appears deep glossy black from any direction, but the colour of the space between the black portions varies, being bright emerald-green or blue or purplish-blue or deep purple, and constantly altering as the view is changed; the punctures, however, appear to be entirely purple.

Calomela Curtisi, Kirby.

The typical form of this species has been well described by Dr. Baly,* who also describes four-colour varieties, and ranks *punctipes* (Germar) as a synonym. The Rev. T. Blackburn, however, regards *punctipes* as a good species, but in this I cannot follow him. I have specimens which differ from the typical forms in the details noted by him,† but cannot regard them as forming more than a variety. I have seen all the varieties mentioned by Dr. Baly except D, and note the following ones:—

Var. E. Elytra unicolourous except for a very narrow margin, and the basal third of suture; the prothorax with a wide discal vitta extending to base and apex, and irregularly dilated near the base; towards the sides with an irregular blotch, almost confined to the punctures. *Hab.*—Tasmania.

Var. F. Prothorax with a moderately wide median vitta, appearing (in conjunction with the scutellum) lanceolate in shape, the sides immaculate. *Hab.*—Tasmania.

Var. G. Prothorax with a wide median blotch, suddenly terminated at one-third from base, with which it is feebly connected by a narrow infuscate line, each side with a feebly infuscate spot; markings purple. *Hab.*—Tasmania.

Var. H. The same, but markings bright green. *Hab.*—New South Wales.

Var. I. Prothorax with a very narrow median infuscate line on apical half only, the sides immaculate; the disc unusually sparsely and finely punctate; elytral stripes bluish-green. *Hab.*—New South Wales.

Var. J. Prothorax with a moderately narrow blue median vitta on apical half only, the sides immaculate, the disc more coarsely punctate than usual; elytral stripes pale violaceous; apex of tibiæ and apical half of femora black. *Hab.*—West Australia.

Calomela ioptera, Baly.

This is a very variable species. I have several specimens in which the elytra are quite concolourous with the prothorax, and the punctures not purplish; others with purplish punctures (as described by Dr. Baly); others in which the entire elytra are purple; and yet others in which the elytra appear purple from some directions and bright metallic blue (or green) when the view is altered. The punctures are coarsest in the largest specimens. The size

* T.E.S., 1856, p. 241. † P.L.S., N.S.W., 1888, p. 1490.

varies from 6 to 10mm. My specimens are from Galston, Sydney, Manning River, and near Jenolan Caves.

It is quite possible that this species is the *Chrysomela nitidipennis* of Dejean and Boisduval.

CALOMELA CRASSICORNIS, Fabr.

It appears to be difficult to obtain two specimens of this species exactly alike in all details, so that its varieties are legion.

CALOMELA CAPITATA, Jacoby.

I have a number of specimens which agree exactly with Mr. Jacoby's description of capitata. They were all taken in company with specimens of *ruficeps* (on various species of *Acacia*), and I have always regarded them as forming a (distinct) variety of that species.

C. MACULICOLLIS, Boi.

Hab.—N.S.W.; T.; W.A.

C. RUFICEPS, Boi.

Hab.—N.S.W. (coastal regions).

C. PALLIDA, Baly.

Hab.—N.S.W.: Armidale; Q.: Brisbane, Cairns.

C. DIGGLESI, Baly.

Hab.—N.S.W.: Tweed River.

C. VITTATA, Baly.

Hab.—N.S.W.

C. PULCHELLA, Baly.

Hab.—N.S.W.: Galston.

C. SUTURALIS, Jacoby.

Hab.—N.W.A.

C. FLAVESCENS, Blackb.

Hab.—N.S.W.: Richmond River.

C. SATELLES, Blackb.

Hab.—W.A.: Beverley, Geraldton.

C. IMPERIALIS, Blackb.

Hab.—N.S.W.: Whitton.

C. GENICULATA, Baly.*

Hab.—Cairns.

C. TARSALIS, Blackb.*

Hab.—Cairns.

* These species are not included in the tabulation, as they were returned to the Macleay Museum before it was prepared.

- **Prothorax testaceous or reddish, immaculate.**
  - **Elytra concolourous with prothorax, immaculate.**
    - Elytra coarsely and irregularly seriate-punctate ... *ioptera*, Baly.
    - Elytra regularly seriate-punctate.
      - Prothoracic punctures coarser at sides than in middle.
        - Antennæ entirely pallid ... ... *intemerata*, n.sp.
        - Antennæ pallid at base only.
          - Head coarsely punctate ... ... *pallida*, Baly.
          - Head finely punctate ... ... *cephalotes*, n.sp.
      - Prothoracic punctures no larger at sides than in middle.
        - Brownish-red ... ... *monochromatea*, n.sp.
        - Pale flavous ... ... *flavescens*, Blackb.
  - **Elytra** maculate ... ... *crassicornis*, Fabr.*
  - **Elytra** darker than prothorax and not striped.
    - Head partly blue... ... ... *amethystina*, n.sp.
    - Head entirely pallid.
      - Elytra irregular behind shoulders.
        - Elytra greenish ... ... *pulchella*, Baly.
        - Elytra black ... . *nigripennis*, n.sp.
      - Elytra regular behind shoulders.
        - Prothorax coarsely punctate in middle as well as at sides ... ... *ioptera*, Baly.*
        - Prothorax almost impunctate in middle ... *viridipennis*, n.sp.
  - **Elytra** striped.
    - Suture blue (or green) ... ... *suturalis*, Jac.
    - Suture concolourous with prothorax (sometimes narrowly infuscate)
      - Head partly black.
        - Scutellum black ... ... *nigricornis*, n.sp.*
        - Scutellum not black ... ... *vittata*, Baly.
      - Head not at all black.
        - Markings of elytra narrow and curved ... *juncta*, n.sp.
        - Markings wider and straight.
          - Markings bright blue or green ... ... *parilis*, n.sp.
          - Markings "dusky violaceous," the punctures with a greenish or bluish gloss *satelles*, Blackb.
- **Prothorax** entirely dark.
  - **Head** red ... ... *ruficeps*, Boi.
  - **Head** (except for metallic shades) concolourous with prothorax.
    - Upper surface of one shade of colour.
      - Black ... ... *nigra*, n.sp.
      - Blue ... ... *cœlestis*, n.sp.
    - Upper surface with various metallic shades of colour.
      - Each elytron with ten rows of punctures.
        - Clypeus with strong and dense punctures *punctifrons*, n.sp.
        - Clypeus sparsely and minutely punctate... *fugitiva*, n.sp.
      - Each elytron with more than ten rows of punctures ... ... *imperialis*, Blackb.
- **Prothorax maculate.**
  - **Elytra** maculate.
    - **Markings** transverse ... ... *Digglesi*, Baly.
    - **Markings** longitudinal ... ... *crassicornis*, Fabr.*
  - **Elytra** striped or uniformly coloured.
    - **Head** partly black.
      - **Elytra** with a black sutural stripe ... ... *gloriosa*, n.sp.
      - **Elytra** at most infuscate along suture ... *nigricornis*, n.sp.*
      - **Elytra** uniformly coloured ... ... *maculicollis*, Boi.
    - **Head** entirely red ... ... *Curtisi*, Kirby.

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* In part.

STETHOMELA LATERALIS, n.sp.

Bluish-violet, with a more or less greenish gloss, especially on the head; sides of prothorax pale yellow; under-surface (except prosternum) black, with a bluish or greenish gloss; muzzle, antennæ (apical joints infuscate), and legs red.

Head with sparse punctures around the margins, becoming moderately numerous and larger at the base; clypeus punctate, its suture deep (from its middle a depressed line extends half-way to the vertex, but traceable to the base). *Prothorax* more than twice as wide as long, with minute scattered punctures, and with moderately large punctures confined to the dark portion, where they are condensed into three feeble clusters (extreme base on each side with larger shallow punctures). *Elytra* not much wider than prothorax, each with ten rows (the first short) of distinct punctures of moderate size, but becoming very small posteriorly, transversely impressed below shoulders; epipleuræ transversely wrinkled posteriorly. *Tibiæ* strongly arcuate. Length $7\frac{2}{3}$, width 6mm.

Hab.—Cairns (type in Macleay Museum).

In build resembling *limbata*, but very differently coloured, and with tibiæ more strongly curved than in any other species known to me. The yellow portion of the prothorax occupies more than half the surface.

STETHOMELA DISCORUFA, n.sp.

*. Head black, with a greenish gloss; under-surface (except prosternum and middle of metasternum) and legs (except anterior femora) black; antennæ brownish-black, the two basal joints diluted beneath; prothorax lemon-yellow, a wide median patch (dilating to base) stained with red, a narrow irregular transverse line at base greenish-black; scutellum and elytra deep black, the latter with the sides narrowly testaceous, the border angularly dilated near and continued across apex; disc on each side with an almost circular reddish macula extending across four interstices.

Head very finely and sparsely punctate; clypeus separated (but not throughout) from the face by a rather deep groove, from the middle of which a distinct impressed line extends backwards to the base. *Prothorax* more than thrice as wide as the length down middle, with very minute scattered punctures, and with small sparse punctures on disc and on each side of middle at base. *Elytra* with regular series of small

* Male.

punctures, becoming smaller towards apex and sides; interstices with sparse minute punctures, feebly transversely impressed behind shoulders. Length 7½, width 5½mm.

Hab.—N.Q.: Cairns (Macleay Museum).

Appears to be allied to *caudata*, but the head of that species is described as "*fortiter sat crebre . . . . . punctulatis*"; in shape it approaches *limbata*. The punctures on the paler portions of the elytra are surrounded by watery rings.

A female specimen (having simple claws), which possibly belongs to this species, is entirely reddish, except for the elytra; these are deep black, with the apical fourth and a large irregularly rounded patch on each elytron (covering six interstices) reddish; the head also is without an impressed median line.

STETHOMELA T-SPLENDENS, n.sp.

*. Upper-surface deep metallic purplish-green, with coppery-violet reflections in places, but apparently constant in middle of base of prothorax and suture of elytra; epipleuræ violet. Under-surface coloured almost as upper, but the violet reflections almost absent; legs and antennæ testaceous.

Head flat, without median line; a few small punctures between eyes and on clypeus. *Prothorax* highly polished, about twice as wide as long; disc with a very few small punctures, base and sides with more numerous (but still rather sparse) and larger (but rather small) punctures. *Elytra* with regular series of small and rather distinct punctures, becoming very small towards apex; behind shoulders rather strongly transversely impressed, and with a single fovea on the tenth series of punctures; interstices with very minute and scarcely traceable punctures; epipleuræ finely wrinkled on apical two-thirds. Intercoxal process of *prosternum* with a few very distinct punctures. Length 6, width 4¼mm.

Hab.—N.S.W.: Tweed River.

A small compact species, in shape resembling *limbata*, the violet markings of the elytra forming (from some directions) a distinct T.

STETHOMELA CUPRIPES, n.sp.

*. Deep metallic blue, from the sides appearing almost purple; clypeus coppery-violet. Under-surface black, with

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* Male.

a coppery gloss; legs metallic coppery; antennæ pale yellow.

Head finely and sparsely punctate; clypeus separated form the face by a deep groove, from the middle of which an impressed line extends backwards to the base. *Prothorax* about twice as wide as long; disc impunctate, base (except in middle) with a few moderately large punctures, each side near base and each side near the anterior angles with a few punctures. *Elytra* with regular rows of small punctures, becoming smaller towards apex; interstices with sparse minute punctures, behind shoulders moderately transversely impressed. Length $8\frac{2}{3}$, width $5\frac{2}{3}$mm.

Hab.—N.Q.: Barron Falls (Mr. A. Koebele), Cairns (Macleay Museum).

The shape approaches that of *prasina*; the coppery tone of the legs is continued even to the tarsi.

Stethomela chlorophana, n.sp.

*. Upper-surface of a delicate pale (almost transparent) green; scutellum, under-surface, legs (the third tarsal joint brown or not), antennæ (the terminal and basal joints feebly infuscate), and muzzle pale yellow, and with or without a feeble greenish tinge.

Head feebly punctate, a feeble impression in middle starting from clypeal suture, but not extending to vertex. *Prothorax* scarcely twice as wide as long, with very minute punctures, and with scattered larger punctures, except on disc. *Elytra* with series of moderate-sized punctures, placed at irregular intervals, but never very close, and becoming very small towards apex; interstices scarcely visibly punctate; behind shoulders very feebly impressed, but the punctures there larger than elsewhere. Length 5, width $2\frac{3}{4}$mm.

Hab.—N.S.W.: Clarence River.

A singularly delicate species, allied to *prasina*, but differing considerably in the size and punctures. The locality given is the most southerly record as yet for the genus.

Stethomela prasina, Baly.

This species sometimes has the head and prothorax concolourous with the under-surface, sometimes the prothorax is tinged with pale green on all its borders, and sometimes it is entirely green.

* Male.

Stethomela limbata, Baly.

I have two specimens of this species, in which the elytra (except at the sides) are dark (somewhat purplish) blue; one of them has a spot on each side of the prothorax, but none in middle; the other has the prothorax immaculate.

S. submetallica, Baly.

Hab.—Cairns.

S. poroptera, Baly.

Hab.—N.S.W.: Richmond River; Q.: Cairns.

S. cornuta, Baly.

Hab.—Q.: Somerset, Mount Dryander.

S. fulvicollis, Jacoby.

Hab.—Q.: Cairns.

Mandibles of male projecting	*cornuta*, Baly.
Mandibles not projecting.	
Elytra maculate.	
Head strongly and irregularly punctate	*caudata*, Blackb.
Head scarcely visibly punctate	*discorufa*, n.sp.
Elytra with a pallid margin but not maculate ...	*limbata*, Baly
Elytra unicolourous.	
Colour pale green and not at all metallic.	
Size large	*prasina*, Baly.
Size small	*chlorophana*, n.sp.
Elytra metallic.	
Prothorax unicolourous	*fulvicollis*, Jacoby. *submetallica*, Baly.
Prothorax with pallid margins	*lateralis*, n.sp.
Entire upper surface more or less metallic.	
Legs metallic and dark	*cupripes*, n.sp.
Legs non-metallic and more or less red.	
Sides coarsely and irregularly punctate ...	*poroptera*, Baly.
Sides not coarsely punctate.*	
Elytra with double series of punctures...	*fraternalis*, Baly.
Elytra with single series of punctures	
Antennæ entirely pallid	T-*splendens*, n sp.
Antennæ with apical joints black ...	*Parryi*, Baly.

Augomela ignita, n.sp.

Of a fiery metallic copper, sometimes with a slight greenish tinge; under-surface and legs more or less diluted; antennæ at base (the apex infuscate) and palpi red.

Head impunctate, except for a few punctures near eyes; clypeus distinctly punctate, its suture somewhat sinuous, from its middle an impressed line traceable almost to base.

* Sometimes a few large punctures or foveæ behind shoulders.

Prothorax with sparsely scattered but distinct punctures, becoming larger on each side of base, and sparser (and no larger) at sides than elsewhere. *Elytra* not much wider than prothorax, each with ten rows of small punctures; interstices impunctate; below shoulders feebly impressed. Length 5½, width 3½mm.

Hab.—Illawarra (types in Macleay Museum).

The two specimens under examination agree in all details, except for slight shades of colour.

A. ELEGANS, Baly.

Hab.—Richmond River.

A. HYPOCHALCEA, Germ.

Hab.—N.S.W.: Wentworth, Forest Reefs.

ELAPHODES LARINUS, n.sp.

Briefly ovate, clothed with short white pubescence, denser on under than on upper surface; on elytra longer hairs, forming a feeble fascia at base, and a more distinct one beyond middle. Testaceous, head and elytra testaceous red; base of elytra and prothorax very narrowly margined with black.

Densely punctate all over, punctures of head coarser than elsewhere. Head shallowly but rather distinctly impressed. Basal lobe of prothorax notched. Elytra seriate, towards sides striate-punctate; apical portion confusedly punctate. Length 5⅓mm.

Hab.—N.W.A.: Behn River (Mr. R. Helms).

A short broad species, which should be very distinct, owing to the entire absence (except at extreme base) of dark elytral markings.

ELAPHODES ILLOTUS, n.sp.

Ovate; moderately densely clothed with rather stout hairs, each of which (except a few which are entirely white) is stramineous at base and white at apex; under-surface with longer and white pubescence. Testaceous brown; prothorax and elytra at base narrowly margined with black; each elytron with two large transverse blotches, one on the shoulder and one beyond middle; prothorax and elytra with small and obscure piceous blotches; femora tinged in places with piceous.

Densely punctate all over. Head gently concave, and distinctly impressed between eyes. Prothoracic lobe obtuse. Elytra feebly punctate-striate, the striæ appearing to be moderately distinct, owing to infuscation; towards base distinctly, elsewhere feebly transversely, strigose. Length $5\frac{1}{3}$mm.

Hab.—N.S.W.: Inverell.

Of the size of *Dohrni*, *rutilus*, and *murinus*, but very differently marked.

ELAPHODES OBLONGUS, n.sp.

Briefly oblong-ovate; clothed with pale yellowish hair, rather longer, sparser, and darker on upper than on under surface; head with longer hairs (almost concentrically arranged) than elsewhere. Reddish-brown; antennæ, legs, and abdomen paler; elytra reddish, with markings the colour of prothorax.

Densely punctate all over; punctures, especially of head and prothorax, clearly cut. Basal lobe of prothorax slightly notched. Elytra striate—strongly at sides, feebly towards middle; shoulders and basal portion of suture feebly transversely wrinkled. Length 4-$4\frac{2}{3}$mm.

Hab.—Thursday Island (Macleay Museum).

Regarding the paler portions as forming the ground-colour of the elytra, the brown markings consist of a rather narrow basal fascia, which opens out into an elliptic spot on suture (and which does not quite extend to middle), a post-median fascia rather broad towards sides, and narrowed towards suture, and extending to apex from suture and sides, so that a somewhat triangular space is enclosed near the apex of each elytron. Appears to be close to *amictus*, but is larger, and the elytral markings not black; *rufovarius* is described as having the elytra trifasciate.

E. EPILACHNOIDES, Chp.

Hab.—N.S.W.: Tamworth.

E. TIGRINUS, Chp.

Hab.—N.S.W.: Widely distributed.

E. PILULA, Chp.

Hab.—N.S.W.: Glen Innes.

PRASONOTUS RUFICAUDIS, Baly.

Hab.—N.S.W.

DITROPIDUS INTONSUS, n.sp.

Briefly ovate; moderately densely clothed with pure white pubescence. Coppery; under-surface obscure coppery-green; antennæ, mouth-part, and legs (tarsi infuscate) red.

Head and prothorax very indistinctly punctate, the former very feebly longitudinally impressed; basal lobe of the latter entire, but feebly transversely depressed. Elytra with about three distinct lateral striæ, elsewhere very feebly impressed; punctures dense, but very small and indistinct, from some directions appearing to form feeble series. Length $2\frac{3}{4}$mm.

Hab.—N.S.W.: Whitton.

The clothing is longer and more distinct than in any other species with which I am acquainted.

DITROPIDUS HOLOPORPHYRUS, n.sp.

Briefly ovate; rather sparsely clothed with very fine whitish pubescence. Purple; mouth-parts, antennæ, and tarsi testaceous; scutellum coppery.

Head moderately densely punctate, from some directions appearing to be feebly wrinkled between eyes; median line feebly impressed. Prothorax with small but distinct punctures, larger towards base and sides than elsewhere; basal lobe feebly notched. Elytra nowhere striate, but with rather small punctures arranged in numerous (between 20 and 30 on each elytron) series, punctures rather larger towards sides than in middle. Length 4mm.

Hab.—Sydney.

A lovely species. The specimen described was beaten from drying Eucalyptus leaves.

DITROPIDUS VIRIDIŒNEUS, n.sp.

Oblong-ovate; bright metallic coppery green; apex of elytra almost white; mouth-parts, antennæ, abdomen, and legs testaceous; sterna dark coppery green.

Head feebly rugose; median line feebly impressed. Prothorax microscopically punctate, and rather densely (especially at sides) and briefly longitudinally strigose; basal lobe feebly notched. Elytra seriate—the sides striate-punctate; interstices very finely punctate, and indistinctly wrinkled. Length 2mm.

Hab.—W.A.: Bunbury.

A handsome species. In this and all the following species the prothorax and elytra are entirely glabrous.

DITROPIDUS XANTHURUS, n.sp.

Briefly ovate; coppery-bronze; mouth-parts, antennæ (apical joints infuscate), legs, part of abdomen, pygidium (and the elytra narrowly at apex) yellowish-red; sterna black.

Head transversely and obliquely finely wrinkled; median line distinct. Prothorax strigose in middle, becoming at sides very densely and finely corrugated; punctate only in middle; basal lobe notched. Elytra seriate—towards sides striate-punctate; interstices not visibly punctate. Length $2\frac{3}{4}$mm.

Hab.—W.A.: Karridale, Bunbury, Swan River.

The abdomen is sometimes wholly black, except for a narrow border; sometimes the black forms a subquadrate basal patch of the three first segments, in several specimens the red is continued to flanks of metasternum. The species differs from *apiciflavus* in being much shorter, with less parallel sides, not tinged with green, by the corrugations at sides of prothorax, &c. In colour (except as to being coppery) it agrees with the description of *lœvigatus*, but that species is said to have the prothorax impunctate.

Ditropidus nigripennis, n.sp.

Oblong-ovate; pale reddish-testaceous; elytra black, with a slight bluish gloss, the extreme apex and margins very feebly diluted with red; apical joints of antennæ infuscate.

Head feebly wrinkled; median line scarcely traceable. Prothorax impunctate; basal lobe entire. Elytra seriate, sides striate-punctate; interstices impunctate. Length $2\frac{1}{2}$-3mm.

Hab.—N.S.W.: Galston (Dumbrell and Lea), Tamworth (Lea).

The dark elytra, in striking contrast to the rest of the body, should render this species peculiarly distinct. At a glance it is not unlike *Pascoei*, but that species has part of the under-surface dark.

Ditropidus elutus, n.sp.

Oblong-ovate. Head and prothorax red; elytra black, each diluted with red in middle; mouth-parts, antennæ, and legs testaceous; sterna and abdomen black.

Head rather sparsely and finely punctate; median line indistinct. Prothorax almost invisibly punctate; basal lobe feebly notched. Elytral seriate-punctate, punctures very distinct; sides deeply striate. Length $2\frac{1}{2}$mm.

Hab.—N.S.W.: Forest Reefs.

Apparently not very close to any species hitherto described.

Ditropidus mandibularis, n.sp.

*. Oblong-ovate; black, with a slight bronzy gloss; mouth-parts, base of antennæ, knees, and pygidium obscure testaceous; prothorax red, but largely stained with piceous.

Head densely punctate; median line distinct; mandibles large and prominent. Prothorax with moderately dense and large punctures, becoming substrigose at sides; basal lobe acutely notched. Elytra seriate, sides striate-punctate; interstices very indistinctly wrinkled. Length 3⅓mm.

†. Differs in having the head and mandibles smaller and the prothorax narrower at apex.

Hab.—Swan River.

Allied to *fugitivus*, but considerably different in colour. The piceous stain on the prothorax covers almost the entire apical half, and is connected with base along middle and towards each side.

Ditropidus subsimilis, n.sp.

†. Oblong-ovate; black; the elytra with a slight coppery or greenish gloss; prothorax (including flanks of prosternum) red, except at extreme base and apex; mouth-parts and base of antennæ obscure testaceous.

Head densely punctate; median line distinct. Prothorax distinctly but not densely or strongly punctate, and nowhere strigose; basal lobe acutely notched. Elytra seriate—the sides striate-punctate; interstices impunctate. Length 3⅓mm.

Hab.—W.A.: Geraldton.

Allied to *fugitivus*, but the head (except mouth-parts) entirely dark. I have three specimens (all females) under examination. A specimen from Queanbeyan (New South Wales) differs in having the median line of the head more distinctly impressed, the elytra without a coppery gloss, and the black basal margin of the prothorax slightly wider.

Ditropidus nigricollis, n.sp.

Briefly elliptic ovate; pale testaceous; head stained with piceous towards sides and base; prothorax, basal eighth of elytra, sterna, and basal segments of abdomen (except at sides) deep black.

Head indistinctly punctate; median line feeble. Prothorax with the basal lobe but feebly produced and obtuse; very densely and finely longitudinally corrugated throughout. Elytra striate-punctate, punctures distinct, but striæ

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* Male. † Female.

feeble towards suture; interstices impunctate. Length 2mm.

Hab.—N.S.W.: Loftus.

The colour, corrugations, and shape of the prothorax at the base render this species very distinct. The complete longitudinal corrugations of the prothorax are seen in the following species, but in no other with which I am acquainted.

Ditropidus corrugatus, n.sp.

Very briefly ovate. Head and prothorax coppery; pygidium and elytra pale testaceous; suture of the latter narrowly black, two small black spots on each at base; one on humeral callus, and one between it and suture, punctures slightly infuscate; under-surface black; palpi, base of antennæ, and parts of tibiæ obscure testaceous.

Head and prothorax densely and finely longitudinally corrugated; the former with median line very distinct. Prothorax with a few very indistinct punctures scattered about; basal lobe notched. Elytra seriate-punctate, sides with two feeble striæ; interstices densely and very finely transversely wrinkled, sides (especially towards base) very indistinctly wrinkled. Length $2\frac{3}{4}$mm.

Hab.—Swan River.

In colour resembling some of the varieties of *pictus*, but the prothorax very differently sculptured.

Ditropidus tarsalis, n.sp.

Briefly ovate; head piceous, diluted in front; prothorax and elytra of a peculiar reddish-yellow, the former with a large chocolate-brown transverse blotch occupying the greater part of the surface, but nowhere touching the margins, its base (and base and suture of elytra) narrowly black, punctures more or less infuscate; under-surface black; antennæ, knees, anterior tibiæ (with part of femora), and all the tarsi testaceous.

Head moderately densely punctate; median line strongly impressed; eyes rather larger than usual. Prothorax sparsely and indistinctly punctate; basal lobe acutely notched. Elytra seriate-punctate, sides with two or three feeble striæ; interstices very indistinctly transversely wrinkled. Length $3\frac{1}{2}$mm.

Hab.—N.S.W.: Armidale.

The elytral punctures are slightly infuscated, otherwise they would be invisible; the transverse wrinkles are visible only in certain lights (in certain lights there appear to be very feeble striæ along the lines of punctures). The colour of the elytra is something like that of *antennarius*. Compared with the description of *rufescens*, this species appears to be larger, prothorax not at all strongly punctured, and there appear to be a number of differences in colour.

DITROPIDUS LÆVICOLLIS, n.sp.

Briefly ovate; testaceous; head and prothorax tinged (but not very strongly) with piceous, but having a very decided coppery gloss, and which is continued on to base of elytra, its base (and base and suture of elytra) narrowly black, punctures infuscate; sterna and legs in places (and all the tarsi) infuscate.

Head not densely punctate; median line feebly impressed. Prothorax not very densely punctate, but punctures clearly defined, becoming slightly strigose at base near sides; basal lobe notched. Elytra seriate-punctate, sides unistriate; interstices almost invisibly wrinkled. Length 2mm.

Hab.—W.A.: Pinjarrah, Swan River, Darling Ranges, Vasse.

The prothorax at a glance appears to be coppery, but when closely examined it is seen to possess but a coppery gloss, being really testaceous, with a slight piceous tinge.

DITROPIDUS PULICOSUS, n.sp.

Oblong-ovate; testaceous red; head black, except in front, or at base only, or entirely red; prothorax narrowly stramineous at sides and apex; elytra stramineous, punctures infuscate, base and suture with base of prothorax narrowly black.

Head coarsely punctate; median line deeply impressed. Prothorax moderately punctate at sides, not strigose, but punctures sometimes slightly elongate; basal lobe obtuse. Elytra seriate-punctate, the sides feebly bistriate; interstices impunctate. Length 3mm.

Hab.—W.A.: Bridgetown.

The elytral punctures would be moderately distinct by themselves, but, being infuscated, they are rendered very distinct. In colour the species appears to approach *pallidipennis*, except that the abdomen is not paler than the sterna, but the punctures are very different.

DITROPIDUS INSULARIS, n.sp.

Briefly ovate; dull blue, in places with purple reflections, sides with coppery reflections; under-surface and pygidium black; mouth-parts, antennæ, and legs (except part of posterior femora) red.

Head densely and between the eyes coarsely punctate; median line distinctly impressed in front. Prothorax with dense clearly-cut punctures; basal lobe feebly notched. Elytra indistinctly seriate-punctate, sides tristriate, inner stria distinct only on apical half; interstices very finely rugulose. Length 3⅓mm.

Hab.—W.A.: Rottnest Island.

A specimen differs in having the legs (except apex of tibiæ) and the tarsi black.

Ditropidus cœlestis, n.sp.

Briefly oblong-ovate; steely-blue; the elytra with purplish reflections; palpi, antennæ (except at apex), extreme apex of tibiæ, and apical joints of tarsi obscure red.

Head densely punctate; median line deeply impressed in middle. Prothorax with dense, round, clearly-cut punctures, nowhere elongate or confluent; basal lobe entire. Elytra seriate-punctate, sides on apical half tristriate; interstices faintly rugulose. Length 4½mm.

Hab.—W.A.: Geraldton.

The elytral punctures are very distinct, and there are frequently a few in the vicinity of the regular series, so that these in places appear to be somewhat irregular; the punctures of the prothorax are remarkably uniform. The species resembles the blue variety of *concolor* to a certain extent, but may be at once distinguished by its punctures.

Ditropidus vigilans, n.sp.

Very briefly ovate; blue; the prothorax with a feeble greenish gloss; the elytra, under-surface, and legs somewhat purplish; labium, palpi, and basal part of antennæ obscure testaceous.

Head sparsely punctate; eyes large, and very much closer together than is usual. Prothorax with very small and indistinct punctures; basal lobe entire. Elytra seriate-punctate, the punctures rather strong, sides tristriate; interstices impunctate. Length 2¾mm.

Hab.—N.S.W.: Tweed River.

The eyes are much larger and more approximate than is usual, and this (combined with the colour) should render the species (which to a certain extent resembles many of the *Saprini*) very distinct. Quite possibly, had this species been before Dr. Chapins, he would have referred it to *Cœnobius*; it seems, in fact, fairly close to his *C. lucidulus*, but differs in being larger, upper-surface almost uniformly coloured, legs darker, scutellum without basal notch, &c.

Ditropidus striato-punctatus, n.sp.

Briefly ovate; black; legs piceous-black, base of antennæ obscure testaceous.

Head with rather small punctures; median line distinctly impressed. Prothorax densely (especially at sides) and finely aciculate-strigose; basal lobe entire. Elytra striate-punctate, punctures much larger than is usual, median striæ feeble, the lateral deeply impressed; interstices scarcely visibly rugulose. Length 2⅓mm.

Hab.—W.A.: Darling Ranges.

Ditropidus melasomus, n.sp.

Oblong-ovate; black; mouth-parts, antennæ, anterior tibiæ, and all the tarsi testaceous.

Head moderately densely punctate; median line distinctly impressed. Prothorax distinctly but not very densely or coarsely punctate. Elytra seriate-punctate, punctures very distinct, sides tristriate; interstices impunctate. Length 3mm.

Hab.—N.S.W.: Forest Reefs.

Appears to be close to *gagatinus*, but that species is described as having the first joint of the antennæ blackish.

Ditropidus sobrinus, n.sp.

Oblong-ovate; black; antennæ (except at apex), mouth-parts, anterior legs, and tarsi obscure testaceous.

Head coarsely punctate; median line strongly impressed. Prothorax scarcely visibly punctate; median lobe obtuse. Elytra bistriate at sides, towards suture (except near apex) scarcely visibly seriate-punctate; interstices very faintly rugulose. Length 2¾mm.

Hab.—Swan River.

Ditropidus chalceus, n.sp.

Briefly oblong-ovate. Head and prothorax coppery, elytra bronzy, under-surface black, mouth-parts, antennæ, and legs red.

Head densely punctate; median line feebly impressed. Prothorax with dense clearly-cut punctures, at sides becoming somewhat confluent, but not strigose; basal lobe feebly notched. Elytra seriate-punctate, punctures rather small, but distinct, sides bi-(towards apex tri-) striate; interstices impunctate. Length 3⅓mm.

Hab.—Swan River.

In general appearance somewhat like *nitiduloides*, but with differently coloured legs.

Ditropidus strigiceps, n.sp.

Oblong-ovate; coppery; under-surface black; mouth-parts, antennæ (apex infuscate), and legs red.

Head transversely and obliquely strigose, and with a few punctures; median line moderately well impressed. Prothorax faintly punctate, punctures at the sides moderately distinct; basal lobe obtuse. *Elytra* faintly seriate-punctate towards suture, near sides much more strongly; sides tri-striate; interstices impunctate, from some directions apparently faintly rugulose. Length $2\frac{3}{4}$mm.

Hab.—N.S.W.: Galston (Mr. W. Dumbrell), Sydney, Glen Innes (Lea).

Differs from the preceding (which it strongly resembles) in the punctures of the head and prothorax. From the description of *ochropus*, it differs in having the posterior femora (not piceous but) red.

Ditropidus scitulus, n.sp.

Briefly ovate; coppery bronze, under-surface black; antennæ, palpi, and legs pale red.

Head sparsely punctate; median line invisible. Prothorax rather densely and (except at the sides, where the strigæ are longer) briefly strigose, and with small punctures scattered about; basal lobe acutely notched. Elytra seriate-punctate, punctures rather indistinct; sides tristriate; interstices densely and very finely wrinkled. Length 2mm.

Hab.—W.A.: Swan River, Geraldton.

Appears to be moderately close to *cupreus*, but the prothorax is differently sculptured, the legs are of a rather pale red, and the size is less than $2\frac{1}{2}$mm.

Ditropidus micans, n.sp.

Ovate; metallic green; head and sides with fiery copper reflections; disc of both prothorax and elytra with bluish, purplish, and coppery reflections; under-surface black, with a slight coppery gloss; antennæ, palpi, and legs pale red.

Head moderately punctate; median line faintly but distinctly impressed. Prothorax and elytra sculptured as in the preceding species. Length $2\frac{1}{6}$mm.

Hab.—W.A.: Geraldton.

The prothorax is punctate and strigose, and the elytra punctate and striate, as in the preceding species, from which, however, it may be distinguished by its more oval shape and by its very beautiful colour.

Ditropidus venustus, n.sp.

Very briefly ovate. Head and prothorax coppery, elytra bronzy-purple, pygidium coppery bronze; under-surface black, antennæ and palpi obscure testaceous, four anterior legs obscure piceous-red.

Head densely punctate; median line widely and rather faintly impressed; eyes rather larger than usual. Prothorax with dense clearly-cut punctures, sides strigose; basal lobe indistinctly notched. Elytra seriate-punctate, punctures very distinct, sides tristriate; interstices smooth and impunctate. Length 2½mm.

Hab.—Brisbane (Mr. A. J. Coates).

Possibly close to *cupreus trabeatus* or *angustifrons*, but in both specimens under examination the elytra are of a beautiful bronzy-purple, very different to the coppery tone of the prothorax.

Ditropidus lateralis, n.sp.

Briefly ovate; bluish; the head and the sides of prothorax and elytra with coppery reflections; under-surface black; mouth-parts, antennæ, tarsi, and extreme apex of tibiæ testaceous.

Head rather densely punctate; median line distinct. Prothorax with dense and distinct but not very clearly-cut punctures; basal lobe notched. Elytra faintly seriate-punctate, sides bistriate; interstices very faintly rugulose. Length 3¾mm.

Hab.—W.A.: Garden Island.

Ditropidus brachysomus, n.sp.

Very briefly oblong-ovate; black, the upper-surface with a slight bronzy or coppery gloss; basal joints of antennæ obscure testaceous.

Head with rather small punctures; median line faintly impressed. Prothorax (except at sides) not very distinctly punctate, sides tristrate; interstices faintly but distinctly rugulose. Length 2mm.

Hab.—W.A.: Geraldton.

Following is a tabulation of the species above described:—

- Pubescent.
  - Coppery, densely pubescent ... ... *intonsus.*
  - Purple, finely pubescent ... ... *holoporphyrus.*
- Glabrous.
  - Prothorax and elytra not entirely concolourous.
    - Elytra, except at apex, concolourous with prothorax.
      - Prothorax and elytra, except at apex, metallic coppery green ... ... *viridi-aeneus.*
      - Prothorax and elytra entirely without green tinge ... ... *xanthurus.*
    - Elytra darker than prothorax.
      - Under-surface entirely pale ... ... *nigripennis.*
      - Under-surface more or less black.
        - Elytra diluted with red in middle... *elutus.*
        - Elytra entirely uniform in colour.
          - Disc of prothorax stained ... *mandibularis.*
          - Disc of prothorax clear ... *subsimilis.*
    - Elytra paler than prothorax.
      - Prothorax densely longitudinally corrugated.
        - Abdomen and legs pallid ... ... *nigricollis.*
        - Abdomen and legs more or less black *corrugatus.*
      - Prothorax punctate, the sides sometimes strigsoe.
        - Sterna and abdomen black... ... *tarsalis.*
        - Sterna and abdomen pale (sterna sometimes infuscate).
          - Prothorax with a coppery gloss *laevicollis.*
          - Prothorax without a coppery gloss ... ... *pulicosus.*
  - Prothorax and elytra concolourous.*
    - Blue, sometimes with a purplish gloss in parts.
      - Tarsi pallid ... ... *insularis.*
      - Tarsi dark.
        - Prothorax with dense clearly cut punctures ... ... *cœlestis.*
        - Prothorax indistinctly punctate ... *vigilans.*
    - Black, without a coppery or bronzy gloss.
      - Prothorax strigose ... ... *striato-punctatus.*
      - Prothorax punctate.
        - Punctate striæ very distinct to suture *melasomus.*
        - Punctate striæ indistinct near suture *sobrinus.*
    - With a coppery or bronzy gloss, wholly or in part.
      - Legs entirely red.
        - Prothorax punctate.
          - Prothoracic punctures dense and clearly cut... ... ... *chalceus.*
          - Prothorax indistinctly punctate *strigiceps.*
        - Prothorax strigose, at least towards sides.
          - Prothorax and elytra uniformly bright coppery ... ... *scitulus.*
          - Derm with various reflections.. *micans.*
      - Legs more or less black.
        - Prothorax laterally strigose ... *venustus.*
        - Prothorax punctate.
          - Very distinctly so ... ... *lateralis.*
          - Feebly so ... ... *brachysomus.*

* Not always entirely concolorous, but never red or diluted with red; the colours usually metallic.

Ditropidus concolor, Saund.

This species is variable to a certain extent in size. Specimens may occasionally be taken which are of a bright blue colour. In Western Australia, where the species is very abundant, it is very destructive in spring to the young shoots and leaves of fruit trees; it occurs also on many wild plants. In New South Wales I have taken it on *Acacia decurrens* at Braidwood.

D. pubicollis, Chp.

Hab.—N.S.W.: Windsor, Tamworth.

D. subæneus, Chp.

Hab.—Tasmania.

D. punctulum, Chp.

Hab.—Sydney.

D. tibialis, Chp.

Hab.—N.S.W.: Armidale, Sydney.

D. frontalis, Chp.

Hab.—W.A.: Swan River, Pinjarrah.

D. fugitivus, Chp.

Hab.—Swan River.

D. antennarius, Chp.

Hab.—Brisbane.

D. cuneatus, Chp.

Hab.—N.S.W.: Cootamundra.

D. nitiduloides, Chp.

Hab.—N.S.W.: Near Jenolan Caves, Sydney.

D. maculifrons, Chp.

Hab.—W.A.: Geraldton.

D. apiciflavus, Chp.

Hab.—N.S.W.: Gosford, Armidale.

D. abdominalis, Chp.

Hab.—N.S.W.: Forest Reefs.

D. Suffriani, Chp.

Hab.—Forest Reefs.

D. CANESCENS, Chp.

Hab.—N.S.W.: Whitton.

D. LENTULUS, Suffr.

Hab.—Tasmania.

D. RUFIPES, Saund.

Hab.—N.S.W.: Gosford, Rhine Falls, Braidwood.

D. ODEWAHNI, Baly.

Hab.—N.S.W.: Whitton

D. ORNATUS, Baly.

Hab.—W.A.: Vasse

D. CARBONARIUS, Baly

Hab.—W.A.: Geraldton

D. PICTUS, Baly.

Hab.—Geraldton.

D. ELEGANTULUS, Baly

Hab.—N.S.W.

D. PASCOEI, Baly.

Hab.—Forest Reefs

D. DIMIDIATUS, Baly.

Hab—N.S.W.: Tamworth

LIST OF THE DESCRIBED COLEOPTERA OF TASMANIA.

By ARTHUR M. LEA.

THE Coleoptera of Tasmania have never been considered as a whole since the time of Erichson, ([a]) and no list or catalogue of the species has ever been compiled. About 10,000 species have now been recorded from Australia and Tasmania, of which scarcely 400 have been described from Tasmania. A very imperfect knowledge of what species are confined to the island exists, as species supposed only to occur there, are constantly being found in Victoria and New South Wales, and even sometimes in Western Australia and Queensland; on the other hand, Tasmanian collectors frequently obtain mainland species which have never been recorded from Tasmania.

I have considered it advisable, therefore, to prepare a list of the species hitherto recorded from Tasmania, adding to the list such species as I have seen in Tasmanian collections, or have myself taken in Tasmania. In this list, the genera and families are placed as far as possible in the order in which they appear in Masters' "Catalogue of the Described Coleoptera of Australia;" the species are placed alphabetically. All known synonyms have been omitted.

In the list an asterisk (*) has been placed after those species which are known to occur on the mainland, whilst another (†), has been placed after those species which have been introduced. Deducting the introduced species (40) there remain 1000 species and varieties, of which 423 are so far, known only from Tasmania; and one being known only from New Zealand and Tasmania; but probably many of these will be found to occur on the mainland, especially as the beetles of the Australian Alps (and Mount Kosciusko in particular) become better known.

When the Coleoptera of Tasmania have been thoroughly worked out, it will probably be found that there are over 2000 species, whilst in the whole of the Australian States, there are probably at least 20.000 species.

CARABIDÆ.

Calosoma Schayeri, Er.*
Lacordairia anchomenoides, Cast.
Erichsoni, Cast.

([a]) Wiegmann's Archives, 1842

Cymindis Illawarræ, Macl.*
Xanthophæa angustula, Chaud.*
infuscata, Chaud.*
Plagiotelum opalescens, Oll.
Diabaticus Australis, Er.
pauper, Blackb.
Anomotarus olivaceus, Chaud.*
Homethes elegans, Newm.*
guttifer, Germ.*
rotundatus, Blackb.*
Dromius Yarræ, Blackb.*
Pentagonica vittipennis, Chaud.*
Trigonothops lineata, Dej.*
longiplaga, Chaud.*
tridens, Newm.
Sarothrocrepis benefica, Newm.*
civica, Newm.*
corticalis, Fab.*
luctuosa, Newm.*
Ectroma grave, Blackb.
inquinita, Er.
Philophlæus eucalypti, *var.* Tasmaniæ, Blackb.
Agonocheila bicincta, Blackb.
binotata, White.*
biguttata, Chaud.*
corticalis, Chaud.*
sinuosa, Chaud.*
vittula, Chaud.*
Scopodes boops, Er.*
intermedius, Blackb.
Tasmanicus, Bates.
Silphomorpha decipiens, Westw.*
Tasmanica, Cast.
Adelotopus hœmorrhoidalis, Er.*
Tasmani, Blackb.
Carenum politum, Westw.*
Scaraphites insulanus, Sln.
Macleayi, Westw.*
rotundipennis, Dej.*
Clivina heterogena, Putz.*
lepida, Putz.*
vagans, Putz.*
Promecoderus Bassii, Cast.
brunnicornis, Dej.*
gibbosus, Gray.
modestus, Cast.

Promecoderus ovicollis, Cast.*
subdepressus, Guer.
Tasmanicus, Cast.
Percosoma carenoides, White.
percoides, Cast.
sulcipenne, Bates.
Lychnus ater, Putz.*
Gnathaphanus Adelaidæ, Cast.*
Anisodactylus rotundicollis, Cast.*
Diaphoromerus Australasiæ, Dej.*
australis, Dej.*
mæstus, Dej.*
quadricollis, Chaud.*
rectangulus, Chaud.*
Hypharpax inornatus, Germ.*
latiusculus, Chaud.*
Thenarotes Tasmanicus, Bates.
discoideus, Blackb.*
Notophilus niger, Blackb.*
parvus, Blackb.*
Harpalus promptus, Er.
verticalis, Er.
vestigialis, Er.
Drimostoma alpestre, Cast.*
Oopterus Tasmanicus, Cast.
Amblytelus curtus, Fab.*
Pterostichus coracinus, Er.
Catadromus Lacordairei, Boi.*
Notonomus chalybeus, Dej.*
politulus, Chaud.
tubericauda, Bates.
Rhabdotus Diemenensis, Cast.
floridus, Bates.
reflexus, Chaud.
Rhytisternus cyathoderus, Chaud.*
liopleurus, Chaud.*
miserus, Chaud.*
Chlænioidius prolixus, Er.*
Leptopodus subgagatinus, Cast.*
Loxandrus gagatinus, Cast.
Hormochilus monochrous, Chaud.*
Simodontus elongatus, Chaud.*
orthomoides, Chaud.*
sexfoveatus, Chaud.*
Dichrochile minuta, Cast.*
punctipennis, Cast.*

Lestignathus cursor, Er.
Simsoni, Bates.
Cyclothorax ambiguus, Er.*
Platynus marginellus, Er.*
nigro-aeneus, Newm.*
Colpodes australis, Er.
dilatatus, Er.
Trechus Diemenensis, Bates.
Simsoni, Blackb.
Tasmaniæ, Blackb.
Trechodes gibbipennis, Blackb.
Bembidium Hobarti, Blackb.
Tachys captus, Blackb.*

DYTISCIDÆ.

Pelobius Australasiæ, Clark.*
Sternopriscus Tasmanicus, Sharp.
Antiporus interrogationis, Clark.*
Macroporus Gardneri, Clark.*
Howitti, Clark.*
Necterosoma costipenne, Lea.
penicillatum, Clark.*
Schmeltzi, Sharp.*
Wollastoni, Clark.*
Antiporus femoralis, Boh.*
Platynectes 10-punctatus, Fab.*
obscurus, Sharp.
Tasmaniæ, Clark.
Lancetes lanceolatus, Clark.*
Rhantus pulverosus, Steph.*†
Copelatus nigritulus, Sharp.*
simplex, Clark.
Hyderodes Shuckhardi, Hope.*
Chostonectes gigas, Hope.*
Cybister tripunctatus, Oliv.*
Homœodytes insularis, Hope.
Eretes australis, Er.*
Hydaticus ruficollis, Fab.

GYRINIDÆ.

Macrogyrus Howitti, Clark.*
obliquatus, Aubé.*

HYDROPHYLLIDÆ.

Hydrobaticus australis, Blackb.*
Cercyon dorsalis, Er.

STAPHYLINIDÆ.

Falagria Fauveli, Sol.*
pallipes, Oll.*
Silusa melanogastra, Fvl.*
Aleochara actæ, Oll.*
baliola, Oll.
hæmorrhoidalis, Guer.*
punctum, Fvl.*
speculifera, Er.*
Poylobus apicalis, Fvl.*
cinctus, Fvl.*
insecatus, Fvl.*
Tasmanicus, Oll.
Pelioptera astuta, Oll
Calodera atypha, Oll.
carissima, Oll.
eritima, Oll.*
inæqualis, Fvl.*
pachia, Oll.
Simsoni, Oll.
Homalota atyphella, Oll.*
chariessa, Oll.
coriaria, Kraatz.*†
indefessa, Oll.
pavens, Er.*†
psila, Oll.
sordida, Marsh.*†
Leucocraspedum lugens, Blackb.*
validum, Blackb.*
Conosoma activum, Oll.
australe, Er.*
enixum, Oll.*
fumatum, Er.
Tachyporus vigilans, Oll.
Cryptommatus Jansoni, Matth.
Tachynoderus hæmorrhous, Fvl.*
Heterothops picipennis, Fvl.*
Quedius cuprinus, Fvl.*
Diemensis, Blackb.
hybridus, Grav.*
ruficollis, Grav.*
Sidneensis, Fvl.*
Creophilus erythrocephalus, Fab.*
var. lanio, Er.*
Philonthus aeneus, Rossi.*†
discoideus, Grav.*†

Philonthus longicornis, Steph.*†
nigritulus, Grav.*†
sordidus, Grav.*†
Cafius amblyterus, Oll.
areolatus, Fvl.*
laetabilis, Oll.*
læus, Oll.*
littoralis, Fvl.*
pacificus, Er.
sabulosus, Fvl.*
sericeus, Holme.*†
Xantholinus chloropterus, Er.*
cyanopterus, Er.*
Leptacinus socius, Fvl.*
Metoponcus enervus, Oll.
Sunius guttula, Fvl.*
Scymbalium simplarium, Fvl.*
Pæderus australis, Guer.*
cingulatus, Macl.*
Simsoni, Blackb.
Pinophilus rufitarsis, Fvl.*
Oxytelus collaris, Er.
discipennis, Fvl.*
melas, Fvl.*
semirufus, Fvl.*
subaeneus, Fvl.*
vulneratus, Fvl.*
Wattsensis, Blackb.
Trogophlæus exiguus, Er.*†
punctatus, Fvl.*
Amphichroum Adelaidæ, Blackb.*
Homalium Morrisi, Blackb.
philorhinoides, Fvl.*
Tasmanicum, Blackb.

Pselaphidæ.

Eupines aurora, Schfs.
Eupinopsis perforata, Schfs.
Ctenisophus morosus, Raffr.
Schaufussia formosa, King.*
Rytus punctatus, King.*
Tychius Tasmaniæ, Schfs.
Batrisus australis, Er.
Bryaxis atriceps, Macl.*
electrica, King.*
hyalina, Schfs.*

Bryaxis laticlava, Schfs.
melanocephala, Schfs.
picta, Schfs.
var. aethiops, Schfs.
var. ebenifer, Schfs.
var. frontalis Schfs.
var. verticalis, Schfs.
sobrina, Schfs.
strigicollis, Westw.*
talpa, Schfs.
vitrea, Schfs.
Articeros curvicornis, Westw.*

SILPHIDÆ.

Ptomaphila lachrymosa, Schreib.*
Choleva antipodum, Blackb.*
australis, Er.*
Anisotoma Tasmaniæ, Oll.

TRICHOPTERYGIDÆ.

Ptilium Simsoni, Matth.

SCAPHIDIDÆ.

Scaphidium 4 pustulatum, Oliv.*
Scaphisoma novicum, Blackb.*

HISTERIDÆ.

Apobletes errans, Mars.
Platysoma læve, Mars.
latisternum, Mars.
Teretrius Walkeri, Lewis.
Teretriosoma Melbournium, Mars.*
Somerseti, Mars.*
Acritus Tasmaniæ, Lewis.
Saprinus australis, Boi.*
laetus, Er.*
Gnathoncus incisus, Er.

PHALACRIDÆ.

Litochrus brunneus, Er.
Olibrus Victoriensis, Blackb.*
Phalacrus corruscans, Payk.*†

NITIDULIDÆ.

Brachypeplus basalis, Er.*
blandus, Murray.*
planus, Er.*

Carpophilus aterrimus, Macl.*
frivolus, Murray.*
hemipterus, Steph.*†
Stauroglossicus terminalis, Murray.*
Omosita colon, Linn.*†
Haptoncura Victoriensis, Blackb.*
Circopes pilistriatus, Macl.*
Ericmodes australis, Grouv.*
Pria rubicunda, Macl.*

TROGOSITIDÆ.

Egolia variegata, Er.
Tenebriodes mauritanicus, Linn.*†
Leperina decorata, Er.*
Phycosecis algarum, Pasc.*

COLYDIDÆ.

Sparactus interruptus, Er.*
pustulosus, Blackb.
Ditoma pulchra Black.*
serricollis, Pasc.*
Meryx aequalis, Blackb.*
rugosa, Latr.*
Deretaphrus Bakewelli, Pasc.*
granulipennis, Reitter.*
Bothrideres taeniatus, Pasc.*
vittatus, Newm.*
Penthelispa fuliginosa, Er.*

CUCUJIDÆ.

Ancistria retusa, Fab.*
Prostomis Atkinsoni, Wath.*
cornutus, Wath.*
Bessaphilus cephalotes, Wath.
Ipsaphes maerosus, Pasc.*
Platisus angusticollis, Reitter.*
obscurus, Er.*
Læmophlæus bistriatus, Grouv.*
Tasmanicus, Grouv.
testaceus, Fab.*†
Dendrophagus australis, Er.*
Hyliota australis, Er.*
bicolor, Arrow.*
lucia, Pasc.*
militaris, Er.*

Cryptamorpha Olliffi, Blackb.*
optata, Oll.
triguttata, Wath.*
Silvanus brevicornis, Er.
Surinamensis, Linn.*†
unidentatus, Fab.*†
Myrabolia Grouvelliana, Reitter.*

CRYPTOPHAGIDÆ.

Cryptophagus gibbipennis, Blackb.*

LATHRIDIIDÆ.

Lathridius apicalis, Blackb.*
costatipennis, Blackb.*
costatus, Er.*
nigromaculatus, Blackb.*
nodifer, Westw.*†
satelles, Blackb.*
semicostatus, Blackb.*
Corticaria Adelaidæ, Blackb.*
australis, Blackb.*

MYCETOPHAGIDÆ.

Triphyllus intricatus, Blackb.*
multiguttatus, Lea.*

DERMESTIDÆ.

Dermestes cadaverinus, Fab.*†
lardarius, Linn.*†
vulpinus, Fab.*†
Megatoma morio, Er.
tenuifasciata, Reitt.
Cryptorrhopalum Erichsoni, Reitt.*
Thaumaglossa concavifrons, Reitt.
Trogoderma riguum, Er.
Anthrenus varius, Fab.*†

BYRRHIDÆ.

Microchaetes scoparius, Er.*
Limnichus australis, Er.
Aspidophorus humeralis, Blackb.*

PARNIDÆ.

Elmis Tasmanicus, Blackb.

LUCANIDÆ.

Lamprima rutilans, Er.*
Lissotus cancroides, Fab.
curvicornis, Boi.
forcipula, Westw.
Launcestoni, Westw.
latidens, Westw.
obtusatus, Westw.
opacus, Parry.
subcrenatus, Westw.
subtuberculatus, Westw.
Hoplogonus Simsoni, Parry.
Syndesus cornutus, Fab.*
Ceratognathus niger, Westw.*
Westwoodi, Thoms.*
Mastochilus dilatatus, Dalm.*

SCARABÆIDÆ.

Onthophagus anisocerus, Er.
auritus, Er.*
australis, Guer.*
evanidus, Har.
fuliginosus, Er.
mutatus, Har.*
posticus, Er.*
pronus, Er.*
Proctophanes sculptus, Hope.*
Phycochus graniceps, Broun.
(occurs also in New Zealand).
Aphodius erosus, Er.
Howitti, Hope.*
Tasmaniæ, Hope.
Ataenius Frenchi, Blackb.*
mendax, Blackb.*
Bolboceras Kirbyi, Westw.*
proboscideus, Schreib.*
Trox Australasiæ, Er.*
Phyllotocus assimilis, Macl.*
bimaculatus, Er.
Lottoni, Boi.
Macleayi, Fisch.*
rufipennis, Boi.*
Diphucephala colaspidoides, Gyll.*
Mæchidius corrosus, Wath.
Xylonychus nigrescens, Blanch.
piliger, Blanch.

Liparetrus atratus, Burm.
basalis, Blanch.
concolor, Er.
discipennis, Guer.*
pruinosus, Burm.
salebrosus, Macl.*
ubiquitosus, Macl.*
vestitus, Blanch.
Automolus angustulus, Burm.
Scitala geminata, Boi.*
nigrolineata, Boi.*
sericans, Er.
Colpocheila obesa, Boi.*
Haplonycha scutalis, Blanch.*
Heteronyx australis, Guer.
dimidiatus, Er.
diversipes, Blackb.
fumatus, Er.
glabratus, Er.
jubatus, Blackb.*
nigellus, Er.
ovatus, Blanch.*
præcox, Er.
striatipennis, Blanch.
tempestivus, Er.
unicolor, Blanch.
Caulobius pubescens, Er.
rufescens, Blanch.
Telura vitticollis, Er.*
Nepytis russula, Er.
Rhizotrogus Tasmanicus, Burm.
Anoplognathus suturalis, Boi.*
Saulostomus villosus, Wath.*
Cheiroplatys maelius, Er.
Pimelopus porcellus, Er.
Pseudopimelopus Lindi, Blackb.*
Cryptodus anthracinus, Er.
Tasmanius, Westw.
Microvalgus Lapeyrousei, G. & P.*

BUPRESTIDÆ.

Cyria imperialis, Don.*
Chalcophora albivittis, Hope.*
Nascio carissima, Wath.*
Parryi, Hope.*

Melobasis gloriosa, L. & G.*
hypocrita, Er.
intricata, Blackb.
monticola, Blackb.*
nervosa, Boi.*
prisca, Er.
simplex, Germ.*
splendida, Don.*
Conognatha navarchis, Thoms.
Stigmodera Australasiæ, L. & G.*
Bremei, Hope.*
erythromelas, Boi.
insularis, Blackb.
jubata, Blackb.
Mitchelli, Hope.*
ocelligera, L. & G.
rufipennis, Kirby.*
Thomsoni, Saund.*
undulata, Don.*
virginea, Er.
Wilsoni, Saund.*
Cisseis cupreicollis, Hope.*
maculata, L. & G.*
Neospades Westwoodi, L. & G.
Discoderes Tasmanicus, Germ.
Agrilus hypoleucus, L. & G.*

Trixagidæ.

Aulonothroscus elongatus, Bonv.*

Eucnemidæ.

Phœnocerus subclavatus, Bonv.
Galbodema Mannerheimi, Cast.

Elateridæ.

Lacon caliginosus, Guer.*
guttatus, Cand.*
humilis, Er.
pictipennis, Cand.*
variabilis, Cand.*
Victoriæ, Cand.*
Glyphochilus furvus, Er.
lucidus, Er.
Tasmanicus, Cand.

Monocrepidius Australasiæ, Boi.*
cerdo, Er.*
Cordieri, L. & G.*
coxalis, Cand.
fabrilis, Er.*
fuscicornis, Er.
rutilicornis, Er.
tabidus, Er.
viduus, Cand.
Elater perplexus, Cand.*
Horistonotus humilis, Cand.
Corymbites Tasmanicus, Cand.
Chrosis trisulcata, Er.
Crepidomenus decoratus, Er.*
fulgidus, Er.
tæniatus, Er.
Anilicus 4 guttatus, Er.
Acroniopus humilis, Er.
infimus, Er.

RHIPIDOCERIDÆ.

Rhipidocera femoralis, Kirby.*

DASCILLIDÆ.

Helodes Atkinsoni, Wath.
australis, Er.
maculatus, Wath.
Macrohelodes Tasmanicus, Blackb.

MALACODERMIDÆ.

Metriorrhynchus atratus, Fab.*
erythropterus, Er.*
hæmorrhoidalis, Wath.*
insignipennis, Blackb.
marginatus, Er.
rufipennis, Fab.*
salebrosus, Wath.*
Trichalus discoideus, Er.
Calopteron Goryi, Le G.
Eros scutellaris, Er.
Telephorus nobilitatus, Er.*
pulchellus, Macl.*
tricolor, Cast.*
Selenurus tricolor, Lea.*
Hypattalus abdominalis, Er.
Dasytes fuscipennis, Hope.*

CLERIDÆ.

Cylidrus basalis, Macl.*
centralis, Pasc.*
nigrinus, White.*
Tillus hilaris, White.
Opilo 6 notatus, Westw.
var. pulcher, White.
Thanasimus accinctus, Newm.*
Natalis cribricollis, Spin.*
porcata, Fab.*
Aulicus corallipes, Chev.
instabilis, Newm.*
Tarsotenus zonatus, Blanch.*
Eburiphora patricia, Klug.
Eleale intricata, Klug.
lanata, Chev.
simplex, Newm.*
speculum, Chev.
Tasmaniæ, Chev.
Lemidia hilaris, Newm.*
malthinus, Newm.
nitens, Newm.*
pictipes, Blackb.*
pulchella, Blackb.*
simulans, Blackb.*
subænea, Gorh.*
Tasmaniæ, White.
Tenerus abbreviatus, White.*
Pylus fatuus, Newm.*
Paratillus carus, Newm.*
Necrobia pinguis, Westw.
ruficollis, Fab.*†
rufipes, De Geer.*†

LYMEXYLONIDÆ.

Lymexylon australe, Er.
Atractocerus Victoriensis, Blackb.*

CUPESIDÆ.

Cupes varians, Lea.*

PTINIDÆ.

Ptinus exulans, Er.*
fur, Linn.*†
tectus, Boield.*†
Anobium domesticum, Linn.*†
paniceum, Linn.*†

Cioidæ.

Lyctus brunneus, Steph.*†
costatus, Blackb.
Cis munitus, Blackb.

Bostrychidæ.

Xylodoleis obsipa, Germ.*
Xylion cylindricus, Macl.*
collaris, Er.*
Xylopsocus gibbicollis, Macl.*
elongatula, Macl.*
Leai, Lesne.
Xylopsocus gibbicollis, Macl.*

Tenebrionidæ.

Cotulades fascicularis, Pasc.
Docalis funerosa, Hope.
Prionotus serricollis, Hope.*
Edylius canescens, Champ.
Scymena amphilia, Pasc.*
Sphargeris physodes, Pasc.*
Cestrinus aversus, Pasc.*
obscurus, Er.
punctatissimus, Pasc.
trivialis, Er.*
Ecripsis pubescens, Pasc.
Dipsaconia australis, Hope.*
Ulodes verrucosus, Er.*
Caanthus gibbicollis, Champ.
Latometus pubescens, Er.
Elascus crassicornis, Pasc.*
lunatus, Pasc.*
Ganyme sapphira, Newm.*
Ennebæus australis, Champ.
ovalis, Wath.
Enneboeopsis pruinosus, Champ.
Lyphia Tasmanica, Champ.
Platydema limacoides, Pasc.*
tetraspilota, Hope.*
Tribolium ferrugineum, Fab.*†
Paratoxicum iridescens, Champ.
Uloma ovalis, Perr.
Alphitobius mauritanicus, Luc.*†
Toxicum punctipenne, Pasc.*
Pterohelæus Guerini, Breme.
Reichei, Breme.*

Saragus infelix, Pasc.
laevicollis, Oliv.*
peltatus, Er.*
Promethis angulata, Er.*
Menephilus colydioides, Er.*
corvinus, Er.*
humilis, Er.
longipennis, Hope.*
ruficornis, Champ.
Meneristes australis, Boi.*
servulus, Pasc.*
Tenebrio obscurus, Linn.*†
Tanylypa morio, Pasc.
Decialma Erichsoni, Champ.
Chartopteryx nitida, Er.
Lepispilus sulcicollis, Boi.*
Titæna alcyonea, Er.*
columbina, Er.*
Tasmanica, Champ.
Melytra ovata, Pasc.
Hymæa succinifera, Pasc.
Adelium abbreviatum, Boi.
commodum, Pasc.*
elongatum, Er.
latum, Pasc.*
licinoides, Kirby.
neophyta, Pasc.*
nodulosum, Champ.
obesum, Pasc.*
porcatum, Fab.*
Tasmanicum, Champ.
tenebrioides, Er.
Seirotrana catenulata, Boi.*
Brycopia tuberculifera, Champ.
Dinoria cælioides, Pasc.*
picta, Pasc.
Coripera deplanata, Boi.
Licinoma pallipes, Blackb.*
Phænnis fasciculata, Champ.
Chalcopterus Howitti, Pasc.*
iridicolor, Bless.*

CISTELIDÆ.

Pseudocistela ovalis, Blackb.*
Licymnius bicolor, Blackb.*
Chromomea nigriceps, Champ.

Nypsius æneopiceus, Champ.
foveatus, Champ.
Apellatus Tasmanicus, Champ.
Allecula luctuosa, Champ.
Homotrysis bicolor, Champ.
Nocar latus, Blackb.*

PYTHIDÆ.

Lissodema hybridum, Er.*
Notosalpingus ornatus, Blackb.*

MELANDRYIDÆ.

Dircœa velutina, Champ.
venusta, Champ.
Talayra elongata, Macl.*
Ctenoplectron agile, Champ.*
Orchesia austrina, Champ.*
Mystes planatus, Champ.*
Trichosalpingus fumatus, Champ.*
Lagrioida australis, Champ.*
Scraptia australis, Champ.
laticollis, Champ.
punctatissima, Champ.

LAGRIIDÆ.

Lagria grandis, Gyll.*

XYLOPHILIDÆ.

Xylophilus impressicollis, Lea.*
inconspicuus, Blackb.*
pectinicornis, Champ.

ANTHICIDÆ.

Tomoderus vinctus, Er.
Anthicus australis, King.*
brevicollis, King.*
floralis, Linn.*†
glaber, King.*
Mastersi, Macl.*
rarus, King.*
strictus, Er.*
Tasmanicus, Champ.
Formicomus Denisoni, King.*

Mordellidæ.

Mordella albosparsa, Gemm.*
bella, Wath.*
communis, Wath.*
felix, Wath.
fulvonotata, Champ.*
graphiptera, Champ.*
humeralis, Wath.*
leucosticta, Germ.*
parva, Champ.
promiscua, Er.
pygmæa, Champ.
ruficollis, Wath.*
tristis, Lea.*
trivialis, Wath.*
Waterhousei, Champ.*
Mordellistena jucunda, Champ.*

Rhipidophoridæ.

Nephrites nitidus, Shuck.
Rhipidius pectinicornis, Thunb.*†

Cantharidæ.

Zonitis cyanipennis, Pasc.*
tricolor, Le G.*
Sitarida minor, Champ.

Œdemeridæ.

Copidita Macleayi, Champ.*
nigronotata, Boh.*
punctum, Macl.*
Nacerdes melanura, Linn.*†
Asclera Atkinsoni, Wath.*
sublineata, Wath.*
Dohrnia miranda, Newm.*
simplex, Champ.
Pseudolychus cinctus, Guer.*
hæmorrhoidalis, Fab.*
Techmessa ruficollis, Champ.

Curculionidæ.

Rhadinosomus Lacordairei *var.* Tasmanicus, Blackb.
Prostomus scutellaris, Fab.*
Euthyphasis acuta, Pasc.
Maleuterpes spinipes, Blackb.*

Otiorhynchus scabrosus, Marsh.*†
sulcatus, Fab.*†
Merimnetes oblongus, Blanch.
Leptops tribulus, Fab.*
Amisallus nodosus, Er.*
Ethemaia sellata, Pasc.*
Psalidura impressa, Boi.
Talaurinus exasperatus, Er.*
penicillatus, Macl.
Sclerorrhinus bubalus, Oliv.
tristis, Boi.
Tetralophus sculpturatus, Wath.*
Mandalotus crudus, Er.
hoplostethus, Pasc.
sterilis, Er.
Steriphus solidus, Er.
Perperus insularis, Boh.*
languidus, Er.
Methypora postica, Pasc.*
Oxyops fasciata, Boi.*
Pantoreites illuminatus, Lea.
Syarbis alcyone, Lea.
Gonipterus exaratus, Fahrs.*
scutellatus, Gyll.*
turbidus. Pasc.
Prophæsia confusa, Pasc.
Strongylorrhinus ochraceus, Sch.*
Aromagis echinatus, Pasc.*
Atelicus abruptus, Pasc.
atrophus, Pasc.
guttatus, Pasc.
inœqualis, Wath.*
Aterpus cultratus, Fab.*
rubus, Boh
Pelororrhinus margaritaceus, Er.*
Rhinaria costata, Er.*
granulosa, Fahrs.*
perdix, Pasc.*
transversa, Boi.*
Orthorhinus aethiops, Boi.*
cylindirostris, Fab.*
Klugi, Boh.*
lepidotus, Er.
Lixus Mastersi, Pasc.*
Aoplocnemis phaleratus, Er.*
rufipes, Boh.*
Tasmanicus, Blackb.

Anorthorhinus apicalis, Lea.*
pictipes, Blackb.*
Desiantha maculata, Blackb.*
vittata, Blackb.*
Storeus monticola, Blackb.*
Encosmia cornuta, Blackb.
Misophrice parallela, Black.*
variabilis, Blackb.*
Cryptoplus perdix, Er.
Rhaciodes bicaudatus, Boi.*
dentifer, Boh.*
granulifer, Chev.*
multidentatus, Chev.
Meriphus fullo, Er.*
Eristus setosus, Blackb.*
Myositta cirrifera, Pasc.*
Belus bidentatus, Don.*
bimaculatus, Pasc.*
filum, Jekel.*
Grayi, Jekel.
irroratus, Jekel.
rubicundus, Lea.*
Pachyura australis, Hope.*
dermestiventris, Boi.*
minima, Blackb.*
Rhinotia hœmoptera, Kirby.*
Eurhynchus quadridens, Er.
quadrinodosus, Er.
Auletes melaleucæ, Lea.*
melanocephalus, Er.
suturalis, Wath.*
Diapelmus mendax, Er.
Læmosaccus carinicollis, Lea.*
ocularis, Pasc.*
rufipennis, Lea.*
subsignatus, Boh.
Platyurus brevicornis, Blanch.
Haplonyx albofasciatus, Chev.
fasciculatus, Bohem.*
frontalis, Chev.
Kirbyi, Fahrs.*
mediocinctus, Chev.
nigrirostris, Chev.*
Spencei, Gyll.*
vicinus, Chev.*
Rhamphus acaciæ, Lea.*

Pseudostoreus placitus, Lea.*
Cyllorhamphus tuberosus, Er.
Melanterius maculatus, Lea.*
porcatus, Er.*
Poropterus abstersus, Boh.
antiquus, Boh.
conifer, Er.*
satyrus, Pasc. (Gen. Dub.).
succisus, Er.
zopherus, Lea.
Microporopterus tumulosus, Pasc.*
Acalles acerosus, Er. (Gen. Dub.).
rubetra, Er. (Gen. Dub.).
Euthyrrhinus meditabundus, Fab.*
Ephrycus obliquus, Pasc.*
Isax gallinago, Pasc.*
Achopera lachrymosa, Pasc.*
Tychreus camelus, Pasc.
Exithius capucinus, Pasc.
cariosus, Er.
morbillosus, Pasc.
musculus, Pasc.
Cryptorrhynchus antares, Er. (Gen. Dub.).
infulatus, Er. (Gen. Dub.).
sirius, Er. (Gen. Dub.).
solidus, Er. (Gen. Dub.).
Ampagia femoralis, Er.
Tyrtæosus ustulatus, Pasc.*
Aphela algarum, Pasc.*
Pentarthrum nigrum, Woll.
Pentamimus canaliculatus, Woll.
Cossonus præustus, Redt.*
Tasmanica myrmecophila, Lea.
Rhyncolus polixus, Er. (Gen. Dub.).
australis, Er. (Gen. Dub.).

Scolytidæ.

Cryphalus pilosellus, Er.
Xyleborus truncatus, Er.*

Brenthidæ.

Cyphagogus delicatus, Lea.*
Cordus hospes, Germ.*

Anthribidæ.

Anthribus bispinus, Er.
Tropideres albuginosus, Er.
musivus, Er.

Bruchidæ.

Bruchus rufimanus, Boh.*†

Cerambycidæ.

Cnemoplites australis, Er.
Toxeutes arcuatus, Fab.*
Enneaphyllus æneipennis, Thoms.
Pœcilus metallicus, Newm.*
Phacodes obscurus, Fab.*
personatus, Er.*
Phoracantha fallax, Pasc.*
quinaria, Newm.*
senio, Newm.*
semipunctata, Fab.*
synonyma, Newm.*
Tryphocharia Mastersi, Pasc.*
superans, Pasc.
Epithora dorsalis, Macl.*
Allotisis unifasciata, Hope.*
Coptocercus rubripes, Boi.*
Sisyrium plagiatum, Gahan.
Acyrusa Tasmanica, Gahan.
Bethelium Blackburni, Gahan.
signiferum, Newm.*
Notoceresium impressiceps, Blackb.
Callidiopis præcox, Er.*
scutellaris, Fab.*
Phlyctaenodes fasciatus, Gahan.
pustulatus, Hope.
pustulosus, Newm.*
tristis, Fab.
Tessaromma sericans, Er.*
undatum, Newm.*
Gracilia pygmaea, Fab.*†
Strongylurus ceresiodes, Pasc.
scutellatus, Hope.
Lygesis mendica, Pasc.*
Uracanthus bivittatus, Newm.*
pallens, Hope.
Rhinopthalmus nasutus, Newm.*
Tritocosmia paradoxa, Pasc.*

Tropis oculifera, Newm.
Pterostenus concolor, Macl.*
suturalis, Oliv.*
Syllitus microps, Blackb.
rectus, Newm.*
Macrones acicularis, Pasc.*
exilis, Newm.*
Enchoptera apicalis, Saund.
Brachopsis concolor, Saund.
Pseudocephalus arietinus, Newm.
Zoedia divisa, Pasc.*
triangularis, Pasc.*
V-album, Boi.
Earinus mimula, Pasc.*
Mecynopus cothurnatus, Er.
Hesthesis cingulata, Kirby.*
Distichocera par, Newm.*
Pytheus latebrosus, Newm.*
Brachytria gulosa, Newm.*
Omophæna tæniata, Pasc.*
Ochyra coarctata, Pasc.
Homæmota Walkeri, Gahan.
Amphirhoe decora, Newm.*
Tragocerus Spencei, Hope.*
Dorcadida biocularis, White.
Walkeri, Gahan.
Microtragus luctuosus, Shuck.
Zygocera cænosa, Er.*
lugubris, Pasc.*
Probatodes piliger, Macl.*
Ancita crocogaster, Boi.*
marginicollis, Boi.*
sparsa, Pasc.*
Rhytiphora Simsoni, Blackb.
Acanthocinus plumula, Newm.
Pentacosmia scoparia, Newm.*
Illæna exilis, Er.

CHRYSOMELIDÆ.

Microdonacia incerta, Blackb.*
Ditropidus lentulus, Chp.*
ochropus, Er.
ruficollis, Saund.
rufipes, Saund.
subæneus, Chp.
Lachnabothra Saundersi, Baly.*

Cadmus australis, Boi.*
cognatus, Saund.*
crucicollis, Boi.*
dorsalis *var.* Ewingi, Saund.*
ferrugineus, Fairm.*
pacificus, Suff.*
rufescens, Saund.*
strigillatus, Chp.*
Tasmanicus, Saund.
Cryptocephalus albilinea, Saund.*
apicalis, Saund.*
ater, Saund.*
consors, Boi.*
erosus, Saund.*
hæmatodes, Boi.*
Jacksoni, Guer.*
rufescens, Saund.*
subfasciatus, Saund.*
var. melanocephalus, Saund.
vermicularis, Saund.*
viridipennis, Saund.*
viridis, Saund.*
Loxopleurus Tasmanicus, Saund.*
Noda Tasmanica, Jac.
Agetinus jugularis, Er.
Tomyris elegantula, Laf.
proxima, Er.
viridula, Er.
Phyllocharis cyanicornis, Fab.*
Chalcolampra ænea, Boi.*
constricta, Er.*
luteicornis, Er.
pacifica, Er.
thoracica, Baly.*
Calomela Curtisi, Kirby.*
maculicollis. Boi.*
Paropsis agricola, Chp.
atomaria, Oliv.*
aurea, Blackb.
bimaculata, Oliv.*
Calliope, Blackb.
comma, Blackb.
decolorata, Chp.*
delicatula, Chp.*
ferrugata, Chp.
hamadryas, Stal.*
var. flavitarsis, Chp.

Paropsis hectica, Boi.*
hera, Stal.
lachesis, Stal.*
laesa, Germ.*
lepida, Er.
lignea, Er.
lineata, Marsh.*
lutea, Marsh.*
morio, Fab.*
nobilitata, Er.
nucea, Er.
obliterata, Er.
obovata, Chp.*
orphana, Er.
papulenta, Chp.
papulosa, Er.
picea, Oliv.*
porosa, Er.*
reticulata, Marsh.*
rufipes, Fab.*
rugosa, Chp.*
serpiginosa, Er.
Simsoni, Blackb.
subcostata, Chp.
subfasciata *var.* planior, Blackb.
Tasmanica, Baly.
trimaculata, Chap.*
umbrosa, Chp.*
variicollis, Chp.*
venusta, Er.
Arsipoda bifrons, Er.
Erichsoni, Baly.
variegata, Wath.
Graptodera corrusca, Er.
Haltica australis, Blackb.*
ignea, Blackb.*
pagana, Blackb.*
Chætocnema Erichsoni, Baly.
Psylliodes chlorophana, Er.
Ellopia pedestris, Er.*
Monolepta alpina, Blackb.*
nigricornis, Blackb.*
subsuturalis, Blackb.*
Euryspa vittata, Baly.*
Monochirus fimbriatus, Chp.

Erotylidæ.

Thallis compta, Er.*
femoralis, Blackb.
janthina, Er.*
vinula, Er.*
Episcaphula australis, Boi.*

Endomychidæ.

Daulis cimicoides, Er.

Coccinellidæ.

Leis conformis, Boi.*
Coccinella transversalis, Fab.*
Halyzia Mellyi, Muls.*
Alesia frenata, Er.*
Orcus Australasiæ, Boi.*
bilunulatus, Boi.*
Novius cardinalis, Muls.*
Rhizobius alphabeticus, Lea.*
Boucardi, Crotch.*
calomeloides, Lea.
discolor, Er.*
hirtellus, Crotch.*
Lindi, Blackb.*
pulcher, Blackb.*
tricolor, Lea.
ventralis, Er.*
virgatus, Lea.
Scymnus flavifrons, Blackb.*
trilobus, Lea.
vagans, Blackb.*
Pharus strangulatus, Er.
Bucolus obscurus, Lea.
Serangium nigrum, Lea.
Cycloscymnus minutus, Blackb.*
Epilachna Tasmanica, Crotch
11 variolata, Boi.

Corylophidæ.

Corylophus fasciatus, Er
thoracicus, Er.

SECTION E.

GEOGRAPHY.

PRESIDENTIAL ADDRESS.

By REV. GEO. BROWN, D.D., OF SYDNEY.

THE PACIFIC, EAST AND WEST.

IT is, I think, a very incomplete definition of geography which would confine it to a description of the configuration of the earth's surface, and the divisions, natural or artificial, of the different countries. I purpose giving, as far as possible in the compass of this address, a short popular description of the respective groups which I have visited during the past 40 years, their commercial geography, more especially as regards the products of the groups, their capacity for settlement, and the possibilities of trade, and their ethnological geography, dealing with the respective races, their distribution and their relations to other tribes.

There are, of course, many other branches of this great science, but those I have mentioned are more than sufficient for the present purpose, and can indeed only be dealt with very imperfectly.

SAMOA.

This, the most eastern group in the South Pacific, with which I have had a long acquaintance, lies between the parallels of 13° 30′ and 14° 30′ S. Lat., and consists of the Manua Group, Tutuila Upolu, Manono, Apolima, and Savaii.

The group is principally of volcanic formation, the most recent crater being one called Tutumau, a few miles inland of Safune, on the N.W. side of the large island of Savaii. I visited this 1862. No white man had ever ascended it before. It was at that time a high mountain of volcanic ashes, with a very deep, well-defined crater. The sides of the crater were almost perpendicular, and there was little or no vegetation on the mountain, but we saw no signs of heat or steam.

The islands are all mountainous, intersected with deep valleys shewing marks of denudation from heavy rainfalls and the action of mountain torrents. This is more especially noticeable in the island of Upolu. The coast-line is principally composed of volcanic cliffs, steep too, and with very few places on which landing may be safely effected from boats. The principal exceptions to this are on Upolu, from a point a few miles to the eastward of Apia, on the north coast to Falelatai, on the S.W. coast, a distance of about 50 miles, and from Salelologa, on the N.E. coast of Savaii, to Amoa, on the N.W. coast. Then there is a stretch of volcanic cliffs for about 20 miles (see photo.) to Lealatele, where the fringing reef again begins, and continues to Sasina, on the same coast, for about 12 miles. These parts of the coast are all protected by fringe reefs at distances varying from ½ mile to 1½ or 2 miles from the shore. The country inland from these reef-protected areas is much more level and less broken than it is inland of the ironbound coast. I think it not at all unlikely that the islands were at one time surrounded by reefs, which have been in many places filled up by lava, and that those places where the fringing reefs still remain were out of the line of the lava streams, and so escaped. This is in some measure confirmed by the native traditions. For example, at Tufu, on the south coast of Savaii, there is a proverb in almost daily use to express astonishment at any sudden or unexpected change—"Maupenei went away and left a taifofola (lagoon), and came back and found a tai pupu (ironbound) coast in its place." This evidently refers to an actual occurrence, as inland of the volcanic cliffs which now form the coast is a water-course, and some flat swampy ground, from which large quantities of brain coral (puga) are dug up and used by the natives for making lime. This is interesting as a typical instance of the way in which the physical features of the surface have been altered by volcanic action.

The interior of the large island of Savaii is very rough, and is composed principally of scoria. There is a lake in the centre called Matau Lano, which I visited, and a similar one is found also in Upolu. The soil, composed principally of decayed vegetable matter, is very fertile, and in most places the scoria is covered with tropical vegetation.

Tonga.

Tonga is a fine group lying between the parallels of 15° and 23° 30′ S. Lat., and the meridians of 173° and 171°

W. Long. It consists of three separate groups, Tonga, Haabai, and Vavau, with the outlying islands of Niua Foou and Niua Tobutabu. This group was first discovered by Tasman in 1643. The large island of Tongatabu is a low island of coral formation, and is also the whole of the Haabai Group. The island of Eua is about 1200 feet in height, and is also of coral formation. This island affords one of the most conclusive proofs of upheaval, as it is stated on the authority of the officers of H.M.S. *Egeria* (who were employed in the survey of the group) that an extensive dyke of basalt is found inland, underlying the coral formation.

The northern group of Vavau is also principally coral, but there are several outlying islands on which are active volcanoes, and Tofua, Late, Fonualei, and Niua Foou have all been in eruption in recent years. In 1846 Fonua-lei was laid waste by a terrific eruption, during which immense showers of ashes and pumice were ejected. Captain Samson, in command of an American whaler, sailed through a cloud of ashes, rolling over like great volumes of smoke, for about 40 miles—and Captain Cash, of the ship *Massachusetts*, had the same experience 60 miles to the eastward of Captain Samson's position. On 24th June,1853, a dreadful eruption took place in Niua Foou Island, when the earth was rent open in the very centre of a native village, and 25 people were consumed in the burning gulf, with all their houses and church. Ten miles of country were covered by the streams of lava to a depth of from 8 to 15 feet, the main stream being three miles in width. Another eruption took place in 1867, and a third in 1886. The first two were characterised by an outflow of lava, but in the last one there were only ashes and fire. I visited the island in 1889. There is a lake on the top, about 3 miles long by 1½ broad, in a deep depression in the centre of the island. The land surrounding it is steep, too, in most places, with bold headlands extending some distance into the lake, with well-wooded sides in many parts. On the south and east sides the shores are not so steep as on the north. There are three small islands in the lake, on one of which fresh water is obtainable. At the place where we first saw the lake, near Mataaho, we were in full view of the large piece of land which was thrown up during the last eruption in the centre of the lake. This is of irregular shape, about 70 feet high, and from two to three miles in circumference. Passing along the ridge, which gradually became steeper as we approached Agaha, we could see very distinctly the two craters from which the large black hills of sand and ashes were ejected, which now occupy the place where but a few years ago there was deep blue water. The lake is very deep in many places. The craters are only a few feet above the level of the water. The next day I visited three old craters near the sea. One of them is quite close to the ocean; in fact, it seems to have broken out on the beach or in the sea. The other two are further inland, and are well defined craters, but broken away on the sea-ward side, and had some fair-sized casuarina trees growing on them. The volcanic ash is soon affected by the weather, and disintegrated, and in a short time fens and casuarina trees grow, and cover the black and desolate scene with a garment of verdure and beauty. There is an extensive lake in the crater on the top of the island, in which fresh promontories and hills are being continually formed by volcanic action. Late was also in violent eruption in 1854, and is still active. Submarine volcanoes have in recent years produced several new islands. On Thursday, 6th August, 1857, the Captain of the *John Wesley* reported an island which has appeared above the the surface of the sea within the last few months. This was about 60 feet high, and emitted fire, smoke, and steam. On 19th August, of the same year, he also reported another islet, in the same locality which had also been recently upheaved. On 27th August, he came upon what appeared to be a shoal water, five miles S.S.W. from the island which he discovered on 6th August. A boat was lowered to sound, but no bottom was found with forty fathoms. The discoloured water, he states, was evidently caused by the stream of lava which had flowed in this direction, as the discoloured water was continued from that point to the base of the new island. Both these islands have much increased in size since they originally appeared. A few years ago an island was thrown up near Tongatabu. This was partly washed away, but has again materially increased in size. These are instances which shew the changes which take place in these seas in the earth's surface by volcanic action.

FIJI.

Fiji has been so often described that I shall only give a very brief description here. The group consists of about 200 islands and islets, about 80 of which are inhabited. These lie between the parallels of 15° 30′ S. Lat. and the meridians of 177° E. Long. and 178° W. Long.

They were discovered by Tasman in 1643. Captain Cook only sighted one of the islands, Vatoa or Turtle

Island. Captain Bligh twice passed through parts of the group, and Captain Wilson, of the Mission vessel *Duff*, was nearly wrecked on a reef near Taviuni.

The first settlers were runaway or shipwrecked sailors, and a band of escaped convicts from New South Wales, who landed there in 1804. A Swede called Savage was recognised as head-man amongst the whites, and he possessed great influence in Bau, being made a great chief by the rulers there, as his assistance in their frequent wars was of the greatest value to them on account of the firearms which he possessed. He was killed and eaten, however, by a hostile tribe, in 1813. The remainder of the whites soon died, the greater part being killed in tribal wars, or in private quarrels amongst themselves, until, in 1840, only one man—Paddy Connor—survived. He was such a depraved character that the white residents who had settled in the islands were afraid of his living near them. The islands are principally of volcanic origin, and many of them appear to be the tops of submarine mountain ranges; but at the present time there are no active volcanoes in the group. The mountain ranges, however, especially on Kandavu and Taviuni, shew that in the distant past there were large and formidable craters on them, in full action. Boiling springs are found in several parts, and earthquakes are occasionally felt. The soil is gravelly, and barren in some places, but generally consists of dark red or yellowish clay, which, when well watered, is very fertile. Considerable attention has been given to the geological and coral formation of this group by Prof. Agassiz, of America, in which he was assisted by Mr. E. C. Andrews, B.A., and Mr. B. Sawyer, B.E., both of Sydney University.

New Hebrides.

This group lies between the parallels of 14° 30′ and 20° 16′ S. Lat. and between the meridians 165° 40′ and 170° 30′ E. Long. The general trend is from S.S.E. to N.N.W. The large island of Espiritu Santo was discovered by De Quiros in 1606. Others were visited by Bougainville in 1768, but the principal exploration and discoveries were made by Capt. Cook in 1774, and by him the name of New Hebrides was given to the group. La Perouse passed through a part of it in 1788, and perished at Vanikoro, an island a little further north. The group is about 400 miles in length; the principal islands, begining from the south, are Aneiteum, Tanna Eromanga, Sandwich, Mallicolo, Aoba, Aurora, St. Bartholomew, Espiritu Santo, and other small islands. The group contains at least three active volcanoes—Tanna in the south, and Lopevi and Ambrym in the north. That on Tanna is the largest. The group is distinctly volcanic, and there are many plain proofs of several upheavals, and, in some instances, the volcanic rocks are found cropping out of the upheaved coral.

THE SOLOMON ISLANDS.

This fine group of islands lies between 5° and 10° 53′ S. Lat. and 154° 30′ and 162° 28′ E. Long. It consists of a double row of islands, of which Santa Catalina is the most southerly and Bouka the one farthest north. The principal islands are Santa Catalina, Santa Anna, San Christoval, Gaudalcanar, Mala, Florida, Isabel, New Georgia, Choiseul and Shortlands, which are now all under British protectorate. Bougainville and Bouka are under German protectorate. The length of the group is nearly 700 miles. Most of the islands are mountainous, and all are densely wooded. There is an active volcano on the island of Bougainville, and one on Savo has been in eruption within the memory of living men. Nearly all the islands in this group also shew distinct evidence of upheaval. On Treasury Island, Dr. Guppy believes that there are clear proofs of a recent upheaval of at least 1500 feet, whilst in many of the islands the volcanic rocks are geologically ancient, and afford indications of the insular condition having been preserved from remote ages. An extract from a paper contributed by me some years ago will give some idea of this fine group. "The appearance of the group on the charts gives little idea of the large number of islands and islets of which it is composed. A traveller coasting along the shores of San Christoval, then entering Marau Sound on Gaudalcanar, then coasting up the north side of that splendid island (leaving the large island of Mala and the Florida group to the right), passing through the Russell, New Georgia, Vella Lavella, Treasury, Shortlands and other groups, would pass by a large number of beautiful islands of ever-varying shape and size, and yet he would then have seen only a small part of the great Solomon Group. The extent and beauty of the islands in the Russell, Maravo, and Rubiana lagoons can only be appreciated by those who in some small steamer or sailing vessel have traversed the deep, still, land-locked waterways which separate these lovely islands. There are few places which present to the eye so many attractions to the explorer or to the yachtsman as this little known but most beautiful group."

New Britain.

This is now generally known as the Bismarck Archipelago, and comprises the large islands of New Britain, New Ireland, Duke of York Group, and New Hanover, together with a number of smaller islands.

They are of volcanic origin, and there are several active volcanoes on New Britain, the principal of which are the Mother and Daughters, in and near Blanche Bay, and the Father and Sons, near the Dupourtail Group, in which also there is a volcano. New Ireland appears to be outside the line of activity, and the central part of the island is composed of sedimentary rocks, in which the only specimens of true chalk which have been obtained south of the equator are found. This is manufactured by the natives into images, which at one time were held in great reverence by the natives. I can, fortunately, give from personal experience and observation some facts which will shew how some of these islands are formed, and which will also shew how rapid is the disintegration of the pumice and the growth of vegetation on a recently upheaved island.

In the begining of Feb., 1878, I heard that one of the three volcanic mountains—Mother and Daughters—was in active eruption. These mountains are situate in Blanche Bay, on the Gazelle Peninsula. A few days later I started from Duke of York Island to visit the scene, and to assure myself of the safety of the teachers and their families under my charge. The whole channel was full of floating masses of pumice, and as we neared the New Britain shores our way was blocked by large fields of pumice, through which it was almost impossible to force the boat. We had great difficulty in landing some miles down the coast, and only succeeded by passing long ropes on shore, by means of which the natives hauled the boat through the floating pumice, which was at least three feet in thickness, and was composed of small and large pieces, some of them being as large as small barrels. We reached Malakuna, at the head of the bay, in the evening, having made a long detour inland on the windward side of the mountain. The next day—16th Feb.—we left at daybreak for the scene. On our way down the bay we pulled close past the "Beehive Rocks," which we saw were gradually sinking, as the houses, which were some feet above high water mark on my previous visit, were now quite flooded at high water. A little further down the bay I saw that the small rocks or island off Keravia, on the S.W. side of the bay, noticed in the *Blanche's* survey, were raised up several feet above their former height, and that some other rock-patches not before visible near them were also recently upheaved. About a quarter of a mile nearer the beach we saw the large island which had been thrown out by the submarine volcano. The N.W. side seemed cool and easy of access, so we pulled towards it, and as soon as we got into shallow water I jumped out, and waded through the hot water and pumice to the beach, so that, with the exception of Mr. Hicks, the half-caste trader, I was the first white man to land on this island of a week's growth. I walked from the beach, where we landed, over masses of pumice and hard igneous rocks, fissured in every direction with deep cracks, through many of which smoke and steam still issued very violently. The land sloped gradually from the N.W. beach to the summit of the island, when it terminated almost perpendicularly in a large cup-like cavity, the sides of which were about 70 feet in height at the summit of the island, gradually sloping down in a circular direction towards the S.E., until they nearly united on the opposite side, a passage of about 10 yards alone remaining, through which the boiling waters of the crater flowed out into the bay. The cavity thus formed was full of water, apparently very deep indeed, boiling most furiously, and emitting vast clouds of sulphurous steam. It was a strange sight to see this island bearing witness, as it did, to the great convulsions of nature still going on around us. A few weeks before I had passed over the spot in my boat, and all was quiet and still, with the deep waters of the bay covering the place where now such powerful agents were at work all around us. We kept on our way round the lip of the crater until we came to the 10-yard channel I have mentioned, and, as this was full of a deep current of boiling water rushing through it to the bay, it effectually stopped our further progress. The land at this point was only a few feet above the sea-level, and bore the marks of very recent eruptions of boiling water discharged from the crater having flowed over it. We were not without apprehensions that we might be caught in some such eruption ourselves, and we thought it best to quit such a dangerous locality as soon as possible, more especially as the sulphurous steam was begining to affect us. The water on the beach all around the island was quite hot, and in many places was boiling furiously. For some distance from the island the water was of a muddy yellow colour, which contrasted in a marked manner with the clear blue sea-water a little further out in the bay. It will give some idea of the heat evolved by this volcano when I state that, for some time after it broke out, the water of the bay was all at scalding heat for at least six miles distance from it. Blanche Bay is about 15 miles in length from Praed Point to the head of Simpson's Harbour, and by the *Blanche's* survey had no bottom at seventeen fathoms up the centre of it for nearly the entire length, and yet at Malakuna, at the head of Simpson's Harbour, Mr. Hicks assured us that the water was all at scalding heat for several days, and this was confirmed by our own experience. The fish were all killed, and the turtles were so much cooked that when the natives got them most of the shell (tortoise shell) had dropped off.

I have described this new submarine volcano first because we went to it first, and because it preceded the eruption from the old crater on the mainland by a few hours. The recently-formed island was about three miles in circumference, and about a mile wide. As Mr. Hicks, the trader here, was the first foreigner to land upon it, and had already taken possession of a good portion of it by planting cocoanuts before it was quite cool, we thought it right to name it after him, and so proposed to call it Hicks Island.

The crater on the mainland is on the opposite or north side of the bay, situate between the Mother and the South Daughter. I have no works here to which I can refer, but I believe that Captain Hunter saw this crater in action on his passage from New South Wales to Batavia on May 22nd, 1791; at all events the old people here say that there was a small eruption, not nearly so large as the present one, some 30 or 40 years ago. Since then it has been very quiet indeed. I have ascended it twice during the past two years, and found it to all outward appearance nearly extinct, as there was only a very little light smoke ascending from the bottom of the crater, not even visible on the top of it. I took one or two photographs of it at the time. The side of the old crater on which my camera stood then has disappeared, and that place is now the centre of the new crater.

The present eruption was preceded by frequent earthquakes, which are described as having been very heavy indeed on New Britain, but which we (on Duke of York Island), only 20 miles distant, never felt. On the night of Sunday, 3rd Feb., the earthquakes were very violent indeed, and on Monday morning there were two tidal waves, which destroyed a good deal of the shore-line, soon after which clouds of steam were observed rising from the

the bay, in a direct line between the old crater on the mainland and the shoal from which the island I have just described had been upheaved. As the submarine volcano increased in size, the other steam clouds in the deep water ceased, and the old crater burst out with terrific power. The inhabitants of the bay and of Matupit all fled to the high lands until the first fury of the eruption abated. When we saw it, it presented a grand and awful sight. Billow after billow of thick black smoke was shot out, forming a very high column, which towered up far above the surrounding mountains. For a few minutes there would be a comparative lull, when there would be a loud roar, followed or accompanied by a violent explosion of ashes and pumice, and cloud after cloud of thick smoke following each other in quick succession, the lower one burying itself in the one which preceded it, whilst the upper ones were overlapping, curling, and wreathing round the lower ones as if in very madness of frolic they were revelling in their escape into the pure atmosphere.

As we approached the crater in our boat, we could see that the explosion had taken place on the side of the crater nearest to the bay, and that a new cone was being rapidly formed, having for its centre what was formerly the south side of the old crater. As we approached it from the windward side we were able to get quite close to it, and it was a most awe-inspiring sight. There was no discharge of lava, but large blocks of pumice and rocks were continually being shot out, whilst the roaring could be heard distinctly at Duke of York Group, nearly 20 miles away. Not a green leaf was to be seen, though all was covered with grass and trees a fortnight before. The dead and blackened trees, with almost every branch beaten off by the stones, stood like spectres on all the hill-sides, and gave a most mournful aspect to the scene, whilst the cocoanut trees on Matupit, and places far enough away to escape destruction, were so weighted by the dust and ashes that their leaves hung straight down by the stems, giving them a rather comical appearance; in fact, we all agreed that they were very much like a lot of closed gigantic Chinese umbrellas.

As we could see no safe practicable way of ascending the crater, we decided to return. We could hear the dull thud of the stones as they fell, and we all agreed that we were close enough to them, and that it would not be pleasant to get shut in by the large fields of pumice floating about the bay—an event which might easily take place by a change of wind or tide. We returned to Matupit in the afternoon.

Nearly 20 years after this event it was my good fortune to revisit this place, in August, 1897. I found that the island was much reduced in size and height, and is now only about two miles in circumference, and about 30 or 40 feet high. The crater continued to emit boiling water for at least two years after the eruption, and the lagoon still exists; the pumice has consolidated, part of the shore line has been washed away, and some of the material has been deposited in what was formerly a channel between the new island and a small rocky islet, but which channel is now quite filled up. The whole island is covered with vegetation, and there are casuarina trees on it at least 30 feet in height. This fact will show how rapidly the pumice is disintegrated by the power of wind, rain, and sun, and how quickly the vegetation grows in a land of great moisture and great heat. I have often sailed my boat over the very place where this island now stands, and this, I think, is an unique experience. There is, I believe, no white man living now but myself who saw that fearful eruption in 1878, to which this island owes its birth.

British New Guinea.

"According to a return recently prepared in the office of the Surveyor-General of Queensland, the total area of British New Guinea is about 90,540 square miles. It has an approximate coastline of 1728 statute miles on the mainland, and of 1936 miles on the islands, giving a total coastline of about 3664 miles.

"Its northern boundary lies from 5° south latitude at the west end to 8° south latitude on the east end; the southern boundary in the west is the sea and the Colony of Queensland, and in the east end it comes as far south as 12° south latitude. The eastern and western boundaries are respectively the 141° and the 155° of east longitude. The western boundary meets Dutch New Guinea; the northern boundary meets Kaiser Wilhelms-land."

[The control of this Possession has recently been accepted by the Commonwealth of Australia.]

General Remarks on Physical Features.

It may, I think, be accepted as a fact that most of the islands under consideration are of volcanic origin, and that a large number of them have been formed by upheaval, though it is also probable that some of them have been formed during periods of slow subsidence. Many years ago I wrote in my diary of certain islands in the New Britain group—that it was impossible to account for their present condition by the subsidence theory alone. On several islands I noticed distinct terraces, far above the present sea-level, which still showed deep indentations which had evidently been hollowed by the action of the surf. I noticed also steep points of land, notably one near Point Hunter, which had once evidently been separate islands, but are now united by low lands, and it was not at all difficult to see that this low land had formerly been a channel between the two, and owed its formation in the first instance to tidal waves, or to the backing-up of the tides during the N.W. monsoon; and this was confirmed by native tradition. In Blanche Bay, also, as I have already related, I was myself the spectator of the formation of an island. In New Guinea, also, I have seen islands composed of true coralline limestone, the cliffs of which rise so perpendicularly from the blue ocean that the natives have to ascend and descend by ladders in going from the ocean to the top, or *vice versâ.* A large steamer can go so close to these cliffs that she could be moored alongside of them in calm weather. It is not at all improbable, I think, that in these islands we have the two factors in the formation of islands, viz., subsidence, during which these immense cliffs were formed, and subsequent upheaval. This is the only way, I think, in which we can account for these perpendicular cliffs in the midst of deep blue ocean. The only alternative theory is the highly improbable one that the present sea-level is several hundred feet lower now than it was in former years. The formation of the new island in Tonga is well known as having taken place in recent years, and have grown in size very considerably since they were first discovered, whilst the dyke of basalt underlying the coralline formation in Eua is also another proof of upheaval. Professor Darwin's statement that volcanoes are often present in the areas which have lately risen, or are still rising, is clearly proved by the present condition of the groups under consideration. I think it very probable, however, that many of the atolls have been formed by subsidence, and the steady growth of coral on the shore or fringing reefs round the now submerged land; but, as far as my experience goes, I am inclined to believe in the old theory that by far the largest proportion of the islands in the Pacific are either the tops of mountain ranges, or have been uplifted by volcanic agency.

Commercial Geography.

The products of these countries, and their commercial value, may be very briefly stated. In all of them the cocoanut in its export form of copra occupies the most important position, more especially in the eastern or Polynesian groups. In Tonga and in Samoa it is almost the only article of export. In Fiji it is probably second only to the production of sugar, which in late years has been so very largely developed in that group. In the New Hebrides, the Solomons, New Britain and New Guinea, the produce, though not so large as in the other groups, is still the principal article of export. Cocoa is being extensively grown in Samoa. Pearl-shell is found in the Solomons, and considerable quantities are exported from Manning Straits and other places. Gold is found in New Guinea, and copper and tin are known to exist in the Solomons group. The trade in Beche de mer is almost at an end in the groups under consideration. The commercial value, however, of these islands is still very imperfectly developed; and, in the opinion of many, the exploration of some of the large islands—notably of Guadalcanar, in the Solomons—would reveal many sources of wealth of which we are as yet ignorant.

We find that the physical features of the islands have, as in more civilised places, a most important influence upon the character of the people, their modes of life, their industrial pursuits, and their relations with other tribes. A small island, such as Manono in Samoa, Bau in Fiji, Duke of York in New Britain, Dobu in New Guinea, lying contiguous to the mainland of larger islands, develops a race of seafaring men, whose power, owing to the comparative ease with which they can make raids upon their neighbours, is quite disproportionate to their numbers. The coast tribes of large islands live in constant dread of them, and this fear modifies very materially the location of their villages, the shape of their houses, as well as their relations to their aggressive neighbours. The complimentary name of Manono was "the fleet," symbolic of its sea-power; and so great was the dread of them in olden days that even solitary voyagers were treated with marked respect, and the proud boast, "I am a Roman," was quite equalled by the pride with which a Samoan said, "I am a Manono man," or with which a dark-skinned Fijian said, "I am a man of Bau." In the Solomons, also, the raids made by the head-hunters of the New Georgia Group have almost depopulated the shores of Ysabel, which in the day of the Spanish discoveries were teeming with population. These same raiders also caused a great change to be made in the houses of the people and the location of their villages, as the shore natives were compelled to build large tree-houses in which to take refuge, or to place their villages on mountain ridges or inaccessible positions inland, to escape the ever-present danger of attack.

In the large islands, also, the fact that many of the people lived inland, whilst the others were located on the beach, had a good influence, not only on the character of the people, but also on the commercial relationship. The men on the beach have at once a great contempt for the bushmen, and a constant dread of attack from them, and it may be safely said that on most large islands there was a state of constant feud between the inland and coast people; but each had wants which the others could supply, and so the necessities of commerce arising from the different localities in which they lived often compelled more peaceful relations than would otherwise have obtained. The bushmen wanted fish, salt water, and the articles of trade which the coast dwellers could procure, whilst they in turn required food, weapons, shields, and other articles which the inland people alone could obtain and sell. Even amongst the coast tribes there were articles which, owing again to physical features, could only be obtained in certain localities, but were highly prized in other places; and the necessities of commerce again influenced the character of the people, and necessitated peaceful relations between them. For example, Port Moresby natives are great makers of pottery, but have no sago, and so for many months the women made pottery, which the men took in their large lakatoi for many miles at certain periods of the year, to exchange for sago and other articles. The New Britain money—called diwara or tambu in and about the Gazelle Peninsula—is made of a species of nassa which is only obtained many miles down the coast. It is valueless in the places where the shell is found, but is highly prized in those places where it has become the currency of the country. This necessitates long voyages to procure the shells, and the interchange of property amongst the people. It also affects the character of the people, as the necessity for making these voyages has changed in no slight degree the habits of the people from those of a shore-living race to those of a seafaring people, and has also caused them to improve the quality and capacity of their canoes. In the Solomons, also, the

Bougainville natives are the best makers of spears, and there is a steady demand in the eastern groups for these weapons, whilst the western natives have an equal desire for the various kinds of shell money which are manufactured by the eastern tribes. These facts will show that the influence of the physical features of the land, the localities in which the people live, and the natural products of those places, exercise a great influence upon the character and habits of the people, and constitute no unimportant part of geographical study.

Ethnological Geography.

I may at once state that in my opinion the different groups in the Pacific are not only closely connected to each other, but that the peoples who inhabit them, though differing widely in the stages of civilization which they have attained, are all descended from one common stock.

This opens up the vexed question of the origin or habitat of these races, called respectively by the author of the various theories Malayo-Polynesian, Eastern Polynesian, Mahori Sawaiori, Papuans, Melanesian, Western Polynesian, and several other names. It is indeed a most difficult question, and I can only state here conclusions to which I myself have come, admitting at the same time that there are difficulties to the full acceptance of them which I do not feel competent to explain.

I think it is extremely likely that there was originally one great race occupying these different groups, as far west at least as Borneo, and probably extending upon the mainland on the side of Siam, the Malacca Peninsula, and perhaps as far as Burmah, which probably at that time formed part of one vast continent. The traces of these people are, or have been, found in all the different groups, from the black races found in New Zealand by the original Maori colonists, and who were derisively called by them "black humara," to Western Malaysia, and also on the mainland. The Papuans of the present day, are the purest representatives of this race. In Malaysia, this pre-Malayan race was modified by admixture with the Turanian races of the mainland of Asia; and this constituted the present Polynesian race, which still retains so much of its old Papuan element. This intermixture will probably account for some, if not all, of the differences which exist to-day between the brown and the black races, as they are found on the different groups. At this period

I think it likely that the migration eastwards set in, probably caused by the encroachments of Malay and Hindu immigrations, as Fornander states. In fact, the principal difference between Mr. Fornander and myself is that I hold that the basis of the Polynesian is Papuan, with Asiatic admixture; whilst he describes it simply as a separate and distinct ante-Malayan race, which drove out the Papuan people, only in turn to be themselves driven out by the Malays, and so compelled to look for other lands on which to settle.

With regard to the language spoken, I believe that, much as they appear to vary on first acquaintance, they are radically all of one common stock; that the points of similarity between the two languages, as in the construction and formation of nouns and adjectives, the existence of the dual number in both, and traces of the trinal in the Eastern Polynesian, as in Tonga and Samoa, the use common to all of inclusive and exclusive pronouns, the reciprocal and causative forms of the verbs, the use of transitive terminations, and many other points, are neither few nor insignificant as pointing to a common origin of both languages. The opinion here advanced is strengthened by a comparison of the manners and customs of the different peoples, and especially by the survivals in culture amongst the later Polynesians of the customs and traditions of their Papuan ancestors. Ethnolographically, however, these peoples under consideration may be divided into two races, called Polynesians and Melanesians, or, as I prefer to call them, Eastern and Western Polynesians; as even if it be clearly established that they are from one common stock, the difference in civilisation and culture which now exist, as such as to justify us in considering them as separate people.

The Samoans are of the light-brown Polynesian race, of which the principal members are the Maoris, Tongans, Cook Islanders, Rotumans, Sandwich Islanders, Tahitians, &c. It is very probable, indeed, that wherever the original hatitat of the race may have been, the point from which their dispersion in Eastern Polynesia took place was from Manua, in the eastern part of the Samoa group. Tui Manua claims indeed that the whole group is named from his family. "Sa" is the Samoan word for family, and "Moa" is Tui Manua's family name, so that Samoa really means the family of Moa. It is also true that the traditions of Tonga, Fiji, and other places have constant reference to Manua as the scene of events connected with their earliest history, whilst the Havaihi of the Maories is simply the form which Savaii, the largest island in the group, assumes, in accordance with well-known phonetic changes. That the Cook Islands were peopled from Samoa is a fact of history amongst them, and if the Maories went from there to New Zealand they would still take the name of their ancestral home with them.

The people of Tonga also belong to the lower Eastern Polynesian type. They are in my opinion the most intelligent race in the Pacific, and are specially distinguished for their power in mental arithmetic and mathematics. The political constitution consisted of the Hau or families of the blood royal, the Houuki or chuefs, the Muas or gentry, the Matabules or official attendants, and the Tuas or common people. There was also a sacred king as well as the ruling monarch. This custom also prevails in a more or less modified form amongst other Polynesian races, and is a distinctive mark of a decided advance in civilisation from that of the original Papuan stock. The graves of the Tui Tonga, or sacred kings, are of immense size, and show very clearly the respect and reverence of the people for them, whilst the most probable explanation of the unique trilithon in Tonga is, that the stones were erected to form a gateway to the burial ground of those kings, or were intended as a memorial to some particular individual. These remarkable stones are situate in the centre of the island of Tonga, at the east end, near a village called Niutoua. They are of coralline limestone, and have evidently been cut out of the solid reef formation. The two perpendicular stones are 14 feet high out of the ground, 12 feet wide, and about 5 feet in thickness. The top stone, which is morticed into the two side pillars, and not simply laid on the top as is generally the case in all other similar erections, is 16 feet in length, 4 feet 8 inches wide, and about 2 feet thick. When it is considered that these immense stones had to be quarried from the reef, then dragged up a steep shore-line about 100 feet high, and erected far inland with the aid only of the most primitive appliances, it is very evident that the population of the group, in those days must have been much larger than it now is.

The people of Fiji are of the Melanesian type, modified in all probablity by admixture with Tongans and other Polynesian peoples. The language, which is very full and expressive, is Melanesian in its structure, but in the Eastern groups many Polynesian words have been introduced. They are as fierce, warlike people, with hereditary chiefs, who in olden days exercised the most despotic power. In this respect there is a great difference between the Fijian and other Melanesian races. In New Hebrides, the Solomon Group, New Britain, and New Guinea, the chiefs have comparatively little influence or power, and in very few instances could any of them venture to order or command such arbitrary acts as a Fijian chief did with comparative impunity. In Fiji there was combined in the chief, in former days, the ferocity of the Melanesian savage with the despotic power of the Polynesian chief, and the result was the perpetration of some of the most horrible deeds of cruelty which ever disgraced humanity. The Rev. T. Williams has described the character of a Fijian as follows:—"His feelings are acute, but not lasting; his emotions easily roused, but transient; he can love truly and hate deeply; he can sympathise with thorough sincerity and feign with consummate skill; his fidelity and loyalty are strong and enduring, while his revenge never dies, but waits to avail itself of circumstances or of the blackest treachery to accomplish its purpose. His senses are keen and so well employed that he often excels the white man in ordinary things, in social diplomacy he is very cautious and clever, his sense of hearing is acute, and he has great command of temper and power to conceal his emotions."

The New Hebrides, Solomons, New Britain, and New Guinea peoples are all of the Melanesian or sub-Papuan race, but is is extremely difficult to describe a typical Melanesian, as distinct from a Polynesian. The principal difference appears to be in the hair, which in the Melanesian and Papuan is decidedly frizzly, growing in little tufts or curls, which in mature life grow out either into long curls or into a frizzled mop. The pure Melanesian is often very little darker in colour than the Polynesian, but the general colour is from a deep sooty-brown to dark bluish black. Mr. Alfred Wallace, whilst holding strongly to the opinion that the Malays and Papuans are essentially separate and distinct races, believes "that the brown and the black, the Papuan, the natives of Gilolo and Ceram, the Fijian, the inhabitants of the Sandwich Islands, and those of New Zealand, are all varying forms of one great Oceanic or Polynesian race;" and in this opinion I agree. But I do not accept his explanation of what he calls "the occurrence of a decided Malay element in the Polynesian language." He states that it is "altogether a recent phenomenon originating in the roaming habits of the chief Malay tribes." There is nothing more certain than this, that many of the Melanesian and Polynesian races in whose languages words common, both to them and to the

Malays, occur have never been visited by any roaming Malay tribe. We must go further back for an explanation which will account for the fact. The correct explanation, I think, is that these words were in common use amongst the original peoples who inhabited the Malay Peninsula prior to the Malay irruption, and that they became the common property of both races. There were in the language of the Papuan races, in that of the mixed races which constitute the brown Polynesians, whom the Malays drove out, were adopted by the Malays, and so are found to-day in all branches of these families. One of the most striking examples I know of is in the word "rumah," a house. This word occurs in the form of "ruma," Duke of York Island, San Cristoval, in the Solomons, and in "motu" in New Guinea, "luma" in the Solomons, "uma" in Javanese, "suma" in Fate, and in varying forms in several other islands. As I have stated, there is not the slightest probability that any wandering Malays have ever visited these groups; but the word is there, and it is also in the Malay Archipelago. The word for house in Polynesia is 'fale," "vale," "whare," or some similar form; and widely different as these words "rumah" and "fale" appear to be, I believe that they both belonged to some common ancient stock, for I have found both used by Melanesians in one group in the present day. In Duke of York the common word is "ruma," but the pure Polynesian word "pal" (fale) is also used by that people for an outhouse, whilst in New Britain, only a few miles away, "pal" is the common word for house. "Ruma" has been generally retained in Western Polynesia, whilst "pal," "fale," "vale," "whare," have been adopted by those who travelled farther eastward; but in a pure Melanesian group both words are used by the people living there. In one case "pal" has supplanted "ruma" as the word for house, whilst in the other "ruma" is the common word, and "pal" becomes an outhouse only. A full comparison of these languages will show that in many other instances the same words are used to express the same or similar meanings in Malay, Melanesian, and Polynesian groups. "Prau," a boat, in Malay, is "parau," a ship, in Duke of York, and "folau" in Samoan; and giving the same words in the same order, we have "ikan," a fish; "iam," 'ia," "bua," fruit; "ua," "fua," "mata," the eye; "mata," mata akai," a root; "aka," "aá," "lima," the hand; "lima, lima," and many other similar instances. An objection is sometimes made that it is unreasonable to think that the lower and unaggressive Melanesian race has imposed its language upon the higher Polynesian races, but it is not necessary to assume this at all. What is assumed, is that these words were in the language of the original settlers in Malaysia, as they still are in those of other Melanesian races at the present time; that they were retained in the language of the mixed race which inhabited Malaysia prior to the Malay irruption; and that many of them were adopted into the speech of the Malayan people who drove out the mixed race which now constitutes the Polynesian peoples.

The points of resemblance between the modes of thought, manners and customs, and social organisation of the Melanesian and Eastern Polynesian are very significant; but the subject is too large to be dealt with here. They all share, in common with many other peoples in a similar condition, the belief in sorcery, augury from omens, wailing for the dead in the full belief that the spirit of the dead man or woman hears them, the belief in rainmakers, in the power of certain men to cause disease or death by the use of portions of food which have been touched by the man or woman to be injured, or by blood, spittle, hairs, or anything else belonging to him, offerings and addresses to the dead. Names given at birth as mementos of some special occurrence at the time, interment of property with the dead, disease from evil spirits, strangling of widows, and many other similar customs which are practised by savage people. There are, however, a few of these customs which may, I think, be specially considered. Most of the Melanesian races are cannibals, whilst the Polynesians as a rule will indignantly deny that it was ever practised amongst them; and yet when we examine into the origin of some of their customs, it is very evident that the habit was common even amongst such superior races as the Tongans and Samoans. When the Samoans went to beg pardon for any great offence, they bowed down in front of the offended chief's house, each man holding in his hand a piece of firewood, leaves, stone, earth, &c. These were symbolic of the deepest humiliation, and meant, "here are we, and here are the stones, firewood, leaves, &c., to make the oven in which you can cook us." A Samoan would take out the eye or tongue of a fallen foe, put it on a banana leaf, and pretend to eat it, to show his hatred. These are surely proofs of cannibalism in other days. The Samoans use a polite language when addressing others, and ordinary words when speaking of themselves. The traces of this are found also in Melanesia. The Duke of York people say "un turu" (stand up) as a polite form of good-bye, and "tapula" (made blind) for death, &c. Niggardliness is a great sin in both places. "O le tagata lelei" (a good man) in Samoan literally means a liberal man, and to eat in secret so as not to share with others was a shameful offence; and we find that in Melanesia a niggardly fellow ("pom," in Duke of York) is a contemptible man, and one for whom a special punishment in the other world has been provided. Mutilations for the sick were common in Tonga, and are still offered in many parts of Melanesia.

The peculiar institution of "Tama fafine" in Samoa, "Tama ha" in Tonga, and "Vasu" in Fiji, may, I think, be traced to the class relationship which still exists in Melanesian groups As is well known, the sister of one or more brothers, together with her chidren, occupy a peculiar semi-sacred position with regard to her brothers and to their children. The child of a sister is "tama fafine" in Samoa, and "vasu" in Fiji, to all the families of the mother's brothers; and as such, possesses certain rights and privileges over personal property belonging to them, and is treated by his or her relatives with peculiar respect and deference. In a Melanesian group, the people are all divided into two or more exogamous classes; the members of which can only marry with those of the opposite class to their own. In Duke of York, these are called Pikalaba and Maramara. Each of these has a separate totem, that of the former being the "kam" ("mantis," religious), and that of the latter an insect called "ko gila le" (leaf of the horse-chestnut), because it resembles it in shape. A Maramara can only marry a Pikalaba, and *vice versâ.*

All children are of the mother's class. Now suppose—

Kaplen, a Maramara	Nelig (his sister), Maramara
marries	marries
Nekibil, a Pikalaba	To lig, Pikalaba
|	|
Topam, Pikalaba	Ana, Maramara

Here Kaplen (Maramara) is afraid of or pays respect to Ana (Maramara), his sister's child, because she is of the same class as himself, and so specially forbidden to him, but he would not be so afraid of his brother's child, because she would necessarily be of another class, and so one with whom he was in theory, if not in fact, free to marry. In Melanesia there would be nothing to prevent Tapam (Pikalaba) from marrying Ana (Maramara) his cousin, except the aversion of the natives to such marriages, but in Polynesia at the present time he would be absolutely prevented from doing so, as under the present system they are considered as brother and sister. The respect paid to the sister's children by the brother and his family in Polynesia is probably a survival of these class relationships, involving as they did different totems being used by the respective parties. In Duke of York the members of the secret society called "iniat," would not eat turtle, pig, shark, or cuttle-fish, not because these were considered as gods, but because they were the animals in which the spirits lived for awhile. The same idea is also found in Samoa, and all Polynesian groups. These are but a few of the points of resemblance between these people. Many others could be adduced, but these are sufficient to show that in their ideas, beliefs, manners, and customs, there is much to suppose the presumption that they are all members of one common stock.

NOTE ON SOME REMARKABLE MIRAGE PHENOMENA SEEN AT FALMOUTH.

By Colonel W. V. Legge, F.L.S.

[Plates.]

On the 2nd November last, a party of friends and myself witnessed a series of Mirage phenomena on the east coast of Tasmania, which appear to be worthy of description.

The effects, which had a most remarkable appearance, were apparently produced by smoke. About 20 miles north of Falmouth, the promontory known as St. Helens Point projects from the coast, which itself has an easterly trend towards the north, considerably lengthening the appearance of the Point when viewed from the south. Beyond St. Helens, the coast-line has a northerly direction along the Bay of Fires towards Eddystone Point, and is completely hidden from Falmouth by the Promontory. During the spring and summer, fires are lit along the shore beyond St. Helens, the country being a wild and almost uninhabited region, taken up as sheep-runs, the only capable improvement of which consists in the usual "burning off."

It is no uncommon thing, therefore, at that season of the year to see clouds of smoke of the ordinary shape and appearance rising from beyond the long line of coast, shown in the sketch No. 1.

The approach from the uplands along the Break o'Day River to this part of the coast at Falmouth, is by way of the romantic St. Mary's Pass, which descends from the divide near the township of that name to the sea, and as it winds down the sides of the range near St. Patrick's Head, discloses a full view of the coast to the north.

On the date referred to the weather was bright, with clear blue sky, and a north-easterly sea-breeze, but along the whole horizon, as we afterwards discovered, was an almost imperceptible, though solid, belt of bluish haze, extending up about 15 degrees, and the upper edge of which blended into the blue sky in a line parallel to the horizon. On nearing the bottom of the pass, and opening out the coast to the north, we perceived, standing up beyond the distant shore, an opaque blackish mass with a perfectly flat upper edge, or summit, looking like a huge and distant basaltic mountain, only that its sides were slightly concave, and the upper points projecting out along the line of the top.

GENERAL VIEW OF ST HELENS POINT WITH MORNING MIRAGE

COLUMN SPREADING TOWARDS MASS

FIRST AFTERNOON MIRAGE FORMING

PILLAR SPREADING TOWARDS MASS

FIRST MIRAGE COMPLETE AND SECOND FORMING

DUNE MIRAGE RISING WHILE FIRST MIRAGE IS DISSOLVING

FIRST MIRAGE DISSOLVING, SECOND COMPLETE

SKETCH OF MIRAGES ON EAST COAST _ ENLARGED.

From subsequent observation during the afternoon, this was noticed to be the final stage of the mirage formation, for as we neared our destination, about 11 a.m., the edges of our "mountain" gradually dissolved towards the earth. until the whole vanished. In the afternoon, about 2 p.m., as we were enjoying our siesta on the shore, near one of the interesting "raised beaches" of boulder and pebble common on this coast, we saw slowly rising above the distant land a vast, perfectly wall-sided, columnar mass, followed shortly afterwards by a broad irregular one to the eastward, but quite disconnected from the former. The latter rose to the level of the "haze-bank," and then spread along the top of it, assuming a shape like the letter L inverted, the arm of which lengthened towards the larger irregular mass, which had also risen to the same level, assuming a perfectly flat, or tabular top. This process of amalgamation between the column and the mass continued till the mirage assumed the solid form observed in the first one, during our descent of the pass. These formations are illustrated in the sketches Nos. 2 and 3.

The most interesting phenomenon was, however, to follow, for as we gazed at the newly formed table mountain, we observed slowing rising from the promontory a considerable distance to seaward a lofty black pillar (much narrower than the column already noticed) with perfectly smooth perpendicular sides, and following it at a little distance inwards towards the mirage just described, another irregular mass.

The same process was repeated—the pillar rising to the level of the "haze-bank," which represented at that distance (20 miles) about 1000 feet, and then spreading out at the top into the same form as before, and uniting with the irregular mass, the lower portion of which uniting with the irregular mass, the lower portion of which *extended towards the pillar.* In about twenty minutes the mirage was formed completely, taking much the same shape as the others, the top being exactly on the same level as the haze-bank. This bank, it must be noted, was not visible over the land, being only perceptible on the sea from St. Helens Point along the whole horizon to the south. The last two mentioned mirages took about an hour to dissolve, and during the vanishing of the one farther inland beneath the position of which the shore had a sandy beach, clearly visible on a bright day from the point of our observation, we noticed this latter rising as an enormous yellow dune into the dark mass of the mirage.

It is noteworthy that towards evening the bluish haze-belt in the horizon, which I have alluded to, became more intense, and it was during this time that the two latter phenomena were noticed.

There can, I think, be no doubt that this atmospheric condition was the cause of the phenomena, for such they may without impropriety be styled, so different were they to the ordinary mirage, the appearance of which is familiar to all who have traversed the wonderful plains of Riverina. There one often sees what appear to be large trees standing up above, and disconnected from the horizon, and while riding towards them for miles, perhaps at a hand gallop, hoping to get beneath the shade of some fine "willows," and luxuriate in the cool shelter of their foliage, one suddenly comes to a few stunted "Lignum bushes," standing perhaps by the side of a lonely waterhole.

In the singular shape and gradual methodical formation of the columnar masses at St. Helens Point lay their dissimilarity to the familiar mirage of the Australian plains.

No explanation of their cause can be given other than that they were caused by detached bush-fires, perhaps with quite insignificant volumes of smoke, which seen through the singular haze-belt took the fantastic forms the description of which has been attempted.

The perpendicular and regular form of the columnar mass and pillar were doubtless due to the existence of small and erect masses of smoke rising at a little distance from the large and more straggling volumes. The drift of the upper portions of the columns in opposite directions may have been caused, in spite of the sea-breeze blowing from the north-east, by the presence of a hill, which diverted the air-current and altered the direction of the smoke of the column. Another interesting feature was the absence of the usual suspension in the air of the mirage, for, so far as could be observed, there was no interruption of continuity between the mass of smoke and the hills behind which it rose.

Again the regularity in the outlines of the mass, when completely formed, is an interesting and puzzling characteristic of the phenomena, as we can scarcely assume that the comparatively diminutive volumes of smoke which were the basis of the mirages took any such shape.

The diagrams given show the mirages enlarged, or as they would probably have been seen from a short distance. It is possible that the outlines of the *complete* masses are a little too regular at the sides and corners, but the top in each case was particularly level and straight.

THE ISLAND OF SARK.

By Rev. J. B. W. Woollnough, M.A.

DIEGO ALVEREZ, OR GOUGH ISLAND.

By J. R. M'Clymont, M.A.

Section F.

ETHNOLOGY.

PRESIDENTIAL ADDRESS.

By Walter E. Roth, B.A., M.R.C.S., &c., Late Demy of Magdalen College, Oxford.

GAMES, SPORTS, AND AMUSEMENTS OF THE NORTHERN QUEENSLAND ABORIGINALS.*

At the very outset, I may be allowed to express regret that the classification of the subject-matter which I have adopted is only tentative, though, on the other hand, it has been found to answer the purpose of allowing the many different methods of recreation and amusement to be arranged in certain well-defined groups. These groups, without any attempt at placing them in their order of origin and development, or relative importance, may be briefly noted as follows:—Imaginative games, as the name implies, deal with tales, legends, and other fancies of the imagination. Realistic ones include the pleasures derivable from actual objects of nature, organic as well as inorganic; the same feelings which prompted me as a little boy to catch flies and keep them alive in specially constructed paper boxes, to splash the water about whenever I had a chance in the bathroom, or to have a slide so often as any convenient stretch of mud or ice presented itself. Imitative games constitute far and away the largest category, and may be again subdivided according as they deal with objects and phenomena of nature, or with human actions. The former may be represented by means of attitudes and movements, by string, finger-prints, and sand-pictures, and by pigments. The latter can be discussed according as they refer to matters

* This address forms the major portion of a Scientific Bulletin subsequently issued by the Queensland Government as a Parliamentary Paper (C.A.8.—1902). Several illustrations are now introduced which it was not considered desirable should be shown to the mixed audience before whom the address was originally delivered. The Hon. the Home Secretary, Mr. J. F. G Foxton, has kindly given permission for the reproduction of these illustrations.

of domestic or "home" life, methods of hunting, ceremonial, and warfare. Discriminative sports include the various forms of hide-and-seek and the guess-game. Disputative games comprise wrestling and a variation of the tug-of-war. Toys, or specially manufactured articles, all present the peculiarity that the source of the enjoyment consists in the particular form of motion which may be imparted to them: I may perhaps be allowed to call them propulsive games. Music, which may be either vocal or instrumental, constitutes another of the groups (exultative games) to which attention will be directed. I shall finally have a few words to say with regard to games introduced of late years by missionaries, settlers, and others.

Imaginative Games.—No small difficulty has been experienced in separating certain of the fables and stories which are told for pure amusement from those which, in the minds of the aboriginals, are explanatory of the many natural phenomena around them. Though at first sight it might appear that the intent of some of the tales in the former series is to point a precept or moral, I am afraid that, with few exceptions, such is far from either being the case or serving the purpose—the pleasure derivable from their recital lies rather in the craft and wit delineated, together with the local colouring and personal address of the speaker. The light in which such stories are regarded varies markedly in different districts. In the N.W.-Central areas, the women, and those men who are "lazy"—*i.e.*, those who are always loafing around the camps—are the best hands at telling them. An individual in the full vigour of mental and bodily physique looks upon it as womanish and childish, almost derogatory, to know anything concerning them, and will almost invariably refer to his gin when any such matters are inquired of. At Princess Charlotte Bay (East Coast), on the other hand, it was the men who prided themselves on spinning these yarns, and many a night have I spent in the camps listening to their narration, each tale being interpreted for my benefit. In all cases these stories appeared to be well known to the tribesmen of the particular individual relating them, and hence, locally, might almost be described as national; so much so, indeed, that it was of no uncommon occurrence for the reciter to be suddenly interrupted and corrected, and the general thread of the story to be resumed only after four or five disputants had had their say. Still further south, among the scrub blacks (*not* the coastal ones) along the lower Tully River, we come upon the professional storyteller; such an one can tell no end of tales, mostly of personal experiences (mostly imaginary). The art is apparently hereditary here, being handed from father to son.

The following will serve as examples of some of these stories:—

Small Things—even Feet—are not always to be Despised. —The kangaroo-rat took his quartz-spear with him, and went to look for a sweetheart. He met a dugong—for in those days dugongs lived on land—and asked her to be his wife. But she said, "No, your hands and feet are too small." Indeed, she was that tickled at what she considered so unimportant an individual's impertinence that she ridiculed him to her friends, who, on the very same evening, introduced the subject into their corroboree by singing aloud, "Kangaroo-rat! Kangaroo-rat! Only fancy! He wants to marry one of us. Look at his small hands! And what small feet!" Naturally enough, the rat resented such treatment, and let fly his spear into the very midst of the singers, wounding the particular dugong who had refused his offer. Some of her mates, taking fright, fled down into the salt water; others, more courageous, turned on their assailant, but never succeeded in catching him. His tiny feet, about which he had been so much taunted, gave the rat his loophole for escape.

The Lady Scored (Pr. Charlotte Bay).—Mother Tortoise, one hot afternoon, feeling very thirsty, went to get some water, but, not being able to find any, asked her lord and master where it was. He was a selfish beast, and told her he had drunk it all. This, however, was a lie, for he was keeping it safe under each armpit in store for the dry season. She also had her suspicions, and threw a lighted fire-stick at him. This made him raise his arms in astonishment, when down fell the water, and she quenched her thirst.

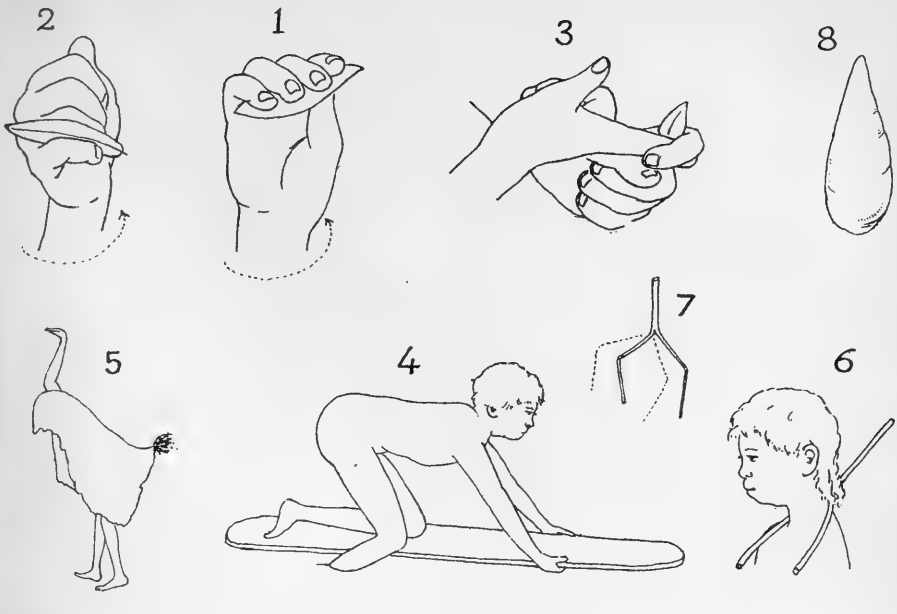
Realistic Games (*Animals*).—Captured animals may be preserved alive, though, with few exceptions, unless able to feed themselves, they soon perish of hunger. Thus, the Bloomfield blacks are very fond of playing with young rats, bandicoots, wallabies, &c., as pets, which they will tie up at night; but they never think of feeding them, with the result that it is not long before they are released by death. At Cape Bedford, young birds, rats, frogs, &c., tied with a string, are given to the children to play with; but any thought of supplying them with food is quite out of the question. So again, in the Cairns district, to amuse the children, and to give them a plaything, frogs are tied by the legs, and iguanas by the tail, with the usual results. On the lower Tully River small carpet-snakes may be caught, have their teeth rubbed down with a stick, and then be caged in gourds, calabashes, &c., until they die. The Kalkadun blacks of the Selwyn, &c.. Ranges practice a form of "coursing," as follows:—A wallaby, dingo, rat, &c., having been previously caught alive, is kept for a time by means of string attached to one of its legs. When all the players are ready, and in position, the animal is let go, and must be caught with the hands only, no sticks, stones, or boomerangs being permissible in its recapture. On the border-line between amusement derivable from temporarily retaining captured animals as pets or playthings and domestication, attention may be drawn to the Torres Strait pigeons, cassowaries, &c., along portions of the eastern coast. After being caught, and their main wing-feathers pulled out (Cairns district) or cut (Tully River), pigeons are thus suffered to wander in and out among the camps, picking up any scraps of food or seed that they can. Young cassowaries are also often captured and fed by the scrub-blacks on the lower Tully, allowed to grow up, living as best they can, and following the aboriginals from camp to camp. Among these same natives pets may also be made of the ring-tailed opossum and the wallaby, both animals often straying away from "home" for hours at a time, hunting on their own account. Only in the case of the dingo does true domestication and training take place. The pups are caught young, brought into camp, and tied up by the leg until such time as they become reconciled to their surroundings. Sometimes a boy (on the Bloomfield), but more usually a gin, is placed in charge of these animals; in the latter case, it is a very common practice for her to suckle them, if necessary. The aboriginals appear to be very fond of their dogs, share their food with them, often speak to them as if they were intelligent beings, and do not believe in "suling" them one on to the other; in the latter case, they will indulge in violent outbursts of anger, even with their children—a most unusual occurrence—for attempting to do so. In the more southerly districts, the domestic cat is now to be met with in many a camp. During 1897, in the vicinity of Gladstone, I came across some humpies belonging to blacks, whose stage of civilisation admitted of their even keeping fowls.

Plants.—At the Bloomfield, swinging on the lawyer-cane (*Calamus*) is a common pastime. The hanging creeper is cut from 2½ to 3 feet from the ground, and the children jump and run at it, or else get others to swing them. They hold on with the hands above and feet below, the knees being extended outwards. I have noticed a similar thing along the Morehead River at the back of Princess Charlotte Bay. Among the northern Maitakudi and Grenada Kalkadun, a sort of skipping-rope, *turi turi*, made from the roots of the *Bauhinia*, or white-gum, is held by two playmates, who swing it backwards and forwards—they do not circle it; but whether this is a development of the Bloomfield, &c., game, or only an imitation of the European pastime, there is but little chance now of discovering.

Inorganic Nature.—(*a*) In the N.W.-Central districts, *Smoke-Spirals* are played thus:—Any leaf, small piece of light bark, or even a mussel-shell, by means of a peculiar motion of the wrist and arm, can be thrown in such manner into the dense smoke rising from an ample fire as to ascend with it like a spiral. There are different ways of holding the article in question, the most usual being represented in Pl. I., 1. The wrist is rotated outwards at the same time that the forearm is jerked sharply forwards and downwards, the object leaving the hand just at the completion of the movement. Another method of throwing the leaf into the smoke is to hold it between the fourth and fifth digits, as in Pl. I., 2, and, with a motion of the forearm similar to that in the preceding, to rotate the wrist inwards. The Kalkadun, amongst whom I have noted this way of jerking it, speak of the game as *piri-jorongo.* A far easier and commoner method of throwing it is to make the firmly-extended forefinger of the one hand act as a sort of spring on the other (Pl. I., 3), the leaf, at the moment of release, being shot at an angle into the smoke. At almost the opposite extremity of the State, in the neighbourhood of Rockhampton, I have seen the leaves of the brigalow (*Acacia harpophylla*, F. v. M.) similarly used in making smoke-spirals.

(*b*) Playing at *Mud-Slides* is very common in and among the moist salt-pans at the back of Princess Charlotte Bay—men, women, and children all joining in the fun, and laughing at every mishap. A corresponding amusement is indulged in by the little boys along the mud-banks, at low-water, in the neighbourhood of Cardwell, &c. They get a longish piece of bark, rest on it with the left knee and shin, and balance themselves in front by holding on tight with both hands (Pl. I., 4). They obtain the necessary impetus by kicking backwards in the mud with the right leg, and, with this movement rapidly repeated, they can skim along the mud-flats at a comparatively high rate of speed. (As

W.E. ROTH



Pl. I.

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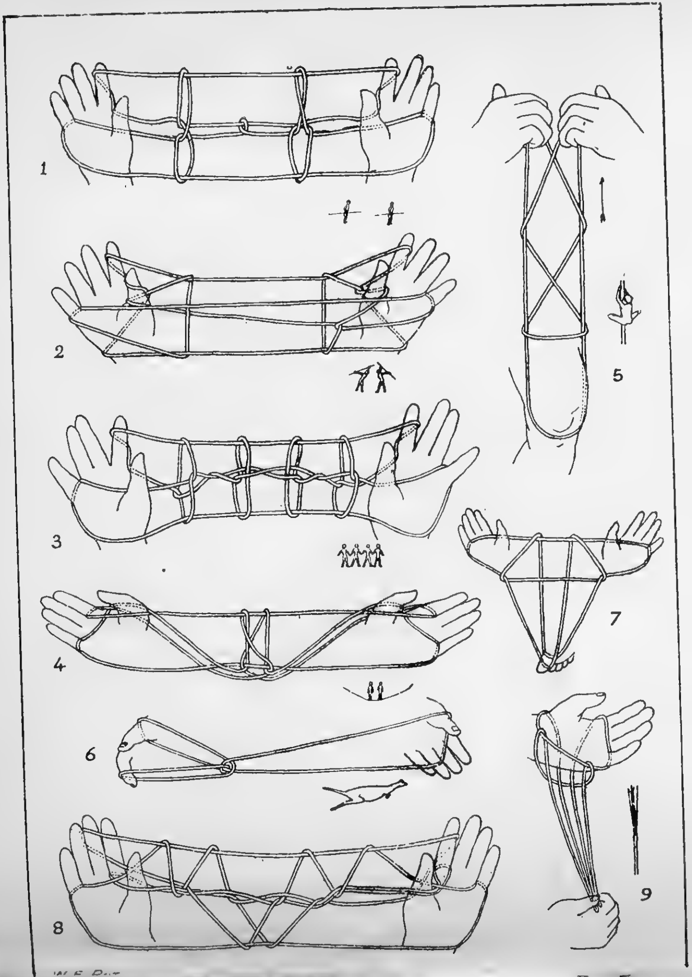
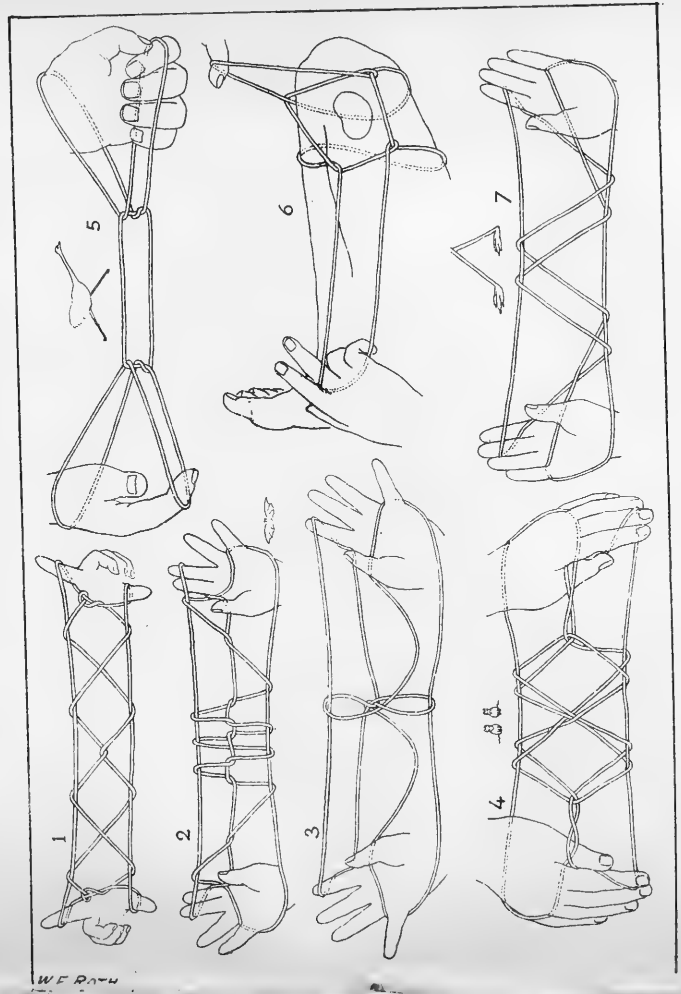
Pl. II.

[illegible]

PL. III.



PL. IV.



might at first sight have been suggested, I do not consider this particular pastime to be imitative of canoeing.)

(*c*) Bathing is, of course, always indulged in at any convenient creek or waterhole, and in its wake comes *splashing*, *diving*, catching, &c. One will dive either to elude being caught himself, or the better to enable him to catch others, any convenient rocks or water-bushes being utilised for purposes of eluding pursuit. Along the Bloomfield, among what may be called such aquatic sports, is one in which the individual will, with a long breath, dive under water, and, as he swims along, blow bubbles up on to the surface; others will try and excel him. This may possibly correspond to the "crocodile" game—a favourite one amongst the Princess Charlotte Bay blacks—where the surface-bubbles, as the native dives along, are intended to imitate the reptile's tracks. The Bloomfield aboriginals will also often see who can jump into the water from the greatest height, this being always done with the feet foremost (R. Hislop).

Imitative Games. (*Objects and Phenomena of Nature—Imitated by Attitudes and Movements.*)—(*a*) The mimicking, by means of attitudes and movements, of various animals, birds, &c., forms an important item in the diversions with which the aboriginals will everywhere amuse themselves in their leisure hours. Emus and kangaroos can be very well imitated. With regard to the former (Pl. I., 5), the mimic's one arm and hand represent the bird's neck and head, his own head and neck being possibly covered with a bark or Government blanket, the extremity of which he tilts up, with a bunch of feathers held in the other hand, to indicate the tail. Where, however, the attitudes require too much "stage property" to produce realistic effects, I must warn the reader that it is somewhat difficult to draw the line of demarcation between this form of amusement as a game distinct by itself and those to be dealt with later, which are distinctly connected with certain ceremonial—*i.e.*, initiation—observances.

(*b*) "*Shark*" is played by little children at Cape Bedford. The two arms are twisted one over the other (Pl. II.), and represent a shark's movements in the water. A boy (or girl) rushes about with her limbs in this position, trying to catch whom she can.

(*c*) Very small children at the Blomfield play "*March-fly*" as follows:—Shutting his (or her) eyes, the one who takes the part of the fly runs about trying to catch someone. As soon as successful, he makes an unpleasant noise (imitative of the insect's buzz) in the ear of the child caught, and also gives it a pinch (indicative of the sting).

Objects and Phenomena of Nature—Imitated with String.—(*a*) With any fair length of twine, adult women and young children, of both sexes, will often amuse themselves for hours at a time. It is thus used in the form of an endless string to play the game known to us Europeans as "*cratch-cradle.*" Thus played with, it is met everywhere throughout North Queensland; also at Murray Island, in the Torres Strait. In some districts it is even indulged in by adult men; it is the women and children, however, who are most partial to it. Among the local names applied to it may be mentioned that of kápan (at Cape Bedford), which signifies in addition any cut or mark; and it is noteworthy that when these Cape Bedford blacks were first taught by the missionaries to read and write, and told that certain letters indicated certain sounds, and that a collection of such letters represented corresponding objects and ideas, they got into the way of speaking of words, letters, writing, &c., as kapan—a term which they still continue to use. Some of the figures are extremely complicated, *e.g.*, Pl. X., 1, 2—the "Sun"—passing through at least eight or nine stages before completion. The diagrams, of course, only attempt to make a record of the finished article. During the progress of manufacture, such an one requires not only the hands; but even the mouth, knees, &c., to make the different loops, twists, and turns. In addition to variations in complexity, certain of the figures may be made with two endless strings, *e.g.*, Pl. VII., 1; while, to complete others again, it may be necessary to have one or even two assistants, *e.g.*, Pl. V., 2. Strange to say, similar figures may be met with at distances extremely remote, with (Pl. X., 5) and without (Pl. VIII., 3) similar interpretations. The following notes, with the places where met with, will serve to amplify the illustrations:—

Plate III.—Mankind. Animals.

1. Two boys carrying spears. Atherton.
2. Two women fighting with sticks. (lower) Palmer River. See Pl. VIII. 7, 8.
3. Four boys walking in a row, holding each other's hands. Cape Grafton.
4. Two men walking down a valley. [Three and four people can thus be similarly represented.] Cape Grafton, Cape Bedford.
5. Man climbing a tree. [The hands are gradually raised to imitate the progress of the motion.] C. Bedford. See Pl. VIII. 8.
6. Kangaroo. Pr. Charlotte Bay. See Pl. XII. 1.
7. Pouch: indicative of a kangaroo. Pr. Charlotte Bay, Pennefather River.
8. Pouch: and so, a wallaby. (lower) Tully River.
9. Strictly represents a spear, see Pl. XII. 1, but commonly expresses a kangaroo speared. C. Bedford.

Plate IV.—Animals : quadrupeds and birds.

1. Bandicoot : indicative of the lobular arrangement of the internal fat. C. Bedford. See Pl. VIII. 3.
2. Bat : Flying Fox. C. Grafton.
3. Flying Fox : the "wings." (lower) Palmer R.
4. Two rats sitting side by side. (l.) Tully R.
5. Emu. Pr. Charlotte Bay.
6. Emu's nest : with the egg represented by a "match-box" bean.
7. Cassowary : the two legs. (l.) Tully R.

Plate V.—Animals : birds.

1. Cassowary. Atherton.
2. Eagle-hawk. Atherton. For Fish-hawk, see Pl. XI. 4 : Hawk's Foot, see Pl. XII. 7.
3. Two cockatoos roosting side by side. (l.) Tully River.
4. Two white cranes. (l.) Tully River.
5. Giant crane. (l.) Tully R.
6. Duck in flight. Pr. Charlotte B., (mid.) Palmer R.
7. Bird's nest, in the bottom of a hollow stump. Pr. Charl. Bay.

Plate VI.—Animals : reptiles.

1. Water-snake. Pr. Charl. Bay.
2. Snake, in general. C. Bedford, Burketown.
3. Deaf-adder : the fingers of the one hand are moved to represent the teeth and mouth. C. Bedford.
4. Crocodile. C. Grafton, C. Bedford, (mid.) Palmer R. See Pl. VIII. 3.
5. Crocodiles' nest, with egg. Pennefather R. "Iguana." See Pl. VIII. 3.
6. Frog. Pr. Charl. Bay.
7. Turtle : the "scutum." C. Bedford, Pr. Charl. B.

Plate VII.—Animals : reptiles and fish.

1. Tortoise : the "scutum." (mid.) Palmer R.
2. Turtle : the "scutum." Pennefather R.
3. Two fish. (l.) Tully R.
4. Fish. Atherton.
5. Mullet skimming along the water. C. Grafton.
6. Eels carried on a hooked stick :—(a common method of carrying fish). C. Bedford.

Plate VIII.—Animals : crustacea and insects. Plants.

1. Crab. C. Bedford.
2. Four shrimps, each "square" indicative of a crustacean. Pr. Charl. B.
3. Honey : the "cells" of the comb. C. Bedford.

   N.B.—This figure has other meanings : *e.g.*, the squares represent the—

   (1) Scales of—crocodile. (mid.) Palmer R.
   —iguana. Night Island. Burketown.

   (2) Lobes of fat—bandicoot. (l.) Palmer R.

4. Wasps' nest. Burketown. See also Pl. XII. 8.
5. Hornet's nest [drawn on the flat]. Pr. Charl. Bay.
6. Hollow log : symbolic of the honey inside it. Pr. Charl. B.

7. Tree : with woman [thumb] hiding below. Pr. Charl. B.
8. Palm-tree : with man [toe] hiding below. Pr. Charl B. [At Night Island this figure represents a woman with outstretched arms and legs, the lower loop indicating the vulva.]

Plate IX.—Plants.

1. Hole in limb of tree : opossum, honey, etc., inside it. Pr. Charl. B.
2. "Zamia" (Cycas) tree. Atherton.
3. Zamia : nuts. Atherton.
4. Two cocoa-nuts. C. Grafton.
5. Cocoa-nut. C. Bedford.
6. "Yams." Night Island.
7. "Yams" : Pr. Charl. Bay. Edible lily root : (l.) Palmer R.

Plate X.—Inorganic nature.

1. Sun : clouded over. Really a stage just previous to—
2. Sun : with full rays. C. Bedford.
3. Sun : with full rays. Atherton.
4. Sun : setting on the horizon. C. Grafton, Atherton.
5. Moon. (l.) Tully R., Atherton, C. Grafton, C. Bedford, Pr. Charl. Bay, Burketown.
6. Star. C. Bedford.
7. Star. (l.) Tully R.

Plate XI.—Inorganic nature (continued). Manufactured articles.

1. Clouds : hanging dark and heavy. (Really a stage just previous to the following figure, effected by separating the hands as rapidly as possible, so far as the string will allow, and at the same time making a hissing sound, to represent the)
2. Lightning. C. Bedford.
3. Rain. Night Island. [Identical with Pl. XI. 8.]
4. River : large and broad. Pr. Charl. Bay. This figure represents a Fish hawk on the l. Palmer R., the two squares indicating the out-stretched wings.
5. Two rocks sticking out of water. C. Grafton, Atherton.
6. Hill, Mountain. Pr. Charl. B.
7. Boomerang. (l.) Palmer R.
8. Two Tomahawks. C. Bedford. [Identical with Pl. XI. 3.]

Plate XII.—Manufactured articles (continued), etc.

1. Four-prong spear. C. Bedford. It represents a speared kangaroo at Pr. Charl. Bay.
2. Canoe. C. Grafton, C. Bedford, Pr. Charl. B., Night Island.
3. Bark Canoe : the "stitches" at either extremity. Pennefather R.
4. Canoe on water : (the four hands rocking it). C. Bedford.
5. Fish-net : (similar figure to preceding)
6. Dilly-bag with handle : Pr. Charlotte Bay. Shell chest-ornament with hanging loop : Atherton.
7. Hawk's Foot. (l.) Palmer R.
8. Wasps' nest. C. Bedford.

(*b*) Occasionally the endless string may be arranged to represent certain ideas, *on the flat* (Pl. XII., 7, a Hawk's Foot, from the Palmer R.), on the *ear* (Pl. XII., 8, a Wasp's nest, from Cape Bedford), &c.

(*c*) At Cape Bedford the *lightning* game (XYI, derrimelli-balkalkal, *i.e.*, lightning to imitate) is played as follows:—Two children, some little distance apart, put an endless string round their necks, and in the loop each places a small stick; these are next turned in opposite directions, so as to make a firm twist in the string (Pl. XIII.). The hands are, at a given signal, removed from the sticks, which immediately commence to revolve (assisted by the resistance exerted by each child pressing backwards), and finally get shot out amongst the surrounding playmates, who thus find themselves "struck."

Objects and Phenomena of Nature—Imitated by finger-prints, sand-pictures, &c.—Next to "cratch-cradle," the most general perhaps of all this particular group of imitative games is the drawing of different *animal* and *bird tracks, &c.*, in the smoothed sand, by means of the fingers, finger-nails, palms, small sticks, &c. After making several of these artificial tracks, I have seen the natives in the Boulia district finish up with a European boot-print, making it about 10 or 12 inches in length, and bursting out laughing at its ludicrous size. Even in the delineation of such apparently simple things as an animal's track, a good deal of art and ingenuity is brought into execution. I have not met with any rock-gravings, though in Glenormiston country, out on the Toko Ranges, I was informed by J. Coghlan in 1895 that up in one of the caves he came across a circle of about 18 inches diameter cut pretty accurately in a piece of solid rock. It may be mentioned here that the representation of a circle is only met with on weapons, &c., coming from and to the west of the Upper Georgina districts. Wooden gravings are to be seen on several of the western district implements, *e.g.*, boomerangs; they are executed by means of an opossum or kangaroo tooth fixed into a handle.

Objects and Phenomena of Nature—Imitated with Pigments.—Rock-paintings are met with in many districts throughout North Queensland, and, were systematic search to be made, would probably be found to be of more common occurrence than is usually supposed. I know of their existence at Clack Island, Cooktown, the Bloomfield, on the Palmer, at Hughenden, Mackinlay, Cloncurry, &c.

The first mentioned locality has a peculiar interest attached to it, in that the paintings here were described in

Captain P. King's Survey of the Coasts of Australia (1818-1822), pages 25-26. He says:—"As this is the first specimen of Australian taste in the fine arts that we have detected in these voyages, it became me to make a particular observation thereon. Captain Flinders had discovered figures on Chasm Island, in the Gulf of Carpetaria, formed with a burnt stick; but this performance, exceeding a hundred and fifty figures, which must have occupied much time, appears at least to be one step nearer refinement than those simply executed with a piece of charred wood." Some 78 years later—in 1899—during the course of a mission from the Government to present the coastal blacks with certain gifts, in return for rendering assistance to the pearling crews shipwrecked in the terrible cyclone at Bathurst Bay, I took the opportunity of visiting this out-of-the-way island. The figures represented, and corresponding with Captain King's description above quoted, are:—Turtles (Pl. XIV., 1, 2, 3); lizards (Pl. XIV., 12); trepang (Pl. XIV., 11); sharks open-mouthed (Pl. XIV., 4, 5, 6)—a very common pattern; and porpoises (Pl. XIV., 13, 14). Starfish, clubs, canoes, water-gourds, and "some" quadrupeds were not seen by me. The fact of water-gourds being depicted here originally is very likely, because, even at the present day, it is a common practice for the aboriginals along this coast-line to carry fresh water in these vessels when going over in their canoes to visit the outlying reefs and islands. Remaining objects not mentioned by Captain King comprise harpoons (Pl. XIV., 8), fish (Pl. XIV., 15), dugong (Pl. XIV., 7), and hands (Pl. XIV., 9-10)—the latter drawn independently of any tracing. The interpretations of the figures quoted were all based on the opinions of the aboriginals who accompanied me.

In the close neighbourhood of Cooktown, several drawings are to be met with in the shelter-caves on the northern aspect of Mount Cook. Plate XV., from a photograph by Mr. A. Dean, shows an example of these. According to local blacks, the three right-hand (charcoal) figures represent men; the two remaining objects are said to be crocodiles, notwithstanding that one of these is minus a tail. Both the latter (one in charcoal, the other in yellow pigment) are peculiar in that they have been "finished off" with a thick white line all the way round. Among the rocks scattered about here are also to be seen life-size representations of the left hand; the white paint has either been sluiced over the hand held close to the rock, so as to leave a silhouette when it has been removed, or else painted close round it and the outstretched fingers, so as to produce a representation in outline. The Koko-yimidir aboriginals of this district have no special name for this amusement beyond "kapan-balkalkal" (*i.e.*, a mark—to make, imitate, &c.), the same term as is applied to cratch-cradle, &c. They tell me it is an amusement special to boys and young men. With regard to the Bloomfield, R. Hislop says that on many a vertical or over-hanging rock are to be met paintings representing human beings, cassowaries, turtles, kangaroos, hands, &c., executed with charcoal, pipeclay, or raddle.

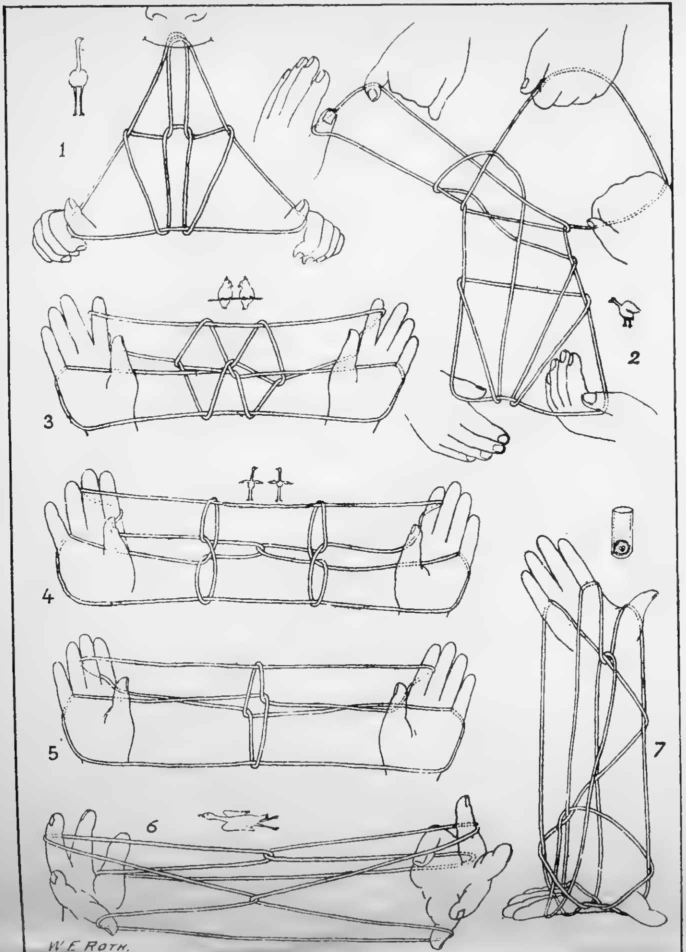
At the water-hole on the old Normanton Road, about six miles from Cloncurry, the "pictures" consist of a saurian type of figure, varying from about 12 inches to over 6 feet in length—and hence possibly representing a lizard, an iguana, or crocodile—painted in red ochre upon the blocks of granite.

Imitative Games. (Human Actions—Domestic).—(*a*) Playing at "*Houses*," "*Grown-ups*," "*Marriage*," &c., is in one form or another as common among black children as it is among white ones. On the upper Normanby, the youngsters pretending to be married will build an impromptu hut, and sit contentedly within its shade; suddenly a boy rushes forward to steal the gin, over whose possession he and the husband now make-believe to have a fight. On the lower Tully, the boys and girls will make miniature huts, &c., and finally go away in couples into the scrub. It is a game often being played, but whenever their parents catch them at it they generally give them both a good smacking. In the Cairns district little boys and girls often amuse themselves by playing at houses in this fashion—"You come into my hut; I've got some yams." "No," says another; "just you come into mine—I've got opossum for you," and so on, each one vying with the other to make his own particular offer the more attractive. The following I have seen played by young women on Keppel Island:—With any small pieces of rock handy, a gin will set up what she calls a hut, a sort of baby cavern or grotto about 8 or 10 inches high. Kneeling just in front, she throws straight into it as fast as she can (with right and left hand alternately) various small pebbles, &c., each being respectively the father, mother, and piccaninnies; these stones she catches up again, then throws them back, and so repeats the process over and over again, the whole being accompanied by some chant. When three or four women are playing, each with her little stone "house" in front, they get extremely excited over it. "Wu-ro" is the name of the game, but neither the words nor principles could be rendered intelligible to me; so, again, the late Mr. Wyndham, the first settler on the island in the early eighties, told me that he found it played by the children, but that he could never make head or tail of it. At Cape Bedford, the small girls often play at the preparation and cooking of yams and other vegetables, mimicking in the process all the actions of their elders.

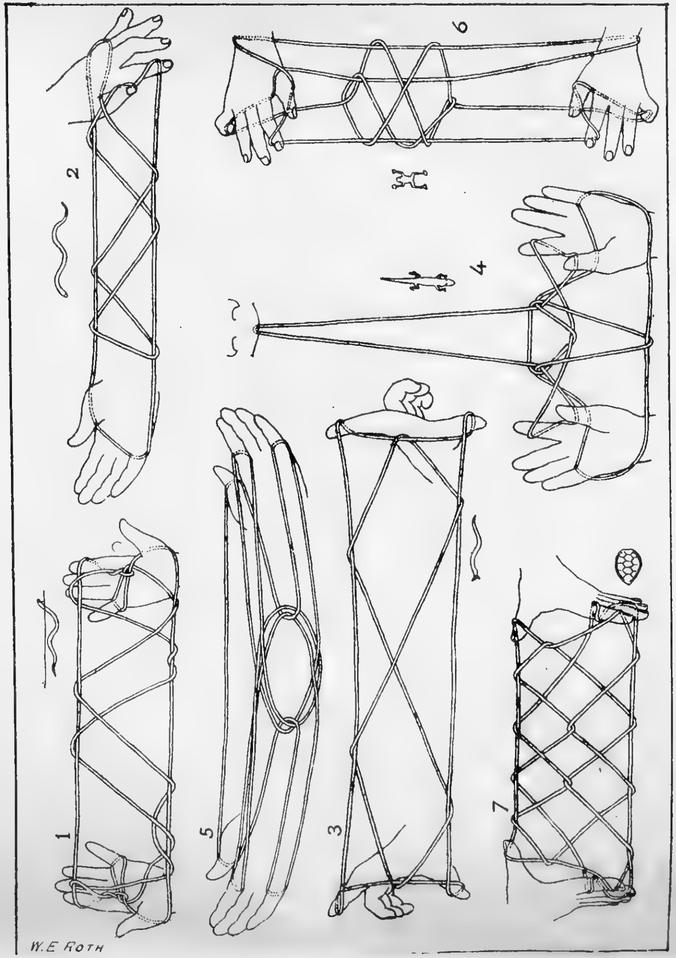
(*b*) *Dolls* for the little girls on the lower Tully River are made from a forked stick or out of a lawyer-cane (*Calamus*). The former (Pl. I., 6) represents the child's legs, which can thus be fixed on to the neck, to indicate a mother carrying her baby with its lower limbs dangling over the shoulders. The latter is split at one extremity, each split half being bent and kinked so as to form a "knee"; by pressure from above, these jointed legs can thus be made to assume different and equally ridiculous positions (Pl. I., 7). There is no more definiteness about these dolls—no heads, arms, ornamentation, or dress. They are called kuchara, a Mallanpara term sometimes, though rarely, applied to a little infant. The parents generally make miniature dilly-bags for their children to carry these dolls in. At Cape Bedford, forked sticks similarly constitute girls' dolls. In the Cairns district I have seen these playthings formed of pieces of bark wrapped up in grass, &c. On Keppel Island I observed girls and women nursing dolls in their arms like babies. These dolls, in the form of cones, varied in length (up to 15 inches) and thickness, were coloured with red ochre, and named "kamma" after the grass-tree (*Xanthorrhœa*) from out of the butt of which they were cut (Pl. I., 8). Mr. Wyndham also noticed these toys when he first went there. As a result of a conversation which I held with two or three of the more intelligent of the women, I have good ground for believing that these cones are also intended as charms for begetting fine, strong children. [Are they of a phallic nature?] I met with several of these articles mixed up with the bones and *débris* in one of the shelter-caves in the North (Keppel) Island.

(*c*) "*Granny*" is a game played by boys as well as girls on the lower Tully River, in mimicry of the sounds produced on being spanked by the old lady in question for being naughty. Putting the one hand high up into the opposite arm-pit, they sharply smack the elbow of the free arm on to the flank, calling out as they do "Papi," "Papi" (equivalent to "Granny," "Granny").

Pl. V.



Pl. VI.



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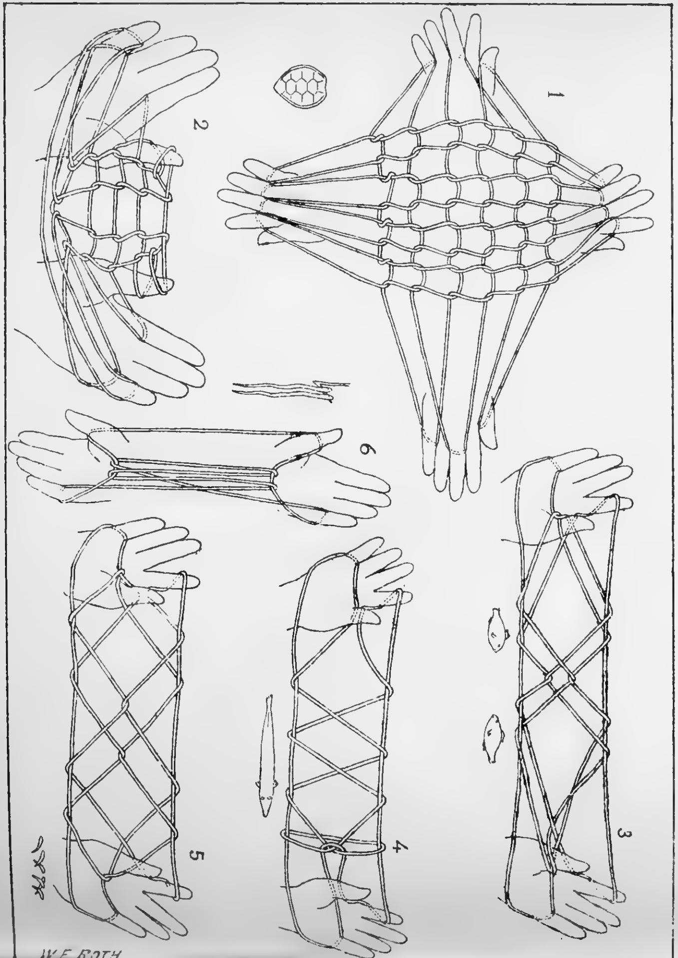
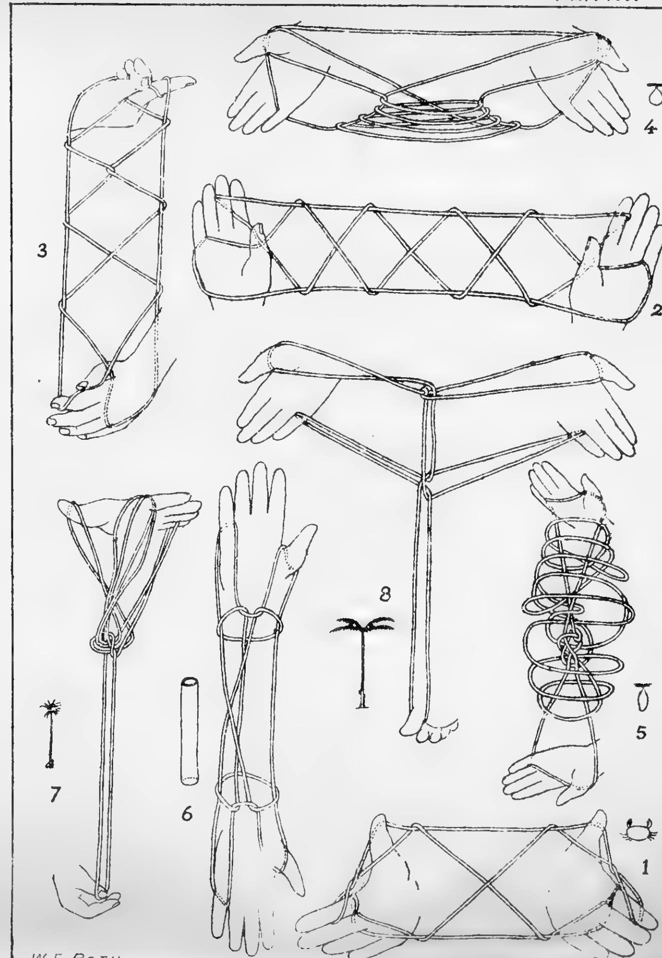
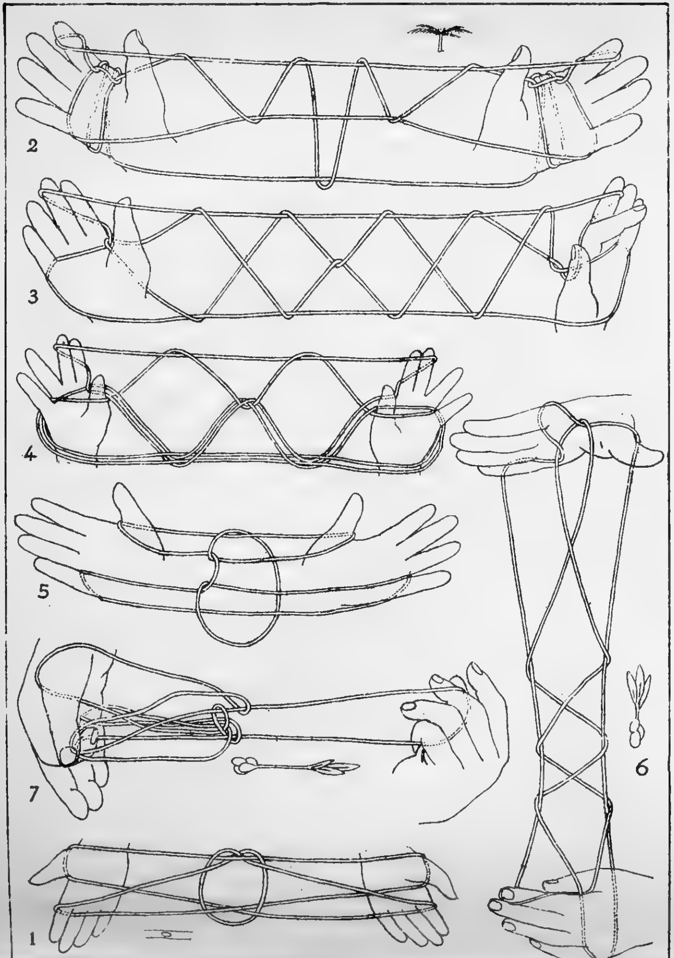


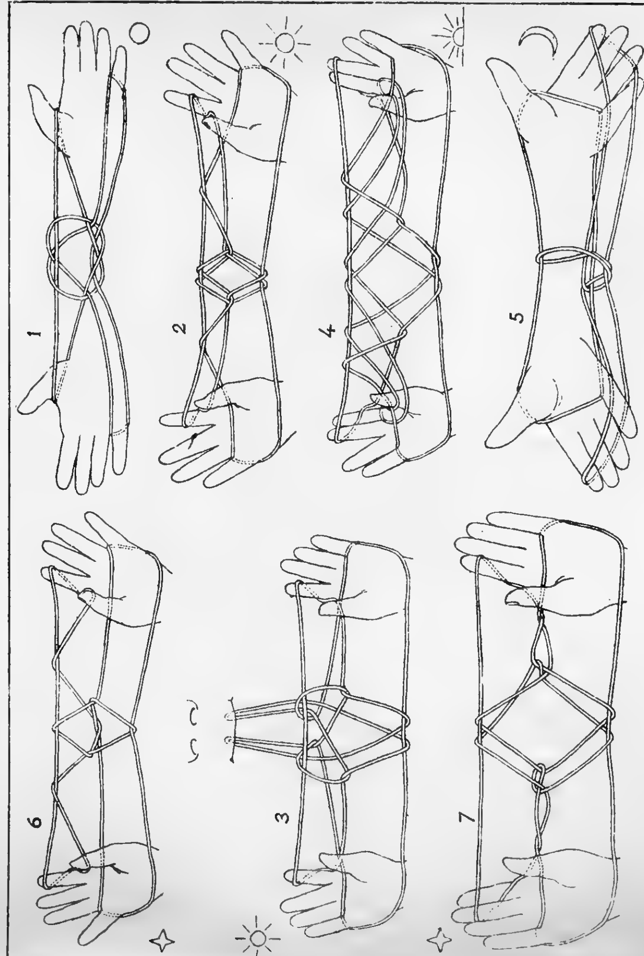
PL. VIII.

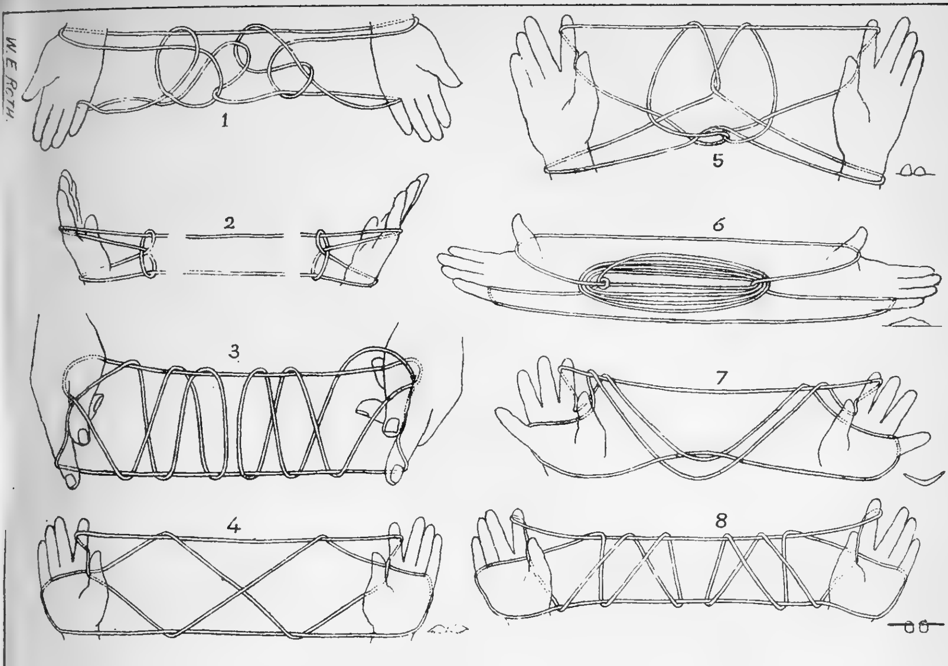


Pl. IX.

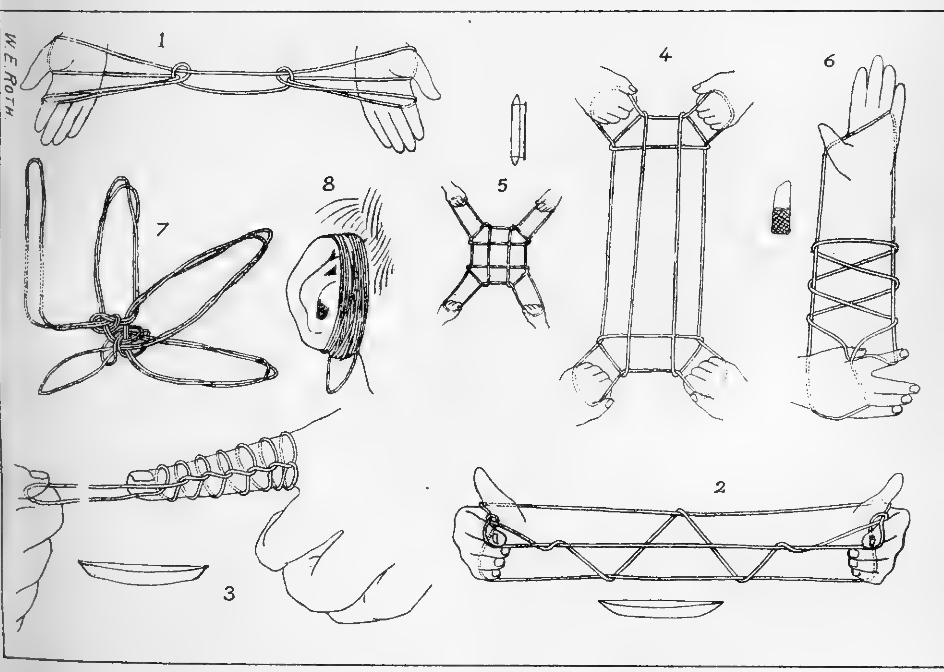


Pl. X.





PL. XI.

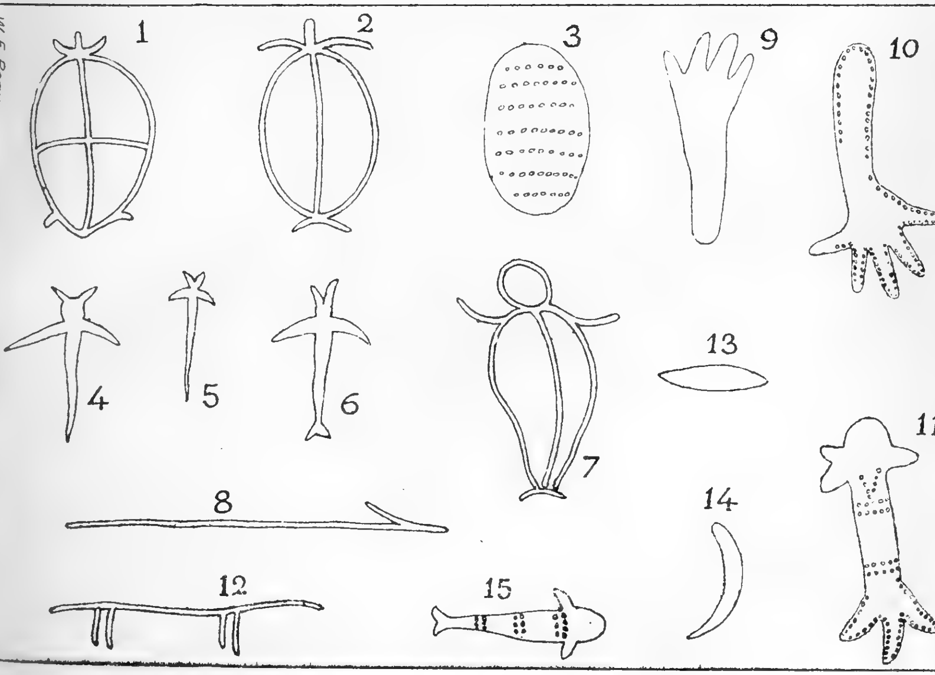


PL. XII.

W. E. Roth.

PL. XIII.

W. E. Roth.



PL. XIV.

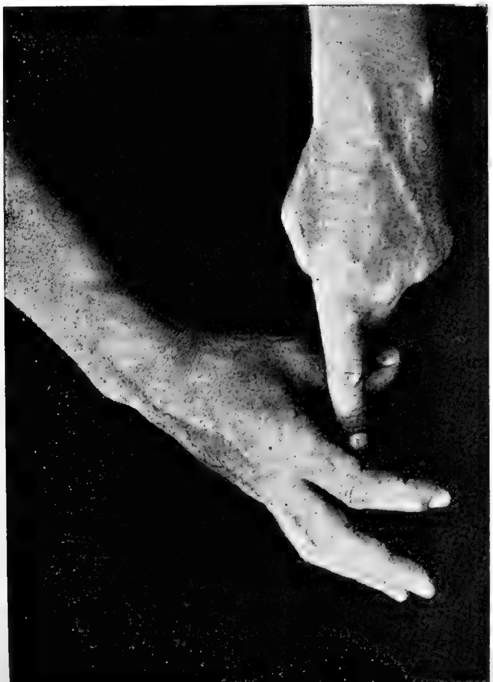
PL. XV.

W.E. Roth

PL. XVI.

W.E. Roth

Pl. XVII.



W.E. Roth

Pl. XVIII.

W.E. Roth.

(*d*) *Plait-work* is met with as a pastime among the boys at Cape Bedford (Bulletin No. 1, sect. 11), in a form imitative of the handles of the dilly-bags met with further north.

Human Actions—Hunting.—(*a*) The *Honey-game*, imitative of the search for honey, is played by two or more children. Squatting on the ground, each places the tips of the fingers upon the hand below, as in Pl. XVI., where three little girls are seen amusing themselves; these six hands represent the trunk of a tree. Each hand is now in turn knocked off from above down with a side-cut—the tree is being felled. Before knocking off the lowest hand, its owner puts her finger into each digital interspace (Pl. XVII.) to feel if any honey has dropped down. She pretends to find a snake there, however, and tells her mates so. All three next hold their hands behind their backs, and the following dialogue ensues:—*A*: "Have you a tomahawk?" *B*: "No!" *A*: "Are you sure you haven't one?" *B*: "I have a very little one." *A*: "Well, then, give me the little one." *B* thereupon pretends to hand over the imaginary tomahawk. *B's* arm, the wrist of which is held by *A*, next represents the trunk or limb in which the honeycomb is. *A* now makes a chop at the elbow (Pl. XVIII.), to cut off the limb, encircling (Pl. XIX.), as far as she can, the joint with her fingers, and from here rubs the limb respectively once upwards and once downwards, so as to indicate complete discontinuity. This little action is significatory of the fact that with certain kinds of bees (*e.g.*, old and new broods) the upper portion of the tree, where the comb lies, is "tabu" (KYI, tabul) to the women, &c., whereas the lower portion, where the dirt and drippings are, is "free" (KYI, daitchen) to them. *A* now does exactly the same to *B's* other arm, then goes over the identical process with *C's* arms, and finally does the same with her own. The honey is next supposed to have been collected from the removed limbs, and, mixed with water, placed in a bark, &c., trough, represented by all the cupped hands resting upon one another, as in Pls. XX., XXI. The trough is shaken up to make a good mixture, and each bends her dead down in turn to get a taste. "Too sweet!" is the verdict they each give, and, consequently, a pretence is made of adding more water. As soon as arrived at the proper strength and consistency, they all make a show of eating it. It is a game played by young children, of both sexes, at Cooktown, Cape Bedford, and the McIvor River.

(*b*) *Catching Cŏckatoos* is indulged in by little boys and girls in the same districts as the preceding. The more children there are in it, the merrier it is. Each hand is placed one on top of the other as before, but in this case the fore-finger of the hand below is encircled by the thumb and three fingers of the hand above (Pl. XXII., XXIII.). These hands represent cockatoos sitting one above the other on a branch of tree. The one free hand in the group of players now makes a dart at the topmost fore-finger, the topmost cockatoo, which it catches in the fork between the fore and middle fingers, the fork being supposed to be a pronged spear. The "cockatoo" is then put up to the spear-owner's mouth (Pl. XXIV.), a click given—the sign of its being eaten—and handed in similar fashion to the other players, each in turn uttering the same note of satisfaction. The remaining birds are speared and disposed of on the same lines.

(*c*) Playing *Bean-tree* is met with among the little boys and girls on the lower Tully River. Several children sit down in a circle, and one starts the game by placing her one hand on her knee, and the other on top; the next child places hers similarly above, and so on, until there results a vertical column of little fists. Each hand is previously twisted out of shape by bending one finger over and behind the other, and, when all the fists are placed in apposition, the thumb of the hand above is always made to rest on the little finger of the one immediately below (Pl. XXV.—the thumb of the second hand has accidentally got loose). This column of human flesh represents the bean-tree (*Castanospermum australe*), and each hand a bean. The girl (or boy) who directs the run of the game next removes the topmost fist by pinching up the skin on its dorsum, at the same time poking her fore-finger up into its palm (Pl. XXVI.); the hand thus falls off, with the fingers free, and lies limp, palm up, at its owner's side. One bean has been gathered. Thus gathering all the beans one after the other, the leader starts pretending to collect them, and finally running away to a distance, is supposed to hide them in the scrub. The other players soon follow, and commence trying to find them, but their efforts are of course in vain; and when she thinks they have had enough of it, the leader will tell them that a flood has suddenly come up and carried all the beans away.

(*d*) *Cracking beans*, another children's game practised in the same district, is in imitation of the sound of the nut cracking when being opened (by hammering with a stone) in order to get the kernel out. The palms are slightly apart, with the ring and little fingers interlocked, the tips of the fore and middle fingers touching; the interdigital space between the last-mentioned is widely open (Pl. XXVII.). With a sharp vertical movement on to the knee below, the fore-fingers, loosely separated from the mid-ones, are thus made to strike upon them with a sharp cracking sound.

(*e*) The *Duck* game played by little boys and girls at Cape Bedford, Cooktown, and the McIvor reminds me very much of the "oranges and lemons" of our own childhood's days. One of the little chaps takes a long stick, and, holding it up at an angle, allows its extremity to touch the ground. The attitude represents a man catching a duck by means of a slip-noose attached to the end of a long slender switch. The other children pass round and round, bobbing underneath the stick in Indian file, when, all of a sudden, down it comes just in front of one who will thus be considered "caught." The latter is now dead, and has to lie down on her back, perfectly still, and with eyes closed. Another and another is respectively caught, until all are lying dead in a row. The child with the stick comes up to the first one, and says, "Where do you come from?" "I come from Cooktown," may be the reply. "Well, then, go home to Cooktown," says the other, and with a poke from the stick she gets upon her feet and makes a bolt, ostensibly for home. And so with all the others.

(*f*) The game of *Tortoise* is also played in this same district, but only by boys. One of them will take a short stick in his hand, which he holds out back, after the manner of a wommera, which indeed it is supposed to represent. He then whistles to his mate, who plays the part of the tortoise. After a time the latter slowly raises his hands, so as to get his fore-fingers on either side of the forehead; such action indicates the animal with flappers rising to the water-surface in answer to the "call." The boy with the imaginary wommera-spear then makes as if to let fly his weapon, whereupon the tortoise tumbles down dead.

(*g*) Playing "*Iguanas*" is practised by the boys in the Upper Normanby district, as follows:—One of them will half-lie on the ground, and dig his fore-arm, up to and including the elbow, into the sand. Here and there he will stick out a finger, and as it projects his mates will try and hit it with a stick. In this same district the lads also have a *kangaroo* and a *crocodile* game. In the former a boy will hop about here and there, after the manner of the marsupial in question, dodging as he goes the toy-spears which are being thrown at him. In the latter he will swim on the surface like the saurian he is supposed to represent, and expose himself to similar treatment.

(*h*) In the N.W.-Central districts, a whole party will be bathing together in the river, and while some may be imitating the actions and "calls" of various water-birds, others will hunt for and try to catch them.

(*k*) In the Carrington scrubs (Atherton district) the children will often amuse themselves in walking up certain trees. They will pull out a thin strip of bark, free it from below, and then drag themselves up on it with their hands, jerking off more and more of the strip as they advance. I have purposely mentioned this trick here, as I cannot help but regard it as imitative of their elders climbing trees—an exertion to which, with but very few exceptions, they are impelled only through the search for food, *i.e.*, for purposes of hunting.

Human Actions—Ceremonial.—Among amusements derivable from ceremonial, one concerning which there cannot be doubt is the implement known to us English boys as the "*roarer,*" "*hummer,*" "*whirler,*" &c., and met with throughout North Queensland. It is a flattened spindle-shaped piece of wood, into one extremity of which an aperture is drilled (Pl. XXVIII., 1), and by means of which it is attached to a piece of string held in the hand or fixed to the end of a small stick. The whirler can thus be rapidly revolved, and with a sudden extra jerk given a little additional impetus, so as to make it "roar." The extremity of the hummer further from the aperture is sometimes cut off obtusely (Pl. XXVIII., 2). These playthings vary from 3 to 6 inches in length, are never graved, but may be painted. In the N.W.-Central districts they are used indiscriminately by either sex, and at any age; on the Bloomfield, Lower Tully, and at Cape Grafton they are employed by young men and boys only. At the Bloomfield, the method of using them is taught at the first initiation ceremony, though the boy so taught can play it in public, and before women, subsequently; on the Tully it is believed to have been introduced only within recent times, and made by the big boys to frighten little ones.

On the Tully, and at Atherton, the boys will take any light flat piece of wood, and, holding it vertically, will, with an apparent initial whirl, throw it face forwards against the air, so as to produce a humming sound. The Mallanpara call it by the same term as applied to their toy-"cross."

Wrestling (sect. 17), as well as some of the corroboree dances, *might* be originally derived from ceremonial. The yiki-yiki of the Bloomfield is taught at the initiation performances.

Human Actions—Warfare.—Wherever blacks are to be met with, the little boys indulge in aping the arts of war as practised by their elders. The miniature weapons so employed are either manufactured for them by their older male relatives and friends, or else designed by themselves. Toy *spears* are thus made from light thin withes or else from grasses, reeds, and rushes, *e.g.*, *Andropogon schœnanthus, Imperata sp.* They are held at their lighter ends, and thrown either with the hand held as in Pl. XXVIII., 3, [which, it should be noted, is held differently to the fighting weapon], or with the toy *wommera.* The latter can be made of a piece of wood, with a flattened projection at its extremity, on lines identical with the full-sized article as met with among the Wellesley Islanders and coastal blacks westward of Burketown (Pl. XXVIII., 4). In other cases (*e.g.*, from Cape Grafton up to Princess Charlotte Bay), the toy wommera can be manufactured from a rush by splitting its end, removing the pith from one of the split halves, and tying the cortex in a loop round the other; the loop retains the reed-spear in position (Pl. XXVIII., 5). Another kind of toy spear has so far been observed (A. Buhot) only among the coastal blacks to the west of Burketown, and at Wollogorang (Northern Territory border). It consists but of a straight withe from 2½ to 3 feet long, more or less pointed at its extremity, and projected with a string which is prevented slipping by the friction presented by a knot. Pl. XXVIII., 6, 7, will explain matters more graphically. The question naturally arises as to whether the string, thus used, is a primitive condition, or only an adaptation, of that highly-specialised implement, the wommera, or spear-thrower. In those districts where *shields* are employed by the adults, these may be imitated on smaller scale, and often with similar ornamentation, out of convenient pieces of bark, &c. As will be stated further on, there appears to be some doubt as to whether the toy-boomerang is really imitative of the fighting article, and its description is accordingly deferred till later on.

The regular *tournaments* which take place in the Cardwell and Tully River scrubs require more than passing notice. To the Mallanpara blacks this institution is known as the Prun. It is essentially an entertainment—though the opportunity may be taken of wiping off old scores, and so settling disputes, either real or imaginary—and gives the men a chance of showing off their prowess and courage before the women.

(*a*) All the year round, except at flood-time, the blacks regularly meet at the prun-ground or Puya. This ground, which is shifted every two or three months, consists of a large cleared circular space, and is usually reserved for these particular fights (with general corroborees). There is no ceremony, &c., at its inception, when it is being constructed, nor are any neighbouring trees marked or in any way ornamented. The prun takes place every seventh or thirteenth day in the Tully and neighbouring district, the latter now merging into the fourteenth, so as to hold it of a Sunday, to suit the convenience of the white settlers, by whom many of the natives are employed; but why these particular (original) intervals have come to be chosen—and it must be remembered that these intervals vary in different localities—is beyond the knowledge of the blacks themselves. It should be noted here that in those districts where such tournaments are regularly held the blacks have special terms for counting the number of days intervening; in all other districts they can count up to three, or perhaps four, only.

(*b*) The tribe on whose territory the prun-ground happens to be is always the first to arrive there on the day appointed—early in the morning—and takes up its position. Some few days previously a messenger has been sent round to the various camps, reminding them of the date. No particular person is sent, nor is he specially decorated in any way, and he does not tell them whose quarrels, should there happen to be any, that are going to be dealt with. At any rate, it is considered the duty of everyone who has been so informed to attend on the day appointed. Well, the people who get there first, and have their own camps there, decorate themselves, as the case may be, on the edge of the ring (*i.e.*, where their huts are). The decoration followed is that of Pl. XXIX., the special fighting costume, formed of cockatoo feathers. Those who subsequently come up get ready at a place somewhat removed from the ring, and put in an appearance there only when fully "rigged up." Such men, fully decorated, are known as the ulmba; they are the "picked" ones, who have to uphold the honour of their particular mob, and are accompanied by other males (not ornamented so much) and females (not decorated at all). With them are four women in particular who carry spears (pointed at their butts—the chukaji spear). All advance in a body, and rushing into the ring do a half-circle round, being led by two or three in the van, who, with the direction in which their spears are held, show the route to be followed. There is no speaking; all of a sudden they stop, congregate together as close as possible into one surging mass, with shields, swords, and boomerangs held on high (Pl. XXX.), give a lusty shout, and retire to that portion of the edge of the circle at which they entered, sit down, and wait there.

And here they stay while the next two or three mobs come up—with same performance in the centre, &c.—each tribe taking up its temporary quarters at the edge of the ring where it originally entered and approached.

They all then rest at these particular positions until the sun is about half-way between mid-day and sunset.

(*c*) The tribe to whom the ground belongs is supposed to start the proceedings by some one or other of the following methods, after having entered the ring:—

i. One, or may be a couple, of the men will let fly a boomerang or a spear into the mob with whom they want to have a "go-in" with.

ii. One fellow will get up and "jaw" at the others collectively, or at one of them individually. It was a case of the latter which started one of the fights which I witnessed. The challenger had had his gin stolen by a man in the opposing mob, and he was employing all the most filthy epithets he could use to get his man to show fight. Before the latter had time to answer, an old virago from the opposing side came forward biting her spear, throwing it with full force into the ground, plucking it out again, stamping and yelling all the time, and rousing herself to a pitch of excitement; and then *she* gave the challenger a sound tongue-thrashing, heaping upon him all the most beastly terms she could think of, &c.

iii. The whole mob will start taunting the others collectively, making remarks about them, and trying to hold them up to ridicule and contempt. They generally get hold of something concerning their women.

iv. Often as not, neither singly nor collectively is there any real cause for quarrel; but they make a start and find one, "out of pure cussedness" almost, it might be said.

Perhaps the other side thus challenged will only get up and stand out (with their weapons, of course), and reply verbally in similar strains. Should this turn out to be the case, one of the challenging mob will come up to those he is trying to rouse up, and, pointing his spear at each, will tell them what *his* lot will do to them if they don't fight. If any one fellow thus individually challenged does not want to fight the one who particularly wants to pick a quarrel with him, he will just put up his shield; his aggressor will thereupon taunt his tribe for owning such a coward; and thus, by pressure from his own people, he may be forced to act on the defensive. But even this may not draw blood, so one of the challenging side will probably sneak right round and let fly a boomerang into the women and children squatting at a little distance outside the circle. Now, it is a well-recognised law that no fighting is permissible outside the circle, and any flagrant breach of the rule such as this generally puts the finishing touch on, and the battle commences in earnest.

(*d*) The combat may be either single or general; the former due or not to some private or personal grudge, in which the others may or may not join. Thus, the others will not join a man challenging his own uncles (father's or mother's brothers), a thing he not infrequently does, if he considers himself to have been slighted by them—they not having been to visit him, or not having sent him any food present. Such a man will get his uncle into the ring, and whack with a sword at the shield with which the latter defends himself. Finally, the uncle puts the shield down, and kisses, or rather blows on, his nephew's cheek—they are friends now. Another sign of friendship at a fight, or a sign of the fight having wiped out the cause for quarrel, is for the opponents to clash the flats (fronts) of their shields together.

During the actual fighting spears are generally the first things to be thrown (generally at the legs, anywhere below the knees); then, as they get nearer, the boomerangs are let fly (at any portion of the body), and, finally, when they get to close quarters, the swords are used for striking at the head from the front. It is wonderful to watch how easily and how gracefully these cumbersome-looking weapons are swung in the one hand and raised from behind the shoulders forwards. There are rarely any fatal results unless the death of a man (for some crime or valid injury committed) has been determined upon. Barring this contingency, were a loss of life to take place, the victim's mob would retaliate, run into the circle, pull out the individual who did it, and promptly make him pay the penalty. Of course, minor wounds often occur; thus, on the Sunday previous to one of my visits, five injuries took place by spear and boomerang—in the heel, thigh, one just above

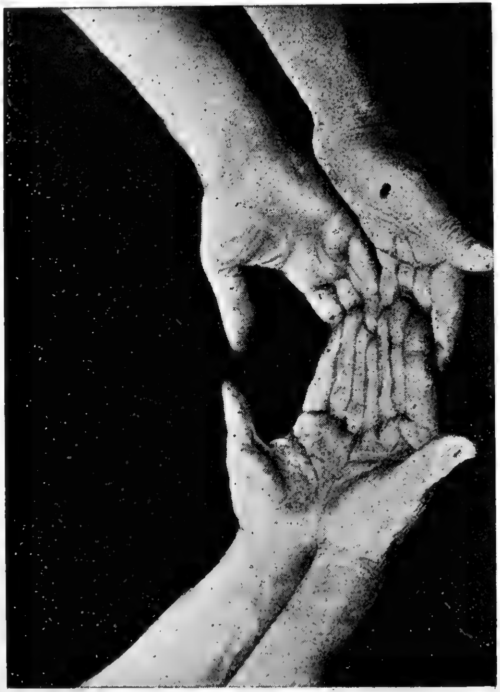
PL. XIX.

W. E. ROTH.

PL. XX.

W. E. ROTH.

Pl. XXI.



W. E. Roth

Pl. XXII.

W. E. Roth.

PL. XXIII.

PL. XXIV.

PL. XXV.

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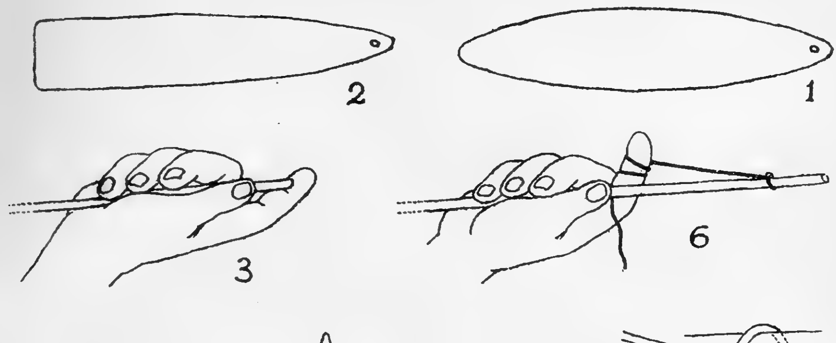
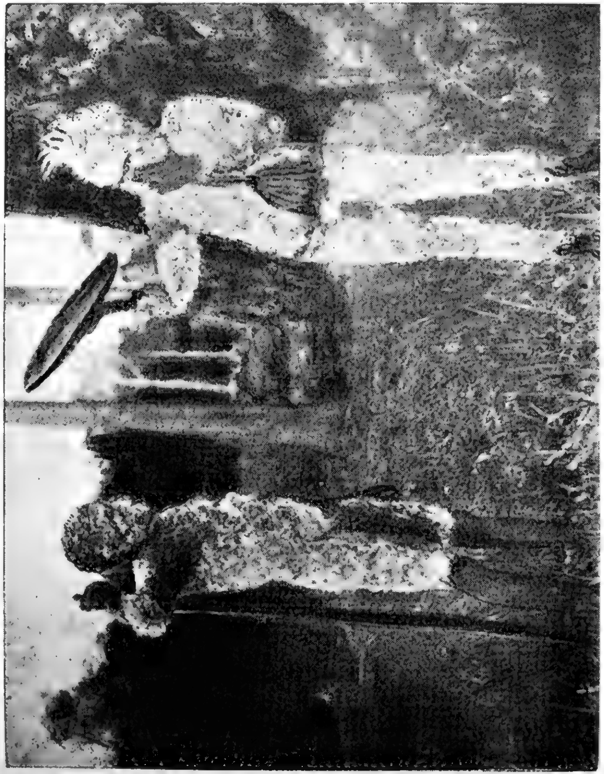
PL. XXVII.



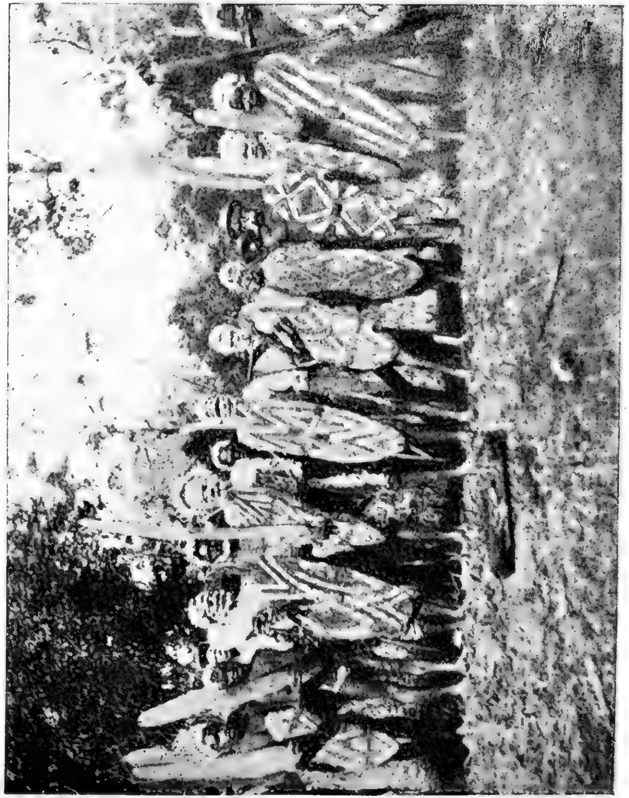
PL. XXVIII.

PL. XXIX.



W. E. ROTH

PL. XXX.



W. E. ROTH.

the hip (in a comparatively dangerous situation), one in the wrist of a gin (boomerang wound), and in the forearm. Women come into the circle and egg their husbands and relatives on; they bite their spears and sticks, strike and throw them on the ground, and will fight with members (female) of the opposite faction. They are using their tongues all the time, and with far greater effect than the men. The din is something terrible while the tournament lasts.

Every ten minutes or quarter of an hour or so there is a rest; the spears and boomerangs may be collected and returned to their owners, the intervals, after once the prun has originally properly started, being of short duration. So, again, if a person is badly injured, there is a short cessation of hostilities (while he is being carried off the ground to safe quarters), but only to be immediately resumed.

Fair play is certainly recognised in these encounters, and supposing only a few members of a mob turn up at the prun, and they are getting worsted by a stronger force. a third mob (even perhaps already at enmity with them) will come to the assistance of and join forces with the weaker.

Thus they go on fighting until dark, when more friendly relations are resumed, the waru-waru and other corroborees are performed, and all goes well until the next morning, when, just as the sun rises, they have another final bout; and, as soon as the fighting is over, they all disperse to their respective homes. Evidently the prun both helps to settle old scores and at the same time promotes social intercourse and amusement.

I have had two opportunities of watching these pruns—one from the time it commenced until dark—and saw upwards of 200 savages congregated. On the second occasion, the Tully blacks had determined upon taking the life of one of the Clump Point boys, for the following reasons:—On the previous Sunday's prun he had thrown a spear high up against a tree, whence it had glanced sharply downwards, imbedding itself in the neck of an old man (Tully native) with fatal results. The unfortunate thrower of the spear happened to be a "doctor," and nothing would satisfy the deceased's tribesmen but that it was some of his witchcraft which was responsible for the death. Mr. E. Brooke, who was with me at the time, did his best to explain that it was a pure accident; but it was no good. After taking sides, the fight commenced amongst these excited savages, with the result that the doctor was ultimately speared (non-fatally) in the knee. I had watched this individual pretty carefully, and saw him ward off two other spears, aimed at his chest and lower trunk, when struck. As soon as he fell, his friends surrounded him, and with their big shields kept his aggressors at bay until he could be removed in safety to his own camp. Of course, any interference on our part was out of the question, it taking us all our time to get cover behind neighbouring trees, out of the way of the spears and boomerangs. Everything, however, was amicably settled by nightfall, when all parties joined in the social, which extended into the early hours.

Discriminative Games.—(*a*) *Hide and Seek* constitute a series of very commonly played games, even by adults, that which is hidden being either a person or thing. In the former case, as practised in the N.W.-Central districts, there may be as many as three seekers in it, these covering their eyes with the hands, or putting their heads with eyes shut close to the ground, while the others hide themselves. If they cannot find those who are concealed, they often make a whistling sound as a sign of defeat. The Kokominni blacks call this game paliwan; but with them the object of the boy who hides is to get "home" if he can without being caught by the others who are looking for him. Where a thing is hidden, this is generally concealed in any small piece of level sandy ground, a circular space of from 1 to 2 feet in diameter being roughly marked out, and carefully smoothed over with the hand; the object of the players squatting or kneeling around is to try and find it. Correctly speaking, the hidden article is the lens, obtained after cooking, from the eye of a fish (Palmer R., Cairns, Pennefather R., Cape Bedford, Tully R.), opossum (Cairns, Boulia, and Rockhampton districts), rat, or wallaby (Boulia D.). Where these do not happen to be available, it may be substituted by a body-louse, small seed, or anything else differing from the constituents of the subjacent soil, so long as it is of comparatively minute size. At Marlborough I have seen the opossum lens rubbed between the hands to make it look a bit dirty, and so rendered more difficult to find. The actual method of hiding the lens varies slightly. On the Palmer it is held between the thumb and forefinger, the palm, turned upwards, being filled with sand; the latter, slipping between the interstices of the fingers, is jerked in all directions over the circular space, the lens being suddenly dropped during the course of the movement. The usual method elsewhere, however, is to pick up the lens together with a little sand, and thus drop it during the sprinkling, the palm being turned down. In the N.W.-Central districts, the object may be hidden in the sand while the players around, at a given signal, shut their eyes. To make a search, the players will pick up a pinch of sand at a time, and let it slowly sift through the fingers; the one who finds it is usually the one to hide it again. The game may be named after the local term signifying an eye, or it may have a special name applied.

Another hide-and-seek game played by the Kokominni boys is the koabangan. While all sit round in a circle with heads low and hands over their faces, an iguana-claw is hidden in the fork of a neighbouring tree; upon a signal being given, they will jump up and commence looking for it.

(*b*) The *Guess-Game* is another good pastime indulged in by young and old at Cape Bedford. One of the party may perhaps notice a new flower just in blossom, a bird half hidden in a bush, a tussock of grass uprooted, &c., and, taking care to look in quite a contrary direction—indeed, anywhere but in the proper quarter—she will say, "What am I thing of? *mim*!" They all try to guess, one after the other, and great laughter is aroused when the right thing is mentioned.

Disputative Games.—(*a*) It was during November, 1898, at a camp near the mouth of the Normanby (about 15 miles from the coast), that I first came across a *Wrestling* contest, a form of amusement which I subsequently found to be apparently very common around this Princess Charlotte Bay district, in connection with certain of the initiation ceremonies, though it may be independent of them. Wrestling has since been met with on the Palmer (KMI, donaman), on the Pennefather (NGG, arúngga), and at Cape Bedford. As originally observed, the combatants were all collected on a cleared circular space, about 8 yards in diameter (a disused initiation ground), where I watched them playing one morning for quite a couple of hours. Any individual who happens to pride himself on his skill in the game will open proceedings by challenging another, while the bystanders, egging them both on, and barracking for their respective favourites, will sing away and clap their hands in accompaniment. The wrestling itself takes place somewhat on the following lines:—Bending forwards, the challenger will grip his adversary with both hands round the loins, where he interlocks his fingers, so as to maintain a very firm hold; the latter, with arms raised, remains passive, and in this position is lifted from off the ground, on to which he is next thrown. Honours are divided so long as he touches ground with his feet, *i.e.*, not thrown off his balance. The individual who is temporarily gripped may, however, steady himself with his arms on the other's shoulders, and usually prepares himself for a fall on his feet by keeping his lower limbs strongly flexed, thus rendering them springy on whichever side he may be thrown. There is no mutual clutching, or both combatants falling. Strictly speaking, it is a throwing rather than a wrestling match. Only males engage in this sport. As soon as one proves himself victorious, another challenges him, and so on.

(*b*) A game, somewhat of the nature of a *tug-of-war*, is played by young and old men on the upper reaches of the Batavia River and at McDonnell. Instead of a rope, a pole some 12 to 15 feet in length is brought into requisition; in place of pulling, there is a pushing. Indeed, the fun consists mainly in balancing the pole *in statu quo* side against side for a few minutes, and then letting it fall with a deep grunt of relief.

Toys (*Propulsive Games*).—As already mentioned (sect. I.), all the toys or specially manufactured articles present the peculiarity that the source of the enjoyment consists in the particular form of motion which may be imparted to them. A ball, a top, or a boomerang—as such—constitutes no source of pleasure or enjoyment; but as soon as each of these toys is respectively thrown and caught, made to spin, or sent on its flight, the amusement and fun commences.

Balls.—(*a*) *Catch-ball* in the N.W.-Central districts is played everywhere by both sexes, and either singly or with sides; in the latter case, the ball is thrown from the one to the other, the participants trying to intercept it while still off the ground. From the fact of the players jumping up to catch it resembling the movements of a kangaroo, the Kalkadun blacks sometimes describe this game as the "kangaroo-play." The ball itself is made of a piece of opossum, wallaby, or kangaroo hide, &c., tied up with twine.

(*b*) *Bowl-ball* or *disc*, a game the blacks appear very partial to on the Bloomfield, is played on a cleared space, about 12 to 15 yards long, down more or less of a slope. At the top end of this slope one of the men will, with his spear, start rolling a ball cut out from the top of a "zamia" (*Cycas*) tree. As it rolls on and on, with ever-increasing momentum, his friends lining the cleared pathway will try and job it with their spears. The spears used for this special purpose are small, made in one piece, thrown with the hand, and known as tchugari. A similar sport is played by both old and young boys at Cooktown and Cape Bedford (Pl. XXXI.), where the ball is replaced by a disc, or rather by a horizontal slice cut from the soft stem of the cycad, the local name for the disc being doba. At Butcher's Hill and elsewhere the cycad disc may be replaced by a circular piece of bark.

(*c*) Corresponding to these variations of one and the same game on the eastern coast is that which I originally described as "*stick-and-stone*," practised in the Boulia district, where the Pitta-Pitta blacks speak of it as pucho-pucho tau-i-malle [*cf.* Kalkadun name, pucho-pucho, signifying a spin-ball, and Pitta-Pitta name, tau-i-malle, the reflexive form of the verb tau-i, to hit, or to strike]. It is played amongst the men, with from four to six individuals on each side, the two groups standing at a distance of from 15 to 20 yards apart; the members of each group, all armed with a stick, stand one behind the other, a space of 3 or 4 feet separating each. The game consists in alternately throwing a stone in the rough, and of convenient size, from one side to the other, each individual trying to intercept it with his stick as it skips or rolls before him on the ground.

(*d*) *Spin-ball* in the North-West-Central districts is a round ball of about 1 to 1½ inches in diameter, made of lime, ashes, sand, clay, and sometimes hair, rolled into shape, either between the hands or the folds of a blanket, and subsequently baked, thus making it smooth and hard; it may subsequently be painted with red or yellow ochre. The ball is spun by being pressed between the fore and middle fingers (Pl. XXXII., 1), upon either a patch of smooth hard ground, or more usually upon a flat board, sheet of kerosene tin, &c. Played by men and women, two or even three at a time; the one whose ball spins longest wins. The game can also be played by the participants taking sides, each backing individual members against its adversary's. It would appear to have been introduced into these parts from the Lower Diamantina River, within but very recent years, coming up the Georgina *viâ* Bedouri. It did not seem to have reached, or been known to, the Cloncurry blacks in 1896.

An undoubtedly indigenous form of spin-ball is, however, met with amongst the scrub-blacks of the Lower Tully River, made out of a gourd (Pl. XXXII., 2). Two holes are drilled, on opposite sides of it, and through them an endless string is passed. A thumb is inserted at either end of the loop of string, and the "ball" rotated over and over. The hands are then more extended, and the doubled string untwirls the ball; the hands are again approximated with the ball twirling in a reverse direction; and so it may be kept spinning for a long time. This particular toy is played with more often by women than by men. It is known among the local Mallanpara blacks as ngor-go, after the name of the gourd.

Tops.—(*a*) *Spin-tops* are manufactured in the same and neighbouring districts, and from the identical gourd, by passing through it a stick which is fixed in position above and below with twine and beeswax. It is used only by the men, and spun by twirling with the flats of the open hands (Pl. XXXII., 3). A string is never used to spin it, while a hole in the side, to make it "hum," has only been introduced of late years. The local Tully River name of this toy has already been given; at Cape Grafton it is called bunbuja.

(*b*) The mamandur of Cape Bedford is made by passing a small wooden splinter through a more or less flattened and circular plate of beeswax (Pl. XXXII., 4), and spinning it like an English boy would a "*tee-to-tum*"—*i.e.*, by a rolling movement between the middle finger and thumb. Indeed, this method of spinning is adopted with the calyx-cups of the *Sonneratia acida* (Linn.), the *Eucalyptus bicolor* (A. Cunn.), and other plants.

Sticks, &c.—(*a*) *Shooting the grass-blade*, or rather its petiole, from the mouth is an amusement which I have seen indulged in along the eastern sea-board from Gladstone to the Peninsula. A piece of "bladey" grass (*e.g.*, *Imperata arundinacea*) is pulled, cut to a suitable length, and split from below up, on either side of the petiole, to a convenient length. Pl. XXXII., 5, 6, and 7, represent the three stages. As usually played, the cut extremity of the grass is held loosely and horizontally between the lips, while the split ends of the leaf are bent over a stick (grasped with the right) and held in the left hand (Pl. XXXII., 8). If the stick be now driven sharply forwards, the petiole is shot away, leaving the two halves of the blade behind in the left hand. Sometimes the stick is replaced by the fore-finger of the right hand; occasionally the position itself of the grass-blade is reversed, the split ends being held between the lips, and the cut extremity in the left hand. Boys, both old and young, are very expert with this toy in the way of killing such birds as small wrens, &c. On one occasion, at the Tully, I saw a boy shooting these grass-petioles at, and hitting, some weaver-birds' nests, quite 100 feet from the ground.

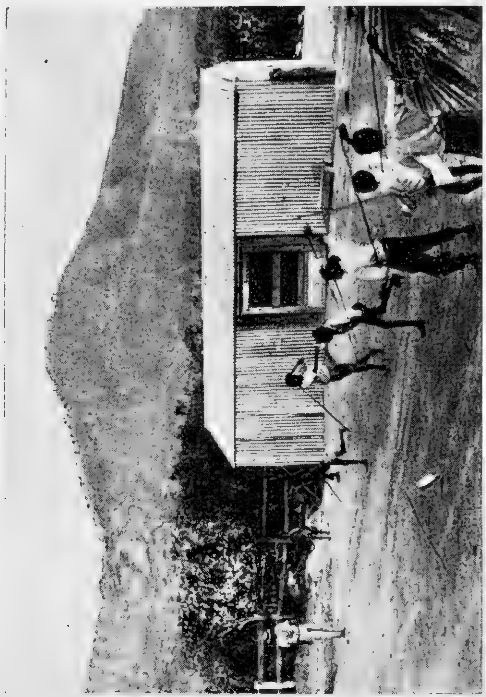
Another method of shooting wooden splinters is recorded from the Upper Normanby, in the middle eighties, and illustrated in Pl. XXXII., 9, 10, and 11. Mr. Robert Austen, the discoverer of the Kimberley (W.A.) Goldfields, tells me that, at Port Leschenhault, Koombana Bay (W.A.), in 1841-43, long before the advent of white settlement, this method of throwing the tips of the grass-tree leaves (about ·3 inches long) proved a source of amusement for the girls and little boys, who would send them sticking into the bodies of the blowflies.

(*b*) *Toy throwing-sticks* are met with throughout North-West Queensland, and are of two kinds. The one is a thin, rounded, straight stick, usually "gidyea" (*Acacia homalophylla*), with an elongately-knobbed extremity (Pl. XXXII., 12, 13), the whole varying from about 12 to 20 inches in length; it reminds one somewhat of a fighting or hunting "nulla-nulla" (but very much attenuated), the larger varieties having even a similar name. Held at the thinner end, with the arm thrust well back from the shoulder, the smaller toy is thrown from a distance of 2 or 3 yards up and against the fringe of some overhanging bushes or leafy branches, or even against some thick foliage held up by a companion. Immediately upon striking the obstacle so interposed, the stick shoots through the air, knob foremost, and with greater impetus to a distance quite half as much again than would otherwise be traversed. The larger toy is similarly employed, but is thrown downwards against a tussock or low-lying bush, whence it shoots along or close to the surface of the ground.

The second kind of toy throwing-stick is known in the Boulia and Cloncurry districts as kandi-kandi. It is thick and rounded, from 18 to 12 inches long, but strongly bent (Pl. XXXII., 14), approaching somewhat the shape of the Birdsville boomerang. On the other hand, unlike a boomerang, it is held on the *convex* side forwards, clasped firmly in the hand, and, simultaneously pressed close against the extended fore-finger, it is thrown downwards against a log or thick branch lying on the ground, from which it rises into the air in a straight direction and revolves in its flight.

While the fighting *boomerang* may be employed as a toy, the implement is often constructed solely and especially for purposes of sport and amusement. No sufficient evidence is as yet available as to which particular use it was primitively applied. It is noteworthy that on the (middle) Palmer River, about latitude 16 degrees—the most northerly limit at which the boomerang has so far been met with—it is employed merely as a toy. The toy boomerang is thrown only by men and boys, and its throwing is the only indigenous North Queensland game wherein any real attempt is made to see who is the "best" man, so to speak; but even then no so-called "prize" is awarded; indeed, it is apparently very difficult for these blacks to understand the more civilised custom of producing emulation by a system of awards. There are two methods of throwing the implement, direct into the air (common everywhere) or straight on to the ground (Cairns and Cardwell coastal districts). The boomerang is said to be right or left handed, not because it is necessarily thrown with the one or other hand, but because it circles to the right or left side of the thrower. Until its manufacture is completed, and it has been tried by experience, the blacks have told me that they cannot determine with any degree of assurance which of the two varieties it will prove to be. When thus made as a toy, and compared with a fighting boomerang, it is lighter and smaller. It varies in shape from a comparatively strong angle (Pl. XXXII., 15) to something approaching a half-moon; the knee or bend is approximately in the centre, and so divides the implement into two halves, the planes of which show indications of both flexion and torsion. Sometimes the toy article is cut down from a fighting boomerang that has been chipped or otherwise damaged. In the N.W.-Central districts, if coloured at all, it is smeared with charcoal; here, also, it may often be ornamented, but there is no rule or uniformity in the gravings, of which some of the designs may be very quaint. It is never used as a recognised article of exchange or barter; that is to say, it does not travel, but is manufactured just as occasion requires.

When thrown into the air, with the concave edge of course forwards, its usual flight is represented in Pl. XXXII., 16, 17, with a right and left handed boomerang respectively, where the line A represents the direction faced by the player. The object of the game varies in different districts. On the Tully River, the best player is the one who can make the boomerang finally reach the ground nearest to him. A good thrower here can hold a spear vertically, and thus catch the implement as it passes on its final flight, making it pass spirally down the spear, so as to fall into his hand. The Cloncurry blacks will fix a peg into the ground, and the one who can strike or come nearest to it with the boomerang when it falls is declared the best man. In the Boulia district, where they can throw a figure-of-eight (Plate XXXII., 22), five, six, or perhaps more men will stand in Indian file, PL. XXXI.



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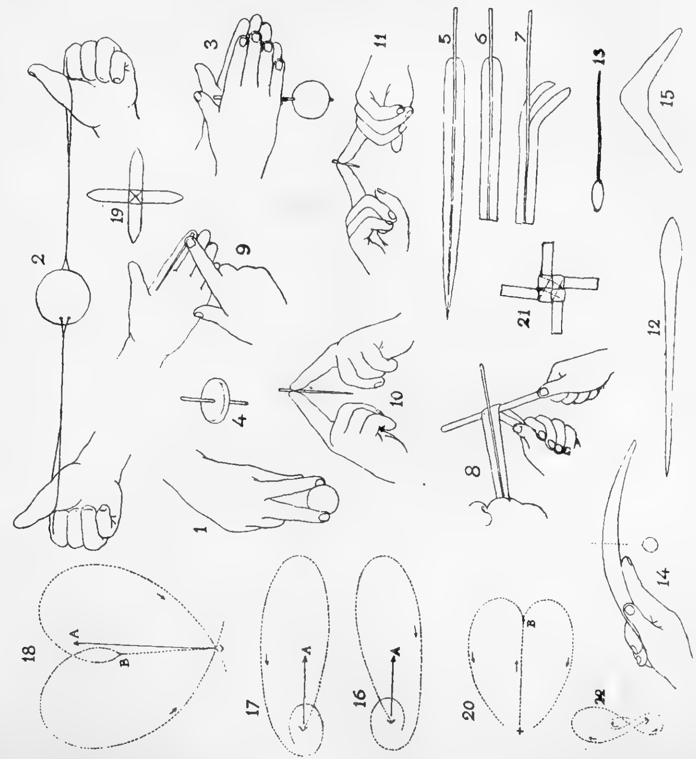
PL. XXXII.



W.E. Roth.

each individual, with raised arms, resting his hands on the shoulders of the one in front; another of the playmates, standing by himself at some distance ahead, and facing the foremost of the file, throws the boomerang over their heads, and as it circles round they all follow it in its gyrations, the game being for any of them to escape being hit, each taking it in turn to throw the missile. Among the Yaro-inga tribe on the Upper Georgina, the blacks often try and arrange to make up two sides, the idea being for a member of the one team to hit an individual of the other.

If the toy-boomerang be thrown direct on to the ground, and slightly to the right or left (never exactly straight ahead), the course of flight is represented in Pl. XXXII., 18, where B indicates the spot struck. R represents that of a right-handed and L that of a left-handed instrument, A having a similar signification as before.

The "*Cross*" is made of two pointed laths, from about 8 to 10 or more inches long, drilled at their centres and fixed cross-wise in position with split lawyer-cane (Pl. XXXII., 19). It is met with in the coastal districts extending from Cardwell to the Mossman, and to the Mallanpara blacks of the Tully is known as pirbu-pirbu. Like the toy-boomerang, it is used by men and boys only, and thrown according to two methods. In the first, thrown direct into the air, the course of flight is similar to the boomerang, but there is more of the circle than the oval, and a *double* circle round the player at its termination. If thrown on to the ground, it is made to strike a spot directly in front of the performer (Pl. XXXII., 20, B), whence it curves to the right or to the left, as the case may be.

The above toy is imitated by some of the smaller children by means of thick swamp-grass, &c. The two strips are either pierced and tied, as in the case of the wooden ones, or else plaited together as shown in Pl. XXXII., 21. It is thrown with a twist of the wrist up into the air, whence it soon returns in a right or left spiral.

Pit-throwing is a game played by the Kalkadun. Any fairly-sized bone, often a human shin, is slung by means of an attached twine over an emu net into a pit or hole excavated on its further side. Considering the great distance often intervening between the thrower and the excavation, great skill is apparently necessary in making the bone fall into the hole without touching the net.

Music (*Exultative Games—Songs*).—Notwithstanding the important *rôle* which song plays in the life-history of the aboriginal, any inquiry into its origin and aims is at the very outset obstructed by the scanty knowledge which any reliable observer can possibly possess of the native dialect in which it is given expression to. During the course of my peregrinations in North Queensland, during the past eight or nine years, I have, for instance, met only with four, or at the most five, individuals having such an accurate knowledge of the language that their translations could be absolutely depended upon. But even such knowledge has, in a sense, its disadvantages, for the reason that its very fulfilment entails intimate relationship between the white and the black for a period of at least many years, during which the personal influence of the more civilised individual undoubtedly exercises important changes in his more unsophisticated friend's thoughts, customs, and general social system, these in the meantime becoming gradually covered with European veneer. The following notes are based upon some scores of songs which I have heard in the N.W.-Central districts, in the Peninsula, and along portions of the eastern sea-board (especially among the Tully River scrubs, where I had exceptional opportunities of obtaining reliable information), *i.e.*, for the most part in those areas where the aboriginals have, comparatively speaking, been least contaminated by civilising influences.

Anybody may "find" or compose a song, adaptable to his or her respective sex, and when pressed for further information will often make the allegation that it came into being in the course of a dream—an idea prevalent both on the western border and eastern coast-line. Accompanying decorations or dances, if any, may also be explained on the same basis. Each song consists of the chanting of some short sentence or sentences repeated *ad libitum*; during the utterance of the last two or three words the singer may be accompanied vocally by the others, thus giving rise to the opinion, often expressed, of the existence of a distinct and separate chorus. It but very rarely happens that a native will sing without a listener. In the actual wording of the Pitta-Pitta songs of Boulia there are undoubtedly variations from the ordinary every-day colloquial language in pronunciation, inflexion, pleonasm, and ellipsis, which may perhaps be regarded in the light of poetical or musical licence. Again, in several of the Tully River songs, many words occur which are not used in ordinary conversation—they may sometimes even have no intelligible meaning—thus rendering an absolutely literal translation impossible. A word may even have a different meaning, according as it is used in prose or poetry; *e.g.*, pandun (MAL) signifies "to freckle" in ordinary conversation, but "to kill" in song. The extreme is met with in those cases where the songs are taught and conveyed long distances from one tribe to the other, for, like articles of exchange and barter, they may travel in various directions and along identical trade routes and markets. As has been already recorded by me in the N.W.-Central districts, when taught to one tribe, the latter may take the song on to the next, and so on, the visitors being given presents, &c., in return for the instruction imparted. Sometimes picked men may be sent long distances just for the sake of learning one. It may thus come to pass, and very often does, that a tribe will learn by rote and sing whole songs in a language absolutely remote from its own, and not one word of which they—the audience or performers—can understand the meaning of. That the words are very carefully committed to memory I have obtained ample proof by transcribing phonetically the same songs as performed by different-speaking people living at distances upwards of 100 miles apart.

On the other hand, there is occasionally undoubted evidence (*e.g.*, on the Tully) that the same song may be found in the camp for years without apparent alterations. The first word or line of the verse often gives the name to the particular song, in the same way as a European speaks of his Paternoster and Alphabet.

Songs.—The *subject-matter* expressed in song deals with obscenity, pure and simple; persons deceased, provocations for quarrels, animal life, everyday experiences of personal or tribal interest, and ceremonial observances. As far as is ascertainable, there is no single touch of sympathy, sentiment, or pathos; no lullabies or love songs in the modern sense of these terms.

Dances.—People always sing in one or other of the squatting positions, and beat time either with the hands or with sticks, &c. Whereas songs may or may not be accompanied with dances, there is never a dance without a song; in other words, dancing is essentially the accompaniment of song. Furthermore, beyond an occasional shout or whoop, the dancers certainly, while dancing, do not participate in the singing. With the males the dancing consists, in the main, of a stamping movement of the feet to the time beaten on the hands or on sticks (Pl. XXXV.). Another fairly common movement of the lower extremities is the alternate external and internal rotation of the knees with the limbs separated (Pl. XXXVI.). Occasionally, one foot may be placed over the opposite knee (in the position of rest), and a hopping step introduced. The various positions assumed by the arms and hands vary in great measure with the different implements that may be brought into requisition; sometimes the ground is struck with the flats of the hands. With the females, the movements of the lower limbs also present great variety; usually a jerky movement, with rarely a separation of the legs. The arms, unless otherwise employed with a string or other ornament, are commonly maintained in such a manner that the hands rest on the hips, while the elbows. sticking out at the sides, are rythmically drawn backwards and forwards. Sometimes a finger is put in the mouth, a typical position on the Lower Tully River (Pl. XXXVII.). In many dances the women never turn their backs on the audience, even when retiring to their places. The dancing is always individual—nothing in the shape of couples, &c.—notwithstanding the many variations in initial position—*e.g.*, square formation, Indian file. In the N.W.-Central districts the dancers are invariably led by one or sometimes two "masters of ceremonies," or "leaders," who may be distinguished occasionally by an extra feather-tuft on the arm, &c. The Pitta-Pitta blacks speak of such a leader as the father, or "old man," the remaining dancers being the "children."

Entertainments.—The "corrobboree," so named by Europeans up here in the North, comprises any ordinary "social and concert," generally, but not necessarily accompanied with a dance—an entertainment by the tribe in general.

The true social commences at sunset, and may be continued late into the night, even until sunrise; and, if some special performance is being enacted, may be resumed for three, four, or even five nights consecutively. Fires supply the illumination. Of course, there are exceptions to this rule of always having their socials at night, but when held in the afternoon are rather for those wherein the women would take a greater share in the performance. and the men, if present at all, far less trouble in their decorations. In a certain sense, "afternoon teas" and "evening parties" would give an idea of their relative importance. Corrobborees, however, have this peculiarity, that all persons present are simultaneously audience, performers, and orchestra; visitors may, of course, be present as spectators, but usually only when ignorance prevents them being participants. In some of these entertainments there may be no personal decorations at all, the performance consisting of a song and plain dance; but, if any decorations at all, they would be on the dancers.

Other corrobborees may each have their own particular decoration; thus, as on the Tully, when the programme consists of dances pertaining to and imitative of the different animals (*e.g.*, flying-fox, cockatoo), portions of these animals, especially the heads, are utilised for purposes of ornament. I have not heard of any cases where men act the part of women, or *vice versâ*. The corrobboree is always held at some distance from the main camp, and the same ground, cleared of bushes, &c., may be thus utilised for months at a time. On the Lower Tully there is no adjoining bough-shelter in which the performers can or do prepare themselves for the slight ornamentation which they sometimes aspire to. Among the N.W.-Central tribes the sexes, in certain corrobborees, decorate themselves in separate localities, the one not being allowed to watch the other; furthermore, no individual is permitted to watch the "dressing" of either, unless he or she shall have previously witnessed that same performance. When, however, the respective toilettes are completed, the performers will betake themselves to what may be considered the "green-room," at all events what would correspond to it among more civilised communities, whence they emerge or whither they retreat, according as their presence is required or not during the course of the performance. In the Boulia district this green-room consists of a sort of bough-shed formed of long saplings placed slantingly so as to rest upon each other at their apices; it is known to the Pitta-Pitta as the dakka-dakka, and to the Maitakudi as jilbi.

Musical Instruments.—(*a*) The *yiki-yiki* (the second *y* being scarcely sounded) is a wind instrument met with in the area included by Cooktown, Laura, Palmerville, Maytown, Byerston, the Bloomfield, Daintree, and Cape Grafton, and known by the same name. From what Mr. R. Hislop tells me, it is said to have been introduced on to the Bloomfield from the Gulf country through the Kokowarra-speaking blacks, *viâ* the Laura, long before the oldest living aboriginal at Wyalla (Bloomfield) was born, and that from here the Daintree blacks got their first instrument. The yiki-yikis in use on the Bloomfield are simply hollow hardwood saplings, about from 7 to 9 feet long, which taper from $3\frac{1}{2}$ or even 4 inches at the larger distal extremity to about 2 or $2\frac{1}{2}$ inches at the smaller proximal (mouth) end. The sap-wood is generally cut off, leaving a shell $\frac{1}{4}$ to $\frac{1}{2}$ inch thick, but the only polish it gets is the constant handling.

The blacks never go to the trouble of charring out a sapling, as they can get plenty of hollow ones; neither are they particular as to straightness, for the reason that the ones which are naturally hollow are usually straight. Before iron tomahawks were available, they used to take great care of the yiki-yikis, but as they are easily made now, and are a great nuisance to carry about when shifting camp to any distance, they are generally left behind, and so get burnt by the first bush fire that comes along. Hence no extremely old ones are usually obtainable. Of course, after they have been in use for several years, they look as if they had been polished, owing to the amount of grease absorbed in the constant handling. Another cause of the instrument being cut off in its prime is that at times the younger boys will keep up the performance at all hours during the day or night, until some exasperated individual gets thoroughly sick of the sound and smashes the instrument. The blacks may then not take the trouble to make another for a year or so. When the musician desires to perform, he supports the larger end on a forked stick, or on the roof of his hut, and, applying his mouth to the smaller end, intones into it for hours at a stretch. The use of this instrument on the Bloomfield, like the "bull-roarer," is taught at the initiation ceremony, but, unlike the latter, it can be played in the camp before the gins and uninitiated males. It is never employed in this locality for imitating the call of the cassowary (*cf.*, the "emu-calls" of the Gulf country), though, curious to say, the blacks have a legend that it was (and still may be) used by certain spirits for that very purpose, long before they themselves knew how to use it.

(*b*) Other wind instruments are the *hollow bones* (Normanton, Cape Grafton, &c.) and *hollow reeds* (Tully River), with ends cut off abrupt, and blown across their tops—something after the manner of the units composing a pan-pipes. Strange to say, this instrument at Cape Grafton is also spoken of as yiki-yiki.

(*c*) At Atherton I have seen young boys produce a sweet whistling sound by means of a leaf-blade—a *leaf whistle*. This was gently folded along its midrib, the free edges of the two halves held between the protruded lips, and the sound produced, not by expiration, but by inspiration. Whistling *per se* is not practised by the wild blacks; indeed, with those individuals, on whom avulsion of the incisor teeth has been practised, it is a physical impossibility. On the Bloomfield and elsewhere whistling is considered the language of certain evil spirits.

(*d*) *Hand-clapping.*—Especially in the Peninsula, where there are no boomerangs, sounding-sticks, &c., both men and women will clap their hands with open or bent palms, and so produce variations of sound depending upon their degree of concavity.

(*d*) A very common practice throughout North Queensland is for the women to hit their inner thighs with the flats of the hand. Pl. XXVIII., taken from two Princess Charlotte Bay women, will assist in forming an idea of the posture assumed in such cases. Occasionally (Cardwell, &c.), the outer sides of the thighs may be smacked for similar purposes. Among the Kalkadun and Maitakudi tribes, the women, instead of striking their thighs, occasionally employ a sort of drum or small *pillow* made of opossum skin, &c., filled with feathers, rags, &c., upon which they will bang with the flats of the open hands. Such a pillow is known as the pikabara in the Maitakudi language.

(*e*) *Sounding-sticks* are met with in the hinterland and coast-line, extending from about the Daintree to the Herbert Rivers—and perhaps a little further south. Both at Cairns and among the scrub blacks along the Tully River, they are known as kokolo. In the latter district they are made of *Hibiscus tiliaceus* timber. They are often hardened with fire at their extremities, and usually of unequal size, the larger being held loosely, and more or less downward (Pl. XXXIX., 1, 2, 3), and sharply tapped with the smaller one. To produce a deeper sound, the distal extremity of the stick struck is made to rest on the foot, heel, &c., according to the particular squatting position in which the performer may happen to be.

In those districts, *e.g.*, the Western, where boomerangs are in use, these may take the place of sounding-sticks. With their concavities turned towards each other, a weapon is held at its middle in either hand, and the tips of each struck together on the flat. If sounding-sticks or boomerangs do not happen to be handy, &c., the spurs or buttresses of certain trees, *e.g.*, figs, conveniently situated, may be hammered with sticks in the rough (in the Cardwell scrubs).

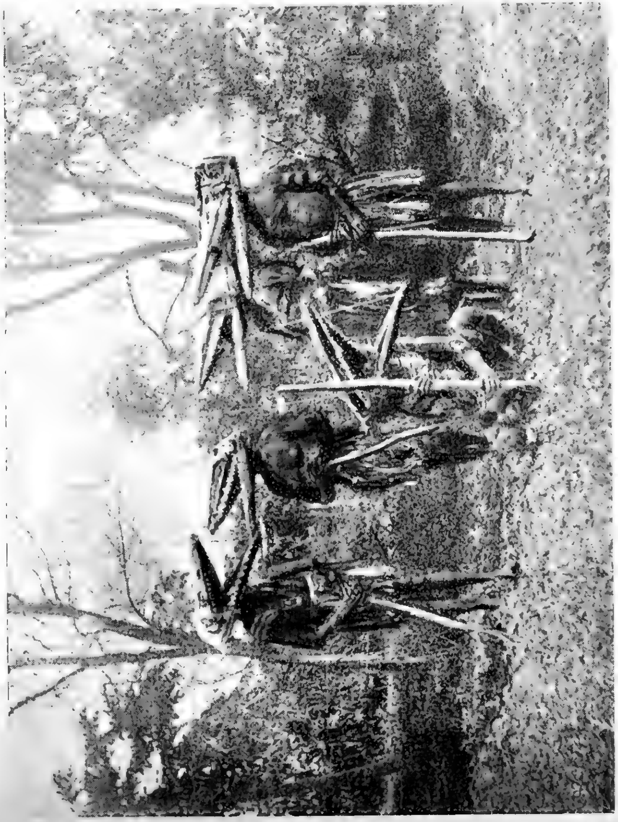
During the course of an initiation ceremony at the back of Pr. Charlotte Bay, in 1898, I saw five or six individuals with sticks hammering away upon the convexity of a hollow log, split in half, with the concavity turned downwards; it acted much like a sounding-board, and a splendid tone reverberation was the result.

(*f*) *Rattles*, for the children, met with on the Pennefather River, are made by stringing together particular shells and tying the ends. The shells so utilised are the *Cypræa subviridis* (Reeve), *Arca pilula* (Reeve), and *Strombus Campbelli* (Gray).

Serving a purpose similar to *castanets* are the bunches of singed, heated, or otherwise dried leaves attached to the shins, or shaken in the hands, of the dancers out in the N.W.-Central districts.

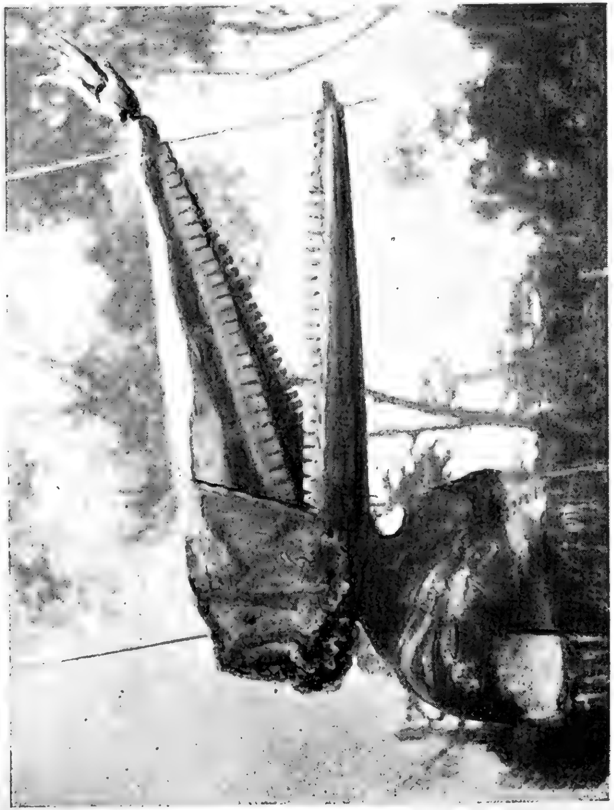
Introduced Games.—There are a few games which have been introduced of late years amongst the natives through the agency of the missionaries, settlers, and others. Amongst such may be mentioned marbles, running races, high-jumping. throwing spears through a suspended hoop. the use of the skipping-rope, &c.

PL. XXXIII.



W. E. ROTH

PL. XXXIV.



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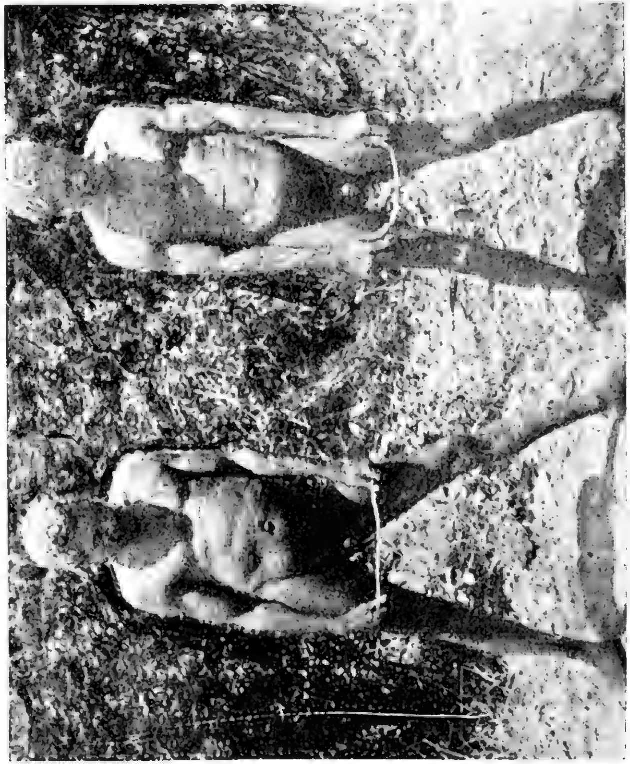
PL. XXXV.

W. E. ROTH.

PL. XXXVI.



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PL. XXXVII.

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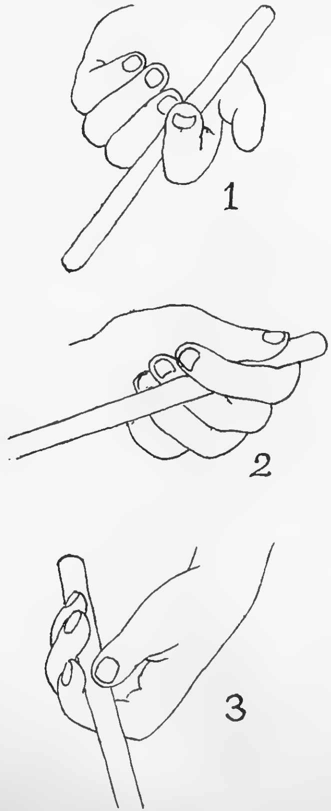
PL. XXXIX.



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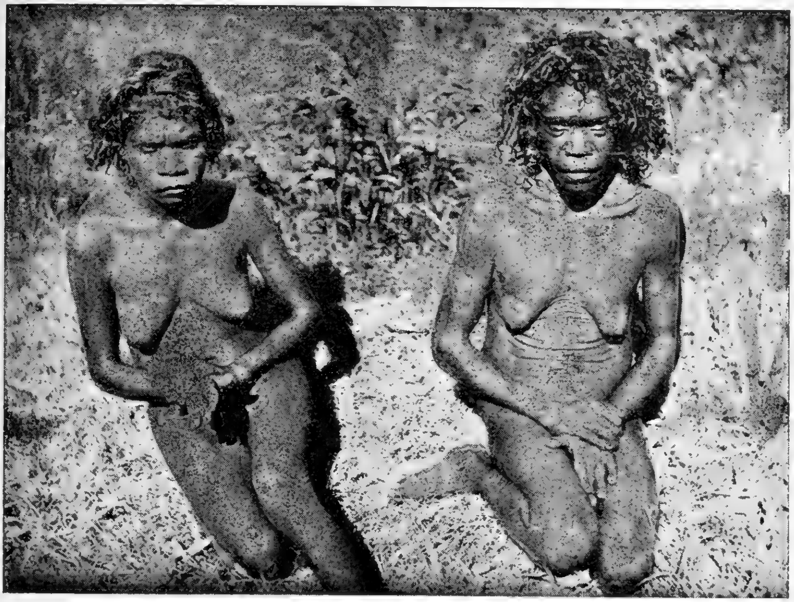

PL. XXXVIII.

ON SURFACE SIMILARITIES IN WORDS.

By Lorimer Fison.

There is nothing more fatal in philological work than the practice of taking mere surface resemblances in words as necessarily marks of connection between them. And yet this practice is a very common one. Thus, Latham often takes what hardly amounts to a similarity—a consonant picked from a word here and another there—as positive proof of connection between two words. Such a process is altogether inadmissible. At all events, if it be good philology, we can get some very queer results from it.

As an example of the futility of arguing from unsupported similarities in appearance or sound, we may take a common South Sea Island word, with which the Queensland Labour Traffic has familiarised us—the word Kanaka, which appears in various forms as kanaka, tangata, tamata, ta'ata, tamaur, tamoli, and so on. It is the word for Man. Now, one of the Australian words for man is karnale, which we get in other forms as kurnai, korna, and so forth. These words have the same meaning as kanaka; they begin with the same letter; they have *n* and *a* in them; and they are much more alike to both eye and ear than are many of Latham's supposed identities; but they have no connection whatever with kanaka. One might just as reasonably connect them with the Assyrian karnu, or the Hebrew keren. Kanaka is especially valuable to us as a warning against putting our trust in mere surface likeness, because it shows us the necessity of taking words to pieces before we compare them with others. Kanaka is very like karnale, but it has not the remotest connection with it; it is very unlike another Melanesian word—natamoli—and yet it is positively identical with it. This is seen when the words are dissected. The initial *na* in natamoli may be discarded. It is only the article, and ought not to be written as a part of the word. Tamoli and kanaka are identical. In each case, the first syllable—*ta* or *ka*—is the word for Man (*k* and *t* are interchangeable letters); moli and naka are only terminations signifying that the *Ta* is alive. Tamoli is the living Ta; the dead Ta would be tamate.

But we may go a step further than this. So far from mere surface likeness being necessarily a proof of connection, it may be in many cases strong evidence against it. Very great similarity in words—nay, complete identity of form—may actually be proof positive against connection.

For instance, in a map of Lake Tanganyika, drawn by Captain Hore, of the London Missionary Society, and published in the Journal of the Anthropological Institute, vol. xii., there are 128 place-names. Of these, 51 are either Fijian words now current, or possible Fijian. There is a prefix ka, which is common in Fiji; also, there is another prefix—*Mu*—attached to points of land projecting into the lake, which, under the form Mua, is used in Fiji for precisely such projections; and two of the names—Kamba and Kalambo—are place-names in Fiji, letter for letter, at the present day; and yet, in spite of all these similarities and identities, there is nothing in the Tanganyika languages, as far as I can learn, which falls in with the Fijian. The fact is that the surface similarity in this case is too great. It is simply impossible that so many words could have travelled all the way from Central Africa to Fiji, retaining their old forms, after all their migrations, extending over many centuries. Words that form the current coin of any language are sure to get more or less defaced in the using; and if those identical forms had really come from Central Africa, they would not have been identical by the time they arrived in Fiji.

Sometimes our philologists have to manufacture their surface similarities, and they do it with all diligence. For instance, Latham takes the Kauarega as an Australian language. This, by the way, should be Kauralaig; and, since *laig* is only a termination, with some such meaning as "folk," the language should be spoken of as the Kaura. It is the language spoken in the Prince of Wales Group, north-west of Cape York. In order to prove his case, Latham takes the Kaura numeral quassur W (=2) as identical with the Australian kootera, kuttara, or kardura, and for so doing he gives no better reason than that the Greeks had both Thalassa and Thalatta! Then, again, he takes the Kaura dual pronoun ngipel to be made up of "thou" and "two"; but, since the Kaura numeral, 2, is not *pel*, but *quassur*, he goes as far as New South Wales, and South Australia, hunting for his *pel*. There he finds purlaitye, purlette, parkulu, and bulla, all of which he connects with pel—for no better reason than that they have *p* or *b* and *l* in them! I do not affirm that Latham's words are not connected with pel; they may be for anything I know to the contrary, though it is wildly improbable that they are; but we have a right to ask for proof of their connection, and Latham gives us none, nor does he seem to think that any is required. Philologists will have to adopt saner methods than these, or they will not get common-sense people to give them any heed. It is true that, while on the one hand mere unsupported similarity is no proof of connection, on the other hand the widest surface dissimilarity is no proof that the words are not connected; but when a man tells us that words so dissimilar as quassur and kootera, or as pel and parkulu, are the same word, he is bound to give tangible proof; and the only satisfactory way of doing this is to produce the intermediate forms.

This method (the presentation of the intermediate forms) often connects the most dissimilar words, and proves indisputably their positive identity. Take, for instance, the dissimilar words ndalinga and taia. Each is the Melanesian word for "ear," and the two words are one and the same. In Fiji, and elsewhere, we find ndalinga; in Fate, it becomes talinga; in Motu, it drops *l* and *ng*, and appears as taia. This, however, should be written ta'i'a, the apostrophe representing a queer catch in the breath, the ghost of a departed letter. Take, again, the Fijian taba and be'e. How unlike they are! And yet they are the same word. In one Fijian dialect the word is taba, in another it is tebe, in a third tebe is reversed and becomes bete, and a fourth drops the t, making the word be'e. But the most striking instance of these unlike identities is the word for "banana," which appears at one end of the line as phitim, and at the other as un. Phitim and un! Were ever two words more unlike? Nevertheless, they are one and the same. Phitim appears in Wallace's Vocabularies of the Malay Archipelago, where, also, we find phudi—both meaning banana. In Fiji the *f* (ph) changes to *v*, and the *d* is strengthened by *n*, the word being vundi; in Aurora, the initial *v* is dropped, and the word becomes undi. Finally, in Duke of York Island it discards its second syllable, and presents itself as *un*.

Surface resemblances, often fanciful or specially manufactured to suit, have had much to do with the etymological guesses of the men of the sun-myths, who based their theories on their conjectures as to the meaning of the names of the old gods, demigods, and heroes, and got the sun, the rosy dawn, the lightning, and the cloud out of the ancient myths by what Professor Tiele calls "mere philological jeux d'esprit." Sober-minded investigators, such as Dr. E. B. Tylor, and others, have risen up in rebellion against them, and even Max Müller himself has been brought to book. Of course, I do not mean to deny that there are real sun-myths; there are plenty of them; but if a man tells me that the Greek Dionusos is derived from the Assyrian Daian-nisi, one of the names of the sun-god, or that Jason comes from the Greek verb "to heal," I do not take upon myself to contradict him, but I have a right to ask, "Where are your proofs?" No proofs are forthcoming. These gentlemen do not deal in proofs; they only surmise. But they will have to deal in them nowadays if they want to be listened to.

There must of necessity be myriads of surface resemblances in words without any connection at all. How many millions of words are there in the thousands of languages now spoken on the face of the earth, to say nothing of the dead ones? The human voice is capable of producing only a limited number of sounds; out of these few sounds, all the words spoken in all the earth have to be constructed, and the possibilities of their permutations and combinations are comparatively few. Is it not, then, a mathematical necessity that there should be numerous coincidences of phonology, and even, to some extent, of grammatical forms, without any linguistic connection at all? Surface-similarities in words, unsupported by corroborating evidence, are therefore positively of no value at all, excepting to suggest an inquiry as to whether there is anything in them. Science is becoming more exact, and more exacting, and some of our philologists will have to come down from the clouds, and betake themselves to the practical methods of the natural-science men, who are doing such splendid work by simply taking infinite pains, and recording nothing but well-ascertained facts. No slight work will be accepted nowadays, especially if it has a big theory hanging to it.

TWO LEGENDS OF THE LAKE EYRE TRIBES.

By A. W. Howitt and Otto Siebert.

For some years Mr. Howitt has, with the co-operation of the Rev. Otto Siebert, been engaged in investigating more critically the organisation, customs, and beliefs of the tribes which inhabit that part of Central Australia which more immediately surrounds Lake Eyre.

In doing this a considerable number of legends have been obtained, which are connected with their initiation ceremonies and with those which relate to the increase of their food supply by magical means. The two now recorded relate to the actions of some of the human race which, according to the tribal belief, preceded them in Central Australia. These they call the "Mura-muras," who are the actors in the legends spoken of, who are represented as being in all respects like the present race, but of infinitely greater magical and supernatural power.

One of the two legends speaks of the existence of animals called "kadimarkaras," which are said to have descended from the sky-land to the earth by means of the huge eucalyptus tree which then grew along the shores of Lake Eyre supporting the sky.

One of the Mura-muras hunting for game came across a kadimarkara and killed it. Being unable to cook it or carry it to his camp he swallowed it raw and whole. This caused his body to change to that of a kadimarkara, which, the legend shows, was a huge reptile with a long tail. The Mura-mura in this form wended his way back to his home, forming the channel of the Cooper in his course, which is now the Cooper. He also named various places in his course, and finally reaching his home he, with his wife, who had also become a kadimarkara, sank into the earth and disappeared.

The identity of the kadimarkaras with some of the Mura-muras is shown by certain of the food ceremonies which are held where one of these creatures is believed to be still existing; in fact, being one of the fossilised extinct creatures which have been found in some places near Lake Eyre. The legend either has been built up to account for the existence of the fossils, or, presumably, may be a survival of a memory of the time when the blackfellows' ancestors hunted them when they still lived in the then marshy trails of the Lake Eyre deltas.

The second legend accounts for certain physical features of the Cooper, particularly of a rock-hole at the place [illegible] shown in the maps as Innamincka—properly Yidni-mingka—meaning "Thou become a hole," referring to the killing by a Mura-mura of an armed party which pursued him. His blows struck them into the ground forming a hole, about which the rocks are the men of the party, who, having been painted black, thus perpetuated the colour in the rocks which they have become.

Legend 1.

Ngura-tu lu-tu luru,[1] *a Yaurorka Legend.*

Ngura-tu lu-turu lu was a Mura-mura belonging to Kilyálpa,[2] who went on his wanderings. He came to a paia-tira,[3] where he saw women beating out seeds and cleaning them.[4] As he came nearer to them they saw him, and surrounded the stranger. They looked at him inquisitively from head to foot, and could not help laughing at his crooked legs and arms, nor could they help being surprised at the light-coloured flies which accompanied him, because those with them were black. Then they began to discuss where he came from and who he was, for not one of the women knew him. But as they thought that an old woman who was a little distance away might know him, they called her. Hastening to them she recognised him as being her ngatamura,[5] and took him on her lap and sobbed unceasingly, "palingi, palingi."[6] When she had wept over him sufficiently, she sent him to her husband, his yenku, who was in the camp with the other men eating paua. Before he reached the camp he could hear the men grinding the seed which the women had collected and cleaned. He thought to himself "that must be a good stone. I wish I had it." Then he went to his yenku's camp, and when he had spoken to him he made his own camp near at hand, and lay as if to sleep. As he lay there all the people camped there collected

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[1] Ngura-tu lu-tu luru is "crooked leg," from ngura, the leg, or, properly, the shank, both in Yaourorka and Dieri. "Tu lu-ti-tu luru," in the former, is "round, bent, crooked;" in Dieri "pirha-pirha." This Mura-mura is also called by another name, "tayi-taùyana, meaning a "grinding-stone in mud." "Tayi" or "marunga" is the slab of stone on which the seed is ground for food, and called in Dieri "ngurdu," and "taupa" is "damp earth or mud;" in Dieri, "mita-pada," "mita" being "earth," and "pada" "damp or moist."

[2] Kilyalpa is from "ki lyera," meaning "loose sandy land, without vegetation." [3] Paia is "bird" The meaning of "tira" is not known to us.

[4] Paua is the seed of plants used for food; for instance, of the *Claytonia*.

[5] Ngatamura (Dieri) is the relation of a boy to his father and father's sister.

[6] Palingi (yantruwinta) is the equivalent term for "ngatamura."

round about him, and made themselves merry over his crooked legs and arms. He, however, secretly watched where they had placed the wonderful tayi-stone which, with so little rubbing, had ground so much paua. When all the people had gone to sleep, Ngura-tu lu-turu luru rose up, and, taking some glowing coals and a piece of fungus,[7] he powdered both and scattered it over the whole camp, to make everyone unable to awake from sleep. After he had spoken his spell, to make sure that everyone was fast asleep, he shouted "Bai, Bai," loudly, but no one moved. Then he touched each one with a burning coal to rouse him, but without effect, and taking the grindingstone out of the damp earth where it had been hidden, washed the mud off it, and about mid-day walked away quietly with it on his head. When he had gone a long way from the camp the people woke up, and to their sorrow found that the stranger had disappeared with their tayi Then they formed a pinya,[8] and having found the track of the thief they followed him hastily. At Ngapa-kangu[9] they met with a man whom they killed, thinking him to be Ngura-tu lu-tu luru, and it was only after he was dead that they found out their mistake. Then they again followed the tracks to Malka-malkara,[10] where they overtook and fell upon him from two directions. When he saw himself suddenly surrounded by a pinya, he took the tayi from his head, and using it as a shield he stopped all the boomerangs thrown at him. Then collecting these he attacked the pinya, and pursued a part of them as far as Pinya-maru,[11] where he killed them and turned them into stones, which are black, because the men of the pinya were painted of that colour. Going back for the tayi, which he had left behind, he was attacked by the rest of the pinya, whose weapons he stopped, using the stone for a shield, and, as before, having gathered them, he killed all the men. So deeply did he strike them into the ground that a deep pit was formed, from which that place has been called Yidniminka.[12] Having done this he went back, and, on his way,

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[7] This fungus is called "wona-waru," that is "white mound," "wona" or "wonpa" being "hill or mound," and "waru" "white." It grows near eucalyptus trees.

[8] Pinya is an armed party sent out usually to avenge death. *See* the Dieri and other kindred tribes of Central Australia, A. W. Howitt, Journal Anthrop Inst., Vol. XX, p. 31.

[9] Ngapa-kangu is, in Yaurorka and Dieri, "flax in water," from "ngapa," "water," and "kangua," flax-like fibre.

[10] From "malka," the *Acacia aneura.* The word means a freshly-shooting mulga bush.

[11] Maru is "black."

[12] Now shown on the maps as Innamincka.

at Madra-yurkuma,[13] he slew a number of those sent against him. Then taking his tayi under his arm he went to Meri-wora.[14] The pinya had by this time again collected against him. When they began to throw their boomerangs against him, he placed the stone in such a manner on his back that no weapon could harm him. But he was buried under the tayi and was turned into stone.

Some of our informants say that it was Ngura-tu lu-tu luru who named the place of Yidniminka, by saying to the men whom he had killed, "yidni minka (nganamai,")" thou a hole (shalt be.") Others, however, say that it was another Mura-mura named Nura-wordu-bununa,[15] who named this place, and about whom the Dieri have the following legend:—

Legend 2.

Nura-wordu-bununa.

This Mura-mura lived at Lake Hope (Pando), and caught rats and mice, which were there in great numbers, for his food. Of their skins he made water-bags. One day he saw a Mari[16] in the neighbourhood of his camp, and followed its tracks the next day, armed with his spear und boomerang, till he found it. When he was preparing to kill it, the animal spoke to him, saying, "Why dost thou come to me as to a stranger? Put down thy boomerang and spear." Doing this, he then wrestled with the Mari and strangled him, and made a large water-bag of his skin. After a time he saw a much larger animal, which only showed itself at times. "I must have that one," he thought to himself, and, having filled all his water-bags, he carried some over his shoulders, and one in each hand. The great bag which he had made from the skin of the Mari he put on his head on a pad which he made of his hair, the ends of which he tied over the top. Being thus prepared, he set out following the tracks of the great animal, further and further away from his home, until his water-bags were emptied one after the other. After a time he saw a great animal, but it was not the one he was tracking, and he still went on into a country

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[13] Madra is "stone." In Dieri "marda yurkuma" is, in Yaurorka and Dieri, "to carry under the arm." The place is so called because the petrified men carried their bags (billi) under their arms, after the custom of the pinya.

[14] "Nura" is "tall," and "wordu" is "short;" "punu" is the part of a creek where it enters a lake. In this sense the name means "he with the short tail at the embouchure," that is, where the creek enters Lake Hope. [15] Mari is a kind of wallabi.

[16] Kirka, "boomerang." Kalti, "spear."

quite unknown to him. Then he saw many great animals, and marched among them, seeking the particular one he was in search of. At length he found him, and prepared to throw his boomerang, and then pierce him with his spear. But the animal spoke to him, saying, "If thou comest to me as a friend, lay down thy kirha and kalti."[17] Much surprised, he said, "Yidni barkana nganti yatani-mara nganai?" ("Thou also animal speech-gifted art?") He laid down his weapons, and both grappled together. The animal tried to seize his throat, but he threw it down and strangled it. Having done this he did not know what to do next. He could not cook it, because it was mura to him.[18] He could not carry it home, because he was worn out with his long marching. Then he decided to swallow it whole and raw. Lying down on the ground, face downwards and opposite to it, he began at the head to slowly draw it into himself. Then he noticed as he turned himself round that his body was becoming longer and longer, until at length he had become an animal. When he had swallowed the whole animal except the tail, this suddenly struck him in the eye and blinded him. He was bent double with pain, and because he could not see he did not know how to find his way back. Then he remembered that the wind had been blowing from his home, but when he drew in a breath and smelled it, it was a strange wind from the north. Then he smelled to the east, but that also was strange to him. After waiting for a time he drew in a breath from the west, and recognised it as the wind blowing from his home. Then he got up and travelled against the wind. When it ceased to blow he rested himself; when it again commenced he again travelled, until after a time he opened his eyes and could see, and he found that his body was wonderfully marked.

The way by which Nura-wordu-bununa went to his home is now the course of the Cooper, and its bends and curves were made by his serpentine movements as he travelled.

Directly the covering had fallen from his eyes his sight became stronger and clearer, and the markings on his body were brighter and more distinct. Thus, it was that at Kályumaru [19] he had become covered with a beautiful new skin

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17 Mura (inquiries still being made).

18 Kalyumaru is a large sheet of water in the Cooper, near the Queensland boundary, where I established my depôt on my second expedition in 1862. "Kalyu" is an "acacia," and "maru" is "a wide extent of country."

19 "Ngapa" is "water," and "ngayimala" is "throat or swallow." A part of the Cooper wheer it is confined between high banks, and being thus narrowed, is called the throat of the water.

from head to tail, beautifully marked and shining, and he saw himself as he had never seen himself before. But even now he was dependent on the wind, for when it blew from the west he wandered on, when it blew from some other direction he rested, and at those places kadimarkara were produced from his excrement.

According to some statements there were at that time two kadimarkara at Yidni-minka who, out of fear of him, hid themselves in their burrows. At Ngapa-ngayimala [20] Nura-wordu-bununa found the way blocked by two kadimakara, which had laid themselves down on the ground head to head. As they would not let him pass, he threw them aside with the kunya [21] with which his forehead was armed, and passed on. Two great eucalyptus trees [22] growing there, one on each side of the river channel, are the two kadimakaras which tried to stop Nura-wordu-bununa.

Passing between them he came to another kályumáru, where there were many kalyu bushes growing, and where many Mura-muras were collected together; but, he being now a tiutyu,[23] could not remain with them. At Kunyani he saw the Mura-mura, Pampo-ulas,[24] Great Wooden Bowl,[25] which he had filled with gypsum,[26] and secured with sticks, in a water-hole to procure rain. Passing by Nganti-wokarana,[27] he saw the Mura-mura of that name with his long tipa [28], and then came to Nura-wordu, which place he named after the kadimarkara which were formed out of his excrement. Thence he went to Nari-wolpu,[29] where an assemblage of Mura-muras was broken up by the deaths among

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[20] Kunya is a Dieri word for a longish piece of a bone which is pointed or a similar piece of wood brought to a point; for instance, the pointed end of a spear, or the thin end of a spear-thrower (kukuru), which are used by the medicine-men (kunki) for evil magic.

[21] These are kaliwaru (*E. rostrata*), but the most frequent eucalypt in that district is *E. microcarpa*, called pattara.

[22] Pampo is one of the rain-making Mura-muras; which is the dual termination. [43] Pirha equals "wooden bowl," ngangrura equals "great."

[23] Tuna-wirinyalka equals "gypsum." [24] Nganti equals "animal; wokara equals "neck."

[25] Tipa is the pendant branch of tassels made of the tails of the rabbit, bandicoot, among those aborigines.

[26] Nari-wolpu is to be translated "dead bones." In Dieri "nari" means "death, or the dead," and "moku" means "bones;" but, in this instance, the Ngameni and Wonkanguru word "wolpu" is used, the equivalent of "moku."

[28] This refers to the legend of the Mura-mura-kuyi-mokuna. *See* " ." Folklore, Journal of, give reference.

[29] Wokatu, or woda-woda, is the equivalent of the Armita churniga (*see* Spencer and Gillen, p. 337; also Roth, fig. 249.

them, caused by the bones of the Mura-mura Kuyi-mokuna.[30] Leaving that place he went to Wokadani,[31] where the female Mura-mura Wariliu-luna[32] formerly came out of the earth and gave birth to her many children, the murdus, which then ran off into different districts, where they settled themselves. Thus Nura-wordu-pununa travelled till at Ugapadia[33] the favourable wind ceased for a long time, and he formed a wide depression as he turned round smelling the wind as it blew first from one direction and then from another. Then stretching his neck westward towards his home, he formed the creek which leads to Kaparamana.[34] Then the wind blew direct from his home, and hastening on, and continually waving his tail with joy, he formed the windings of the creek, down which the flood-waters followed after him. Thus he passed by Mandikillawidmani,[35] where the Mura-mura Darana at one time stayed the rain by sticking his kandri[36] in the middle of the creek channel. Then he came to Wonna-mara,[37] where he made rain by means of the Wonna-mara song, and then, passing by the home-place of the Mura-mura Daranà,[38] he arrived at Yulku-kudana,[39] where, raising his neck to enable him to look round, he saw his camp and his wife. Then he hastened to it, and made a camp at Pando (Lake Eyre), at the place called Nura-wordu-pununa, where, with his wife, who had also become a kadimarkara, he sank deeper and deeper into the earth.

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[30] This appears to refer to another legend which relates how the Murdus (when animals) came out of the earth in an island in Lake Perigundi (Lake Buchanan), and being revived by the heat of the sun, got up and went away as human beings in every direction. *See* our paper on Mura-mura legends, Journal Anthrop. Inst., No .

[31] The appadeer of the maps.

[32] Shown in the maps as Kopperamana. This is incorrect, for the Dieri word Kapara-mara, that is, " root-hand." It has some reference to the barter which took place here between the Dieri and the neighbouring tribes. Kapara, in this connection, has a meaning which approaches our word "master."

[33] In Dieri, mandikilla equals "a wave or waves," widmana equals "to thrust into," because it was there that the Mura-mura Darana, according to another legend, stayed a great flood by thrusting his kandri into the river-bed. A kandri is of wood, and is best described as a somewhat curved, heavy, round stick, about three feet in length, which can be used either to throw or strike with. It also forms a " ceremonial staff" on certain occasions.

[34] Wonna is the woman's digging-stick, also her club. Wonna-mara is the name of a female Mura-mura who made rain, her song being used by Darana.

[35] Dara-is equals " waste, desert." [36] Yulku, in Dieri, means the lowest part of the neck; kudana equals "to lie down, or lower." Referring to the Mura-mura lowering his neck to hasten to his camp.

The fossil remains of diprolodin birds and other extinct marsupials [1] found at Lake Callabunna and other places in the deltas of the rivers flowing into Lake Eyre are considered by the aborigines to be the remains of the kadimarkara.

In these two legends, and in two others, the kadimarkaras are all spoken of as being reptiles, being also identified as woma, *i.e.*, carpet-snakes. The connection of these legends with the sacred ceremonies comes out, especially in one relating to the ceremony of the Mura-mura Nodumpa, also a kadimarkara, which are common to the tribes in the Cooper with those further to the north, being held at Farrar's Creek.[2]

The legends have probably been original explanations of the occurrence of fossil remains, but it is just possible that there may be even a fossilised remembrance of the actual existence of these extinct creatures.

I believe the late Professor Tate considered the deposits at Lake Callebunna to be Pliocene, but it may prove that they are Quarternary, and that the kadimarkaras and the aborigines were contemporaries. In a paper on the origin of the aborigines of Australia and Tasmania,[3] I have shown reasons for believing that their ancestors inhabited Australia at a period when there was a land-bridge between it and Tasmania, and the discovery of fossilised marsupial bones under the sand-bed in the Great Buninyong Mine bearing cuts and scratches with some sharp instrument, show that man then inhabited Australia.

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[1] *See* fossil remains of Lake Callabona, E. G. & E. C. Sterling and A. H. C. Zeety, p. 45, Memoirs of the Royal Society of S.A., Vol. I., Part II.

[2] *See* Journal Anthrop. Inst. (quote).

[3] (quote).

ON THE MARRIAGE RULES OF AUSTRALIAN TRIBES.

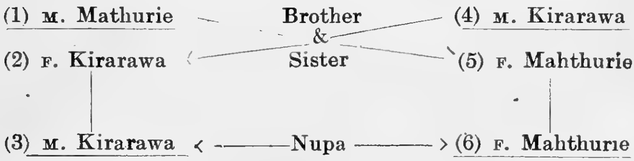
By A. W. Howitt.

In studying the marriage rules of the native tribes of Australia I have found it advantageous to use certain diagrams, which admit of a more ready comparison of their principle and scope, and which have suggested some interesting conclusions. These diagrams have been formed from the direct evidence derived from tabulated statements of actual marriages and descents in the tribes respectively dealt with.

The marriage rules are all based upon the division of the tribe into the intermarrying exogamic moieties. This is now well established, but I mention it as the starting point of my explanation. The further statement seems necessary, namely, that every relationship which I shall mention is not an individual relationship, but a group relation, consisting of what may be spoken of as "own" and also "tribal" relations.

The series of diagrams commence with the most simple form known to me, namely, that of the marriage rule which obtains in some of the Lake Eyre tribes, of which I take the Ugarabana as my example. These people occupy the western and north-western shores of Lake Eyre. They are the Urabunna of Spencer and Gillen, whose form of the class names I use, namely, Mathurie and Kirarawa. It will be seen, by comparison with Diagram II., that they are identical with the Dieri Murdus, or classes, Matteri and Kararu.

Diagram I.



The explanation of this diagram will serve for the following ones. (1) and (6) are brother and sister, so are (5) and (2). Marriage is brought about by betrothal, commonly of children, for instance of (1) and (2), and each such arrangement necessarily includes an exchange of a sister, own or tribal, of (1) as a wife for (5), the brother of (2). The children of these two couples are "nupa" to each other. As Spencer and Gillen put it (p. 65), "a man is nupa to the daughter of the elder brothers of his mother," which includes, as will be seen from the diagram, also the elder sisters of his father. The man (3) is therefore the proper husband of the woman (7), but he only acquires the special right by reason of betrothal; otherwise he remains one of the group of males who are "nupa" to the group of females to which she belongs.

DIAGRAM II.

This diagram represents the marriage rule of the Dieri tribe in the south-eastern side of Lake Eyre.

(1) M. **Matteri**	**Brother** &	(4) M. **Kararu**
(2) F. Kararu ←	Sister	→ (5) F. **Matteri**
(3) F. **Kararu** ←	Kami	→ (6) F. **Matteri**
(7) M. Kararu ←	**Noa**	→ (8) F. **Matteri**

This diagram differs from the former in that there is introduced another level in the generation. The individual numbers (3) and (6) are not relatively the same. Here No. (3) is the daughter and not the son of (2), and the respective children in this level are not in a relation equivalent to "nupa," but in another, "kami," which prohibits intermarriage. It is only in the next following level that this is lawful, the relation being termed "noa," which is the analogue of "nupa" of the Ugarabana. A further distinction may be indicated as follows:—"Ego being a Dieri male, my proper wife is the daughter of my mother's mother's brother's sister's daughter's daughter," therefore also of the mother's mother's sister's sister's daughter's daughter. The incohate right is not, as in the Ugarabana case, restricted to the elder line in the descent.

We see here that first the intermarrying relation is pushed on by one level; second, that the "noa"-"nupa" relation is not restricted by seniority. The latter appears to be more primitive than the Ugarabana rule; the former is clearly an innovation upon it. The explanation of the "noa" relation by the Dieri is that those who are "kami" are "too near to each other." The change, therefore, may be fairly accepted as an intentional one to prevent that which is an abomination to the Dieri, namely, "buyulu parchana," or the unlawful coming together of those who are, according to their system of relationship, too near to each other.

That the institution of the kami relation overriding an earlier "nupa" right has been a comparatively later innovation is shown by the fact that Ugarabana men have been married to Dieri women who were according to the Dieri rule kami to them, but from the Ugarabana standpoint nupa. These marriages were only brought about by the men making gifts to the mothers of the women, by whom principally the betrothal (promising) is made, and who under such an arrangement stand in the relation to such men, not of "paiara" but or "kami-paiara," or as I may put it, "kami-mothers-in-law."

These two cases relate to tribes having the two-class system, which occupy or occupied a very large area in Central Australia, and also extended south to Port Lincoln.

Before illustrating the marriage rule of certain coast tribes which also had the two-class system, it is advisable to show what the rule is in tribes which have not only the two classes, but also their respective subdivision into two, making a system which most frequently appears under the guise of four classes, the original two classes being in abeyance, or even lost.

The best instance will be that of the Kanuluroi-speaking tribe of New South Wales.

The study of this marriage rule is complicated by the peculiar manner in which the marriage and descents in the four sub-classes have been, no doubt unintentionally, arranged.

The four-class system is as follows:—

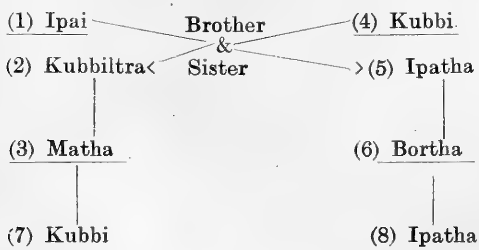
Kupathin { Ipai. Kumbo.   Dilbi { Murri. Kubbi.

The feminine of each name is formed by the addition of "tha."

As Kupathin marries Dilbitha, where children are Dilbitha, we have here a clear equivalence with the Dieri classes, and their diagram would be generally like that of the Ugarabana.

Omitting the two-class names, the marriage and descents in the four sub-classes give the following diagram:—

DIAGRAM III.



This diagram is drawn out according to the now well-known Kanulari rule of marriages and descents, which was first indicated by Mr. Lance and the Rev. — Redy, subsequently elucidated by Dr. Fisin and myself in "Kanulari and Kurnai," and further explained when I had ascertained as a fact the existence of the two classes Kupathin and Dilbi in my communication to the Anthropological Institute.

But up to the present time I have not been able to obtain a tabulated series of the marriages and descents in three levels of a generation of actual Kanularoi people. Therefore it remains, as shown by the above diagram, that although the marriage of Murri, the brother of Matha (3), to Bortha (6), and of her brother Kumbo to Matha (3)—and the respective marriage of their children Kubbi (7) and his sister Kubbitha with Ipatha (8) and her brother Ipai—would be theoretically and under certain circumstances legal, the actual facts have not been ascertained.

All that I have been so far able to learn as bearing on this question is that, according to correspondents, "marriage between cousins is absolutely forbidden."

Here we are at once met by a difficulty through the unfortunate use of our term cousin, which confounds two relationships which under the Australian class relationships are absolutely distinct. We include as cousins the children of two brothers, of two sisters, or of a brother on one side and a sister on the other. With the Australian aborigine, *e.g.*, the Kanulari, the first and second-named children are all brothers and sisters, and as such marriage would be absolutely forbidden between them. But restricting the term "cousin" to these where the Dieri term "kami" applies, we may then be justified in holding that in Diagram III. Murri and Matha (3), and Kumbo and Bortha (6), are such "cousins," and, to use the Dieri term, are "kami." If so, then their children are no doubt marriageable, and Kubbi (7) and Ipatha (8) are so to say in the "Noa" relation.

If such prove to be the case then the Dieri rule and that of the Kanulari are on all fours with each other, with this difference, in the former the prohibition has been created by an express term of relation, while in the latter it is brought about by the subdivision of the classes and the cross marriage and inheritance of the sub-class name in them.

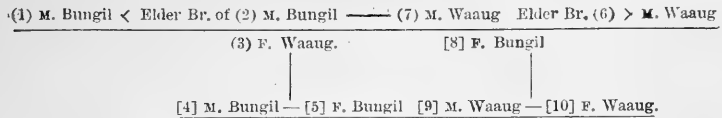
In this case the Dieri must be regarded as the more primitive form, just as that of the Ugarabana must be held to have preceded it. Systems such as that of the Kanulari extend from Maitland in N.S.W. to at least Hughenden in

North Queensland. In Central Australia, extending from the area of the two-class system north of Lake Eyre, probably to the north and north-west coast, there are systems which, built on the same foundation and on the same lines, have developed eight sub-classes by subdivision. In them, according to the splendid researches of Messrs. Spencer and Gillen, their rules of marriage are constructed on the same lines, but more fully developed to fit the subordinates, as those of the Kanulari.

To complete this brief outline of the marriage rules of Australian tribes, which will be fully dealt with in a work which I have now in hand, I add a fourth diagram of the rule which obtained in the now practically extinct Woëworung tribe of Southern Victoria.

In it the two-class system obtained, but apparently through the action of male descent, the two classes had become localised, so that each name was restricted to certain localities. The class-names Bungil and Waaug were intermarrying and exogamic, with inheritance of name by children from their father. In addition to this it may be noted that as these names were restricted to certain localities, these had become exogamic factors. Where in such tribe, as for instance the Kurnai of Gippsland, the class-names had disappeared, exogamy attached absolutely to locality.

DIAGRAM IV.



The two elder brothers Bungil (1) and Waaug (6) arranged for the mutual exchange in marriage of the children 4 and 5, and 9 and 10 of the respective younger brothers.

This diagram shows a fundamental similarity with the Ugarabana rule. If we substitute male descent in the former the principal difference would be in the action of the elder sister of the child's mother being the person to promise her to him in marriage. In both cases there is a further resemblance which is not shown in the diagram. The girl's or woman's brothers in each case have a voice in her disposal, the main difference being that with the Woëworung it is the elder son of Bungil (1) and of Waaug (7) regulating who has a voice in the matter, but under the class system of relationship he is, of course her elder brother.

The following main points may be noted:

(1.) The almost universal existence of a practice of betrothal.

(2.) The change of descent in certain tribes, accompanied by the decay, extinction, or mere localisation of the class-names.

(3.) To this must be added the passage from "group marriage" (piraruru-marriage) in such tribes as the Ugarabana and Dieri to individual marriage in such tribes as the Woëworung.

I have brought this matter under the notice of this Section in the hope that some members may be in a position to obtain tabulated statements from actual individuals extending over three levels in a generation, in tribes having the four sub-classes. If this can be done it will set at rest a question which has so far not been verified. It will connect the most primitive form of the marriage rule shown by the Ugarabana with the rules of the four sub-class system, which have been already connected by Messrs. Spencer and Gillen with those of the eight sub-class tribe of northern Central Australia.

This will therefore complete the series of diagrams which will illustrate the marriage rules of Australian tribes which I have prepared for a work which I have now in hand.

ABORIGINAL BURIAL RITES.

By Wm. Freeman.

[*Abstract.*]

Before the Ethnology and Anthropology section, Mr. Wm. Freeman, of Bourke, N.S.W., read a paper, entitled "A few notes of Burial and Mourning Rites of the Aborigines of Western Division of New South Wales, River Darling localities. Description of an Aborigines' Rockwell." Mr. Freeman produced in illustration of his paper several unique and valuable ethnological specimens, which he is donating to the local Museum, stating that he is indebted to Mr. McInerney, of Lower Budda, Darling River, about 150 miles below Bourke, for the specimens and for much of his information. According to reliable testimony, heavy widows' mourning caps, such as produced, respectively in weight 11lb. 1oz. and 7lb. 1oz., were worn during the periods of mourning, two to four weeks. The material is kopi, or gypsum, placed on the widow's head in a plastic condition, the marks of the fibre, or rush nets, worn over the aboriginal woman's hair, being well defined. Women with obligation to wear such head-gear had ample occasion to mourn, and well might a widow wearing such a cap, with streaks of gypsum drainings on her face and neck from recent additions, say to Mr. Freeman's informant: "Poor fellow me." This some 25 years back. The remaining aboriginals are demoralised, disregard ancient rites, and seem to lose old traditions. On a grave near his home Mr. McInerney found several widows' caps and other relics, including a fine prepared horn record stone (produced) of exceeding hardness, in length 17 in., greatest thickness 3¼in. The markings on this stone are stated to be record of burials of 49 adults and 12 children. Seventeen miles W.N.W. from the village of Filfra, on the Darling, and 22 miles northerly from Lower Budda, an artesian well lease, 11,228, there is an extensive ancient cemetery, recently exposed by the action of simooms, locally known as "Darling showers." Large trees had grown over the graves, and now, with about from four to ten feet of the top soil blown away, roots of these trees are exposed. In ancient cemeteries in the district aborigines are buried heads to the west, faces down, legs doubled back, ligatures severed, shin bones laid alongside thigh bones. Mr. Freeman also made reference to a rock-well excavated by aborigines. It is about 15 miles easterly from the village of

Enngouri, and 50 miles, magnetic, from town of Bourke. He inspected it on 29th November, 1901. This well is on the northerly slope of a low rock hill, and is of reversed shape, the horizontal excavation evidently to obviate loss from evaporation in a district in which the shade temperature at times is in excess of 120 deg. Fahr., with sun temperatures up to about 170 deg. Fahr., and over which fierce hot-winds frequently blow for lengthy periods. The water supply apparently is from surface drainage. At time of inspection there was a good supply, though useful rain had not fallen during several immediately preceding months.

PRIMITIVE WAYS.

By J. Rutland.

SECTION G.

ECONOMIC AND SOCIAL SCIENCE.

PRESIDENTIAL ADDRESS.

By T. A. COGHLAN, F.S.S., Government Statistician
of N.S.W.

CHILD MEASUREMENT.

ANTHROPOMETRY means not only the measurement of the proportions of the human body and its parts, but also the measurement of human faculty generally, including sensibility to heat, sense of location, and the effects of fatigue. Though sometimes described as a branch of anthropology, it is rather a scientific method of investigation than a science itself, and is therefore a branch of Statistics.

From very early times, measurements of the human body have been made by those who devoted themselves to the representation, in marble or pigment, of the form of man; but the artist sought only ideals of human symmetry, models of male and female beauty, and therefore measured none but the well-formed. The statistician cannot afford thus to pick and choose the objects of his investigation. He must measure people just as they are, without selection, indifferent alike to the perfection of face and figure sought by the sculptor, as to the deformities delightful to the caricaturist and the satirist of human frailty.

Modern and scientific anthropometry owes its origin to Quetelet, the Belgian Statistician, who sought "to find what is typical in man," noting "the variations due to sex, age, race, and social condition." Since Quetelet's time, there has been considerable progress in the methods adopted for securing exact measurements, and the extent of the interest taken in the matter may be surmised from the fact that a recent catalogue of works upon anthropometry shows the names of 662 authors, and of 1048 publications. England, the United States, France, Germany, Belgium, Italy, Russia, Poland, Denmark, and Sweden, all contribute to the sum of knowledge attained by anthropometrical methods, and the material already published is a full storehouse of learning and research, of extreme interest, not only to students of biology and psycho-physiology, but also to the vital statistician and the schoolmaster.

Up to the present time nothing of importance in the field of anthropometry has been accomplished in Australia, although isolated measurements have been made. Some years ago, Dr. F. N. Manning measured the height of a number of children, both in the private and public schools of New South Wales. The results of these measurements were not made public, but were forwarded by Dr. Manning to Mr. Charles Roberts, the well-known authority on anthropometry, and are referred to in Mr. Roberts' published works. In 1891, I was desirous of obtaining measurements of school children in connection with the Census, but I did not carry out my ideas, as proposals to do the same work had been made by certain leading surgeons of Sydney to the Minister for Public Instruction. The Minister was favorable to the proposals, and offered every facility for the making of the measurements, but the matter was not proceeded with. In 1894 the Anthropological Society of New South Wales was established, and for several years received an endowment of £150 a year from the State. The Society still exists, although the subsidy has been withdrawn. One of the main objects of the Society is to arouse sympathetic interest in child study, and to establish a laboratory wherein teachers and others having care of children may learn the principles of measurement. I believe that a number of persons have been measured by Dr. A. Carroll, the Secretary of the Society. In 1896 a paper was read before the Australasian Association by Lieutenant-Colonel Surgeon Ahearne as to the effect of tropical climates on the human race. Some measurements of Queensland children were given by the writer, but the number tested could not have been very large.

In most countries a fair share of attention has been devoted to the measurement of adults, but the chief attention is being paid to children. This is as it should be, for the measurement of children is of the utmost importance, because here we are closest to the source of social and national life. The mental and physical defects and abnormalities of the child we may hope to counteract or remove, whereas similar shortcomings and peculiarities of the adult are beyond remedy.

The object of all worthy educational systems is the freest and most symmetrical development of individual minds and bodies, and the training of our future citizens, so that they may approximate, as nearly as possible, the ideal human type. As a first step towards this, it is necessary to determine a standard by which physical development may be tested. This can be done by taking measurements of a large number of children, and summarising the results according to approved methods.

The first and immediate result of this systematic measurement is to render apparent the law of normal growth. This being known, deviations therefrom may then be recognised. All educators periodically examine their pupils to ascertain the mental progress produced by their instruction, but it is no less necessary for the well-being of children that their physical growth and change be submitted to examination equally searching and intelligent. It is only by such examination that the evil effects of over-study, or insufficient nourishment, or lack of exercise, or even of unhappy temperament may be detected and intelligently combated.

Few will venture to doubt that at the age when physical growth advances most rapidly in children there should be a corresponding diminution in the amount of school-work required of them, and that the greatest care should be taken that the mind is not cultivated at the expense of the body, nor the body unnecessarily cared for to the detriment of the mind. The natural inter-relation of the various physical powers and functions of an individual constitutes the health of that individual. From those in whom this condition of equilibrium is wanting, or disturbed, the ordinary amount of labour cannot be exacted without injury. It is of immense importance, therefore, that we should ascertain the effects upon boys and girls of their school life, so that if there be any hygienic faults connected therewith, they may be remedied. A deputation, considerable alike in numbers and in importance, is knocking at our doors, and the countless millions of posterity demand that we should safeguard their interests. It is our duty to heal and develop the stunted and deformed bodies, ill-balanced brains, and defective senses, which are to be found in all our schools, and, by discovering the causes of these defects, to remove them, so that the young of our race may have the full use and enjoyment of life.

Comparative anthropometry will teach us how far excessive study is to be blamed for injuries to the eyesight, chest capacity, or muscular powers, and whether we may not oftener than is supposed trace the objectionable symptoms to preventible causes—to badly ventilated rooms, deficiency of light, or some such neglect of the laws of health. There can be little doubt that many nervous diseases have their origin in the schoolroom, and are due in part to the ignorance and neglect of teachers who do not understand the importance of watching for the signs of incipient mental fatigue in their pupils. There is a widespread opinion in the medical profession that nervousness, as a disease, is largely on the increase; indeed, it has been confidently affirmed that thirty per cent. of the school children of Europe suffer from nervous affections. This, like many another general statement of the kind, will require substantial backing before it can be accepted, but it is safe to say that there is much nerve destruction in children brought on by the exhaustion of school life—by the failure to proportion the amount of work required from any individual child to the strength of that child. Actual malformation of the body, too, may possibly be caused by remediable unhygienic conditions. For example, there are many cases of pigeon-breast and curvature of the spine amongst the children attending school in New South Wales, and there is a strong suspicion that many of these are caused, or at least aggravated, by the faulty positions in which the children have to sit at their lessons.

Apart from the detection of pathological symptoms or malformation, the light which anthropometry sheds on the law of growth and the significance of the physical changes incident to puberty is peculiarly interesting. Investigations made in various countries have demonstrated that boys and girls differ in their rates of growth with respect to stature and weight. It as been shown, for example, "that a depression which occurs in the growth of (English) males from 10 to 15 years of age does not occur in the growth of (English) females at corresponding ages, nor is there any similar depression at any other period of the growth of girls." It is possible, but does not seem probable, that the accession of puberty checks the growth of boys, for previously to the advent of puberty there are no physiological differences in the two sexes. It would have been an argument against the assumption that the accession of puberty checks the growth of boys had it been found that the boys of New South Wales exhibited no retardation of growth between 10 and 15 years. The New South Wales evidence is not conclusive. Up to 10½ years there is no sign of retardation; and from 10½ to 12 years the growth is greater than at any previous period;

while from 12 to $13\frac{1}{2}$ years the growth is certainly retarded. Mr. Charles Roberts believes the more probable explanation is, that boys "do not live under such favourable conditions for their regular bodily development as girls." In England boys are sent to boarding schools at an earlier age, and their education is more persistent and severe, from a sanitary point of view, than that of their sisters; they receive less care and protection in the home life, and are frequently subjected to laborious physical occupations at an early age. Their bones thus are often prematurely consolidated. Moreover, they are sometimes underfed, as well as overworked, at an age when all their developmental energy should be spent in growth. The differences of growth due to difference in race are very important, but as the non-Anglo-Celtic strain is very small in these States any comparison of racial peculiarities based upon local observations would necessarily have little value. The scope of the anthropometrist working in Australia must therefore lie principally in noting the differences which develop themselves in people of the same race living under different social conditions; and I think Australian observations will tend to confirm the conclusions of observers elsewhere, that not to heredity, but to environment, must be attributed the major differences that are discernible among children of the same race who are born healthy. The observations which I have so far been able to make have not been sufficiently numerous to enable me to arrive at any firm conclusions beyond these:—

First.—That the children of the non-labouring classes are physically more robust than the children of the labouring classes;

Second.—That hindrances to growth show themselves at an early age; and

Third.—That many of the conditions that make for evil may be removed or greatly modified in their action.

I now propose to give the results of the measurement of some 2000 children made in Sydney during last year. The number measured form but a small proportion of the children of the State, but they are well representative of the various social grades to be found in Sydney, and I hope some day to be able to record the observation of 25,000 others.

The card herewith circulated shows the description of the measurements made. It will be seen that besides the information necessary for the identification of the child the following particulars were obtained:—As regards the child's parents, their occupations and blood relationship, if any, were ascertained, as well as the number of generations in Australasia each parent represented.

Physical Characteristics.

Skin.—The classification of the skin adopted was that used on the Continent, and devised by Virchow, and is as follows:—

1. Blonde.—Light.
   Medium with blue-grey, greenish, or light-brown eyes.
   Dark.
2. Ruddy—is a blonde, usually pale, and associated with red hair.
3. Brunette—Light with brown, or hazel, or black eyes.
   Dark.
4. Mixed—includes pale or medium skins, with dark hair and light-blue or grey eyes.

Hair.—The hair has been classified after selection and comparison of several hundreds of specimens, and the classification adopted corresponds with that of the Ethnographic Committee of British Association. There are four main classes arranged according to color, viz.:—

1. Blonde—Light or Flaxen.
   Medium.
   Dark.
2. Reddish or Auburn, including Sandy.
3. Brown—Light.
   Dark.

Character.—Hair is divided also into 6 classes by character:—

(*a*) Fine, (*b*) Coarse, (*c*) Straight, (*d*) Curly or Wavy, (*e*) Lustrous, (*f*) Dull;

and into three classes as regards amount:—

(*a*) Copious, (*b*) Moderate, (*c*) Scanty.

The Nose.—The profile of the nose has been classified, to agree with British Association Standard, into 6 classes:—

1. Straight.
2. High Bridge or Roman.
3. Concave.
4. Sinuous or Wavy.
5. Aquiline.
6. Semitic or Jewish.

The Ear has been classified into 7 classes, as follows:—

1. Large.
2. Small.
3. Oval.
4. Rounded.
5. With large lobule.
6. With a Darwin's Tubercle.
7. Projecting.

The Eyes have been classified as follows, (after Beddoes):—

Light	(*a*) All Blue.
	(b) Blue-grey.
	(c) Light-grey.
	(*d*) Greenish.
	(*e*) Yellowish.
Medium...............	(*f*) Light-brown.
	(*g*) Dark-hazel.
Dark	(*h*) Dark-brown.
	(*i*) Dark-hazel.
	(*j*) Black.

The Lips are described as full, thin, wide, narrow, even, or symmetrical, open, or closed.

Teeth are classified as follows:—Large, small, even, uneven, and as good, fair, or bad, according to the number decayed.

Palate.—Notice is taken as to height, width, and shape.

Tonsils are classified as large, small, lobulated, or single.

Mental Ability as stated by the teacher; but this estimate is frequently to be altered or modified by the examiner, for obvious reasons.

State of Nutrition is described as good, fair, poor, &c.

Acuteness of Vision is tested by Snellen's Type cards. This examination only determines Myopia and Astigmatism. Hypermetropia, whether latent or actual, could not be estimated except by more lengthened examination than could be given to the children.

Acuteness of Hearing in young children has been estimated by the ticking of a watch, but up to the age of 9 or 10 their answers are unreliable, as they very frequently anticipate the observer's opinions unless checks are taken.

Nasal Obstruction and Mouth Breathing.—A very large proportion of the children examined, especially up to 10 or 11 years, have been found to be suffering from post nasal adenoid vegetations, and enlarged tonsils. Statistics have been collected, and, in several cases at least, as the result of a message to the parents, the children have been operated on with very beneficial results. The same remark applies to children, myopic and astigmatic, who now wear glasses correcting their errors of refraction. A large number also suffer from headache without any obvious cause, but this may be due in some cases to eye strain.

Physical Measurements.

The following is a brief account of the various measurements taken and recorded on the back of the Census cards. The instruments used are the Head Square, Callipers, and Centimetre Tape, while the vertical heights are measured by the Anthropometer.

Measurements and Anatomical Points.

The Head.—

The Antero Posterior Diameter is taken from the most prominent part of the forehead to the external occipital protuberance, care being taken to hold the cephalometer horizontally.

The Transverse Diameter is greatest width of head above the ears.

Horizontal Circumference is taken with the tape from level of eyebrows over the occipital protuberance.

Nasio Iniac Arc is the length over the head from the two points just mentioned.

The Height of the Head is the distance from the chin to the vertex (head horizontal) taken with Anthropometer.

Face.—

The Length of Face is distance from the naso-frontal suture (root of nose) to point of chin.

Bizygomatic Breadth is greatest width of face in front of the ears (horizontally).

Interocular Breadth, taken by callipers, is distance between internal angles of the eyes.

Nose.—

The Length of Nose is taken from the root of nose, naso-frontal suture, to sub-nasal point.

Width of Nose is taken at level of nostrils during tranquil respiration.

Chest.—

The Circumference is taken over the bare skin over and at level of nipples; both empty and expanded measurements are given.

Antero Posterior Diameter is taken at level of nipples, from sternum to spine.

Lateral Diameter is taken at level of nipples (horizontally) during tranquil respiration.

Pelvis.—

The Interspinous Breadth is taken between the two anterior superior spines of the ilium.

Intercristal Breadth is taken at edge of outer lip of the crest of the ilium.

Intertrochanteric Breadth is taken between the most prominent points of the great trochanters of the femur.

The External Conjugate Diameter is taken between the upper edge of the symphysis pubis, and the lower end of the body of the 4th lumbar vertebra.

Upper Extremity.—

The Upper Arm Length is reckoned as the distance between the acromion tip of the shoulder, and the upper level of the head of the radius.

The Fore Arm is the distance between the head of the radius, and the styloid process of the radius—*i.e.*, length of the radius.

The Length of the Hand is the distance from the styloid of radius to the tip of the middle finger fully extended.

Inferior Extremity.—

The Length of the Thigh has been reckoned as the distance from the antero-superior spine to the knee-joint externally. It was found that the top of the great trochanter is too variable and too hard to find to be absolutely relied on, especially in fat or muscular persons, so that the thigh is reckoned from the anterior superior spine in all cases.

Length of Leg is taken from the knee-joint to the tip of the internal malleolus (ankle).

Weight.—

The Weight has been taken in all cases in ordinary indoor costume, including boots or shoes, no overcoats, or extra clothing, being weighed in. After weighing many complete outfits, it was found that the average weight of clothes was, for children from 5 to 10 years, equal to 6 lbs.; 10 to 13, equal to 7 lbs.; and from 14 to 19 years, equal to 8 lbs. These amounts have not been subtracted from the nett weight, as it is usual to state children's weight as including clothes.

Hand Grasp.—

This has been registered on the dynamometer according to the Echelle de Pression in kilogrammes.

The measurements were taken with special instruments procured for the purpose. The observers, Dr. Brennand, Dr. Mabel Graham, and Dr. Mary Booth, were highly skilled, and every confidence may be placed in the observations made by them, and herein recorded.

The methods of measurement adopted have been those used in Europe and America, and the metric system of lengths has been used throughout. The weights, however, have been taken in pounds avoirdupois, and for the purposes of this paper, and for comparison with English and American observations, the metric lengths have been converted into inches.

I now propose to give some of the results of the measurements actually made.

Height.

The height was taken sitting and standing. The sitting height is the distance from the crown of the head to the stool, on which the child sits, as straight as possible. A convenient height of the stool was found to be from 18 to 20 inches. The standing height was taken from the crown to the floor, the child having no boots on. The observations made on boys from 5½ years to 16½ years give the following average heights:—

Height, Standing and Sitting, in Inches.

Age	Height.		Proportion to Total Height.	
	Standing.	Sitting.	Of Head and Trunk.	Lower Extremities.
Years.	Inches.	Inches.	Per cent.	Per cent.
5½	44·5	24·3	54·6	45·4
6	45·0	24·5	54·4	45·6
6½	45·5	24·8	54·5	45·5
7	46·5	25·3	54·4	45·6
7½	47·4	25·8	54·4	45·6
8	48·2	26·1	54·1	45·9
8½	48·9	26·7	54·6	45·4
9	49·8	26·8	53·8	46·2
9½	50·7	27·0	53·2	46·8
10	51·6	27·3	52·9	47·1
10½	52·5	27·8	52·9	47·1
11	53·6	28·5	53·2	46·8
11½	54·6	28·9	52·9	47·1
12	55·6	29·1	52·3	47·7
12½	56·4	29·4	52·1	47·9
13	57·2	29·8	52·1	47·9
13½	57·9	30·4	52·5	47·5
14	59·1	30·8	52·1	47·9
14½	60·6	31·3	51·6	48·4
15	61·9	31·9	51·5	48·5
15½	63·1	32·4	51·3	48·7
16	64·3	32·9	51·2	48·8
16½	65·1	33·5	51·2	48·8

If the figures be transferred to a diagram, it will be seen that the height does not increase in regular mathematical progression, but in a series of undulations, the points of retardation in growth being at 6½, 8½, and 13½ years. In the first two periods, the retardation is slight, but from the 12th to the 14th year there is a considerable check to the growth as compared with the years immediately previous and immediately following. This corresponds with the observations that have been made in England and elsewhere. During the period of 11½ years covered by the table, the average growth is between eight-tenths and nine-tenths of an inch in six months, varying between one-half an inch in the earlier periods and one and a half inches at about 14 years.

Dividing the height between the lower extremities and the trunk and head, it is found that the two parts grow proportionately up to 8 years and 6 months, after which the length of the lower extremities increases more rapidly than does that of the trunk.

From age 5½ to 8½ the sitting height is about 54·5 per cent. of the standing height; at age 16, it has decreased to 51·2 per cent.

Comparing the growth of the boys in Sydney with the returns for America and England, quoted in the Annual Report of the United States Commissioner of Education for the year 1898, I find that the heights of the children of New South Wales and the United States very closely correspond. Indeed, for most of the years, as the following statement shows, the heights for boys of like age are practically identical. Compared with the English children, the local boys show a marked superiority over the whole period for which there are observations. The superiority in the early years is very striking; at 5½ years it is 3½ inches; at 10½ years it has been reduced to about three-quarters of an inch; and it remains from ¾ to 1 inch up to the 16th year, when the observations cease

Boys' Height in Inches.

Age.	New South Wales.		England.	United States.
	Actual Height.	Increase in 6 months.	Anthropometric Commission.	Report of Commissioners of Education.
Years.	Inches.	Inches.	Inches.	Inches.
5½	44·5	...	41·0	...
6	45·0	0·5	...	44·7
6½	45·5	0·5	44·0	...
7	46·5	1·0	...	46·0
7½	47·4	0·9	46·0	...
8	48·2	0·8	...	47·8
8½	48·9	0·7	47·1	...
9	49·8	0·9	...	49·7
9½	50·7	0·9	49·7	...
10	51·6	0·9	...	51·7
10½	52·5	0·9	51·8	...
11	53·6	1·1	...	53·2
11½	54·6	1·0	53·5	...
12	55·6	1·0	...	55·1
12½	56·4	0·8	55·0	...
13	57·2	0·8	...	56·8
13½	57·9	0·7	56·9	...
14	59·1	1·2	...	59·1
14½	60·6	1·5	59·3	...
15	61·9	1·3	...	61·8
15½	63·1	1·2	62·2	...
16	64·3	1·2	...	64·3
16½	65·1	0·8	64·3	...

Girls do not increase in height with regularity, but in a series of undulations. From 7 to 8 years the growth is very marked, the increase in stature being more than 2 inches; from 8 to 13 years the increase is rapid and fairly regular, the annual growth averaging about two inches and a tenth. After 13 years the rate of growth greatly diminishes, but during the next 18 months it is still an inch and a half per annum. From age 14½ the growth slackens, the average being about one inch per annum, until the maximum height is attained shortly after the 17th year.

Comparing the stature of boys and of girls it is found that at 5½ years of age the boys are almost an inch and a half taller than the girls. About the seventh year girls appear to grow faster than boys, and at 8½ years the heights are about equal, and continue so until approaching the 11th year, when girls grow much faster than boys; at age 13 years, the superiority is one inch and two-fifths (1⅖ in.). At the age 13½ the girls are still the taller, but the difference is rapidly lessened, until at about age 15 the boys again regain their superiority of stature.

The observations do not admit of anything definite being stated regarding children beyond age 16, but it would seem that there is very little increase in the stature of girls after age 17 has been reached, while the boys apparently are still growing strongly at age 18. The following table gives the height of girls sitting and standing from 5½ to 16 years.

Girls' Height, Standing and Sitting, in Inches.

Age.	Height.		Proportion to Total Height.	
	Standing.	Sitting.	Of Head and Trunk.	Lower Extremities.
Years.	Inches.	Inches.	Per cent.	Per cent.
5½	43·0	23·2	54·0	46·0
6	44·3	23·6	53·3	46·7
6½	45·0	24·2	53·8	46·2
7	45·4	24·6	54·2	45·8
7½	46·6	24·8	53·2	46·8
8	48·1	25·0	51·8	43·2
8½	48·9	25·6	52·5	47·5
9	49·5	26·1	52·9	47·1
9½	50·6	26·7	52·6	47·4
10	51·7	27·1	52·4	47·6
10½	52·6	27·4	52·1	47·9
11	53·9	28·0	51·9	48·1
11½	55·3	28·4	51·4	48·6
12	56·1	28·9	51·5	48·5
12½	57·4	29·4	51·2	48·8
13	58·6	30·2	51·5	48·5
13½	59·1	30·8	52·1	47·9
14	59·8	31·1	52·0	48·0
14½	60·9	31·8	52·2	47·8
15	61·5	31·9	51·8	48·2
15½	61·9	32·0	51·7	48·3
16	62·9	32·5	51·7	48·3

WEIGHT.

The increase of weight in boys from 5½ years to 6 years is about 1¼ pounds, during the next six months 1¾ pounds, and in the next 2 pounds; and from 7 to 7½ years the increase is a little less than 2½ pounds every six months; afterwards the weight increases much more rapidly, and at age 16 years it is about 1 pound per month.

The boys measured in Sydney are slightly heavier than English boys up to age 9½ years; thence until the 12th year is reached, they are slightly lighter. Before 12½ is attained the Australian boy regains his superiority, and a year later is about 3 pounds heavier than the English boy. This superiority he retains during his adolescence.

The Amercian child appears to be somewhat lighter in the younger ages than either the English or Australian child, but at about 14½ years his weight is much the same as that of the Australian, and so continues.

The following tables give the observed weights in New South Wales, and the English and American weights given in the 1898 report of the United States Commissioner of Education:—

Boys' Weight in Pounds Avoirdupois.

Age.	New South Wales.		England.	United States.
	Actual Weight.	Increase in 6 months.	Anthropometric Commission.	Report of Commissioners of Education.
Years.	Pounds.	Pounds.	Pounds.	Pounds.
5½	44·0		40·0	
6	45·2	1·2		45·3
6½	47·0	1·8	44·4	
7	49·0	2·0		47·7
7½	51·2	2·2	50·0	
8	53·6	2·4		51·5
8½	56·0	2·4	54·9	
9	58·3	2·3		56·2
9½	60·6	2·3	60·4	
10	63·0	2·4		61·5
10½	65·4	2·4	68·0	
11	67·9	2·5		66·3
11½	70·6	2·7	72·0	
12	74·0	3·4		72·7
12½	77·5	3·5	76·7	
13	81·4	3·9		79·4
13½	85·5	4·1	82·6	
14	90·0	4·5		88·3
14½	95·0	5·0	92·0	
15	100·3	5·3		101·0
15½	106·0	5·7	102·7	
16	114·0	8·0		113·7

The weight of girls averages, at 5½ years, about 6 pounds less than that of boys, and up to age 10½ years the average is about 4 pounds less. After that year the girls increase more rapidly than the boys, and at 12½ years the weights are equal. From 12½ years to 14½ years the girls are slightly heavier than the boys, but at 15 years they are again equal; after 15 years the weight of the boys increases very considerably until adult age is reached, while that of the girls does not increase beyond the 17th year.

Weight in Pounds Avoirdupois.

Age.	Boys.		Girls.	
	Actual Weight.	Increase in 6 months.	Actual Weight.	Increase in 6 months.
Years.	Pounds.	Pounds.	Pounds.	Pounds.
5½	44·0		38·0	
6	45·2	1·2	39·8	1·8
6½	47·0	1·8	43·0	3·2
7	49·0	2·0	47·3	4·3
7½	51·2	2·2	50·0	2·7
8	53·6	2·4	51·2	1·2
8½	56·0	2·4	53·0	1·8
9	58·3	2·3	54·6	1·6
9½	60·6	2·3	57·0	2·4
10	63·0	2·4	60·0	3·0
10½	65·4	2·4	62·3	2·3
11	67·9	2·5	66·3	4·0
11½	70·6	2·7	70·5	4·2
12	74·0	3·4	73·0	2·5
12½	77·5	3·5	76·8	3·8
13	81·4	3·9	82·8	6·0
13½	85·5	4·1	87·7	4·9
14	90·0	4·5	93·2	5·5
14½	95·0	5·0	97·5	4·3
15	100·3	5·3	100·7	3·2
15½	106·0	5·7	105·0	4·3
16	114·0	8·0	106·3	1·3
16½	122·0	8·0	107·9	1·6

Skin.

The prevailing colour of the skin is blonde, and out of every 1000 children examined—

575 are blonde,
235 are mixed, and
190 are brunette.

Of the 575 blondes, 79 may be classified as light, 19 as ruddy, 441 medium, and 36 what is technically known as dark-blonde. Of the 190 brunettes, 71 are light, 104 medium, and 15 dark or olive skinned.

Hair.

The majority of children have blonde hair at birth; it darkens gradually, not assuming its permanent shade until about the tenth year, although sometimes the permanent colour is not assumed until after puberty.

Taking all children examined, 273 per thousand have blonde hair, including 78 light-blonde, 153 medium-blonde, and 42 auburn or red hair; 711 have brown hair, viz., 335 light, 170 medium, and 206 dark-brown; while 16 per thousand have black hair.

The proportions of blondes from 5½ to 7½ years is 360 per thousand, declining to 230 per thousand at ages 7½ to 10 years, and to 210 after the 10th year.

The great majority of children are well supplied with hair; amongst boys the hair of 903 per thousand may be described as copious, 57 as medium, and only 40 as scanty; amongst girls—680 have copious hair, 245 medium, and 75 scanty. The boys, therefore, are the better provided with head covering.

The quality of the hair of 750 per thousand may be described as lustrous, 167 as moderately lustrous, and 82 as dull. The quality of girls' hair is generally superior to that of boys.

The texture of the hair is usually finer in boys than in girls. Amongst the boys 748 per thousand, and amongst the girls, 542 per thousand, have fine hair; 137 boys and 286 girls have hair describable as medium-fine, while 115 boys and 172 girls have coarse hair.

As regards character, the hair of 832 per thousand boys may be described as straight, 99 as wavy, and 69 as curly. Of girls, 760 per thousand have straight hair, 115 have wavy hair, and 125 curly hair.

Eyes.

The majority of children are born with blue eyes, but with many the blue changes into grey, brown, or hazel. This change begins shortly after birth, and it is not until the child is about two years of age that the eyes assume their permanent colour. The majority of eyes are light, and, out of every 1000 children examined, colours in the following proportion were found—

Blue	378
Blue-grey	71
Grey	94
Greenish, including Greenish-blue, and Greenish-grey	37

giving a total of 580 light-coloured eyes per 1000 children.

The medium coloured eyes numbered 269 per thousand, viz.:—

Light-brown	104
Light-hazel	165

Dark eyes were 151 per thousand, viz.:—

Dark-brown	90
Dark-hazel...	61

The colour most frequently met with is blue; there are 378 eyes of this colour per thousand. There is, however, a difficulty in distinguishing with exactness, as the shades vary with the state of health of the child and the amount of light prevailing when the observations are made, so that there is no certainty of colour as between some blues, greys, and greens.

Nose.

The noses of the children were classified and measured, and some of the details of the measurements are given in the papers herewith circulated. No part of the face alters so considerably as the nose, and, as the particular shape assumed by the feature between the ages of 5 and 15 does not necessarily give an indication of its permanent contour, I have not thought it worth while to take up attention with a description of its measurements.

The Ear.

The ears of the children observed were most frequently small in size, 550 per thousand being so describable, 297 per thousand were medium in size, and 153 large. In shape the majority of ears (773 per thousand) were oval, 205 rounded, and 22 oblong or square—very few being of the last description.

Most of the children have normal sized or small lobules to their ears, but in 122 cases per thousand the lobules were large, and in 4 cases entirely absent.

In 162 cases per thousand amongst the boys the ears were projecting; but amongst the girls few cases of projecting ears were noticed, the proportion per thousand being not more than 12. Every child was examined for Darwin's tubercle, and in 236 cases amongst the boys and 376 amongst the girls the tubercle was noticed. The presence of Darwin's tubercle in such a large proportion of the children is interesting, as the tubercle is claimed as an evidence of degeneration, and as indicative of a former condition when the human ear was shaped and developed like that of the quadrumana.

HEAD.

In boys the head grows rapidly in height from 5 to $7\frac{1}{2}$ years, and then remains unchanged for several years. From $9\frac{1}{2}$ to $11\frac{1}{2}$ the height increases and again remains stationary for a year; from about the 12th to the 13th year the increase is rapid, amounting to about 40 millimetres in the twelve months. After the 13th year the growth is regular, but slow, until the adult size is attained.

The development of the head in width presents somewhat analogous features to the development in height. There are periods of growth and non-growth, but these are less marked than in the case of the height. The transverse diameter grows slowly to age $8\frac{1}{2}$ years, the rate of increase being about 15 millimetres a year. From $8\frac{1}{2}$ years to 14 years the growth is very slight, the difference in the $5\frac{1}{2}$ years being not more than 10 millimetres.

From 14 years the growth is more rapid, and the transverse diameter expands fairly regularly year by year until the adult size is reached.

The nasio-iniac-sagittal arc—that is, the length of the dome of the head—does not grow rapidly before the 12th year, the increase during the $6\frac{1}{2}$ years ($5\frac{1}{2}$ to 12) being only 55 millimetres. During the three years following the growth is more rapid, the increase being 130 millimetres. After age 15, there is very little further increase.

The circumference of the head shows somewhat irregular growth up to age $10\frac{1}{2}$ years—or rather there are alternate periods of growth and cessation of growth up to that age. After $10\frac{1}{2}$ there is a regular increase in the dimension, the increase being at the rate of 46 millimetres per annum.

The dimensions of the heads of boys exceed those of girls of equal ages. The difference in length (antero-posterior diameter) is irregular, and is greatest at the earlier ages, viz., about 60 millimetres; towards the period of puberty the difference greatly diminishes, and at 13 years does not exceed 20 millimetres. The transverse diameter of boys' heads exceeds on an average that of girls by about 20 millimetres, but at the younger ages the excess is as much as 50 millimetres. The circumference is also greater at all ages, but the difference is very slight during the years $11\frac{1}{2}$ to $14\frac{1}{2}$; during these years, however, girls are both heavier and taller than boys.

FACE.

The height of the face is considered to be the length from the nasion to the point of the chin, and the bizygomatic breadth is the extreme width between the temples.

The face expands in its two dimensions with great regularity. The width invariably exceeds the height, and for boys between the ages of 5½ and 16½ years the average excess is about 9½ millimetres. From 5½ years to 7 years the height shows little or no increase; from 7 years to 10 years there is a regular increase amounting to 10 millimetres; from 10 years to 13½ years the growth is extremely slow, probably averaging not more than 5 millimetres; from 13½ to 16 years there is fairly regular growth; and after 16½ years the face speedily attains its adult proportions. The expansion of the width follows much the same lines as the height. Compared with the breadth of the head the increase in the width of the face is very considerable. Thus, from 5½ years to 16½ years the transverse diameter of the head increases by 10 millimetres; during the same period the width of the face increases 22 millimetres. The period of least growth in width of face is from 10 years to 13½ years, when the growth is about 3 millimetres.

All European people show two different forms of head—a long and narrow, and a short and broad head. The long head is called the German type, as it prevails or formerly prevailed in that country. It is generally admitted that amongst the Anglo-Celtic people long-headedness is an unfavourable sign, as the dullest boys show the largest percentage of this class of head.

Amongst the boys examined it was found that—

(*a*) Heads of the mesocephalic type—that is to say, whose index is 75 and less than 80—prevail at all ages, but are less numerous as age increases.

(*b*) Short heads (brachycephaly) are far more common at all ages than long heads. They increase in number with age up to the period of puberty, and then decrease.

(*c*) Long heads are more numerous as the age increases.

The following are the proportions of each type at various periods per thousand boys:—

Age Group.	Brachycephaly.	Mesocephaly.	Dolichocephaly.
	Index 80 and over.	Index 75 and under 80.	Index under 75.
5 to 7½ years.	354	609	37
7½ to 10 "	371	598	31
10 to 12½ "	416	546	38
12½ to 15 "	370	573	57
15 to 17½ "	342	542	116

The heads of girls do not follow the same law of growth as those of boys. At nearly all ages the average cephalic index is higher amongst girls, and at the lower ages, up to nearly 12 years, the broad-headed type prevails. After that year meso-cephalic heads are the most numerous. The heads of girls, however, grow more in length than in width up to about the 15th year, when the expansion in width exceeds the expansion in length.

The following is a statement of the number of each description of head per 1000 girls at each age:—

Age Group.	Broad Heads.	Medium Heads.	Long Heads.
5 to 7½ years.	592	370	38
7½ to 10 „	561	408	31
10 to 12½ „	463	492	45
12½ to 15 „	348	558	94
over 15 „	406	531	63

A statement showing the cephalic index at each age does not convey so much information as the figures just given; but, as it is usual to give a statement of the kind, it is here appended:—

Cephalic Index.

Age.	Boys.	Girls.
5½	77·2	79·9
6	78·1	81·9
6½	78·8	81·3
7	78·9	80·5
7½	78·7	82·1
8	79·2	80·8
8½	79·7	79·4
9	79·9	81·4
9½	79 6	80·2
10	79·0	80·3
10½	80·3	80·3
11	79·4	79·3
11½	78·5	79·4
12	79·5	79·4
12½	78·7	78·7
13	79·3	79·2
13½	78·9	78·8
14	79·5	79·0
14½	79·2	78·7
15	78·2	79·6
15½	79·7	79·6
16	78·0	77·9
16½	78·1	79·1

Chest and Lung Capacity.

The chest grows slowly in its lateral dimension up to age 6 years, thence its increase to adult proportions is very regular, the only interruption being from 11½ to 12½ years, when the growth is almost suspended. The anterio-posterior dimension or depth shows a slow growth till 7½ years, when it commences to increase with fair regularity up to 11 years. From 11 to 12 or 13 years its growth is slow, thence to 15½ years the increase is more rapid, and still more rapid after age 15½ has been passed.

In boys the chest circumference at 5½ years is 21 inches, and at 7½ years it barely exceeds 22 inches; thence to the 13th year there is a regular and somewhat more rapid development of these dimensions. From the 12th to the 13th there is a slight retardation of growth in a great number of boys, but after 13½ years the chest circumference grows quickly, its expansion during the three following years being at the rate of about 1¼ inches per annum. The chest growth of girls is much the same as for boys, but the circumference is greater at almost every age.

The chest expansion shows three periods of growth. Up to 8½ years the development is inconsiderable, rising in boys from 525 to 860 cubic centimetres, and in girls from 820 to 1050 centimetres; from 8½ years to about the 13th year the increase is rapid and regular, the capacity at 13½ years being 1800 cubic centimetres. After 13½ years there is still further expansion, so that at age 16½ it has increased in boys to 2680 cubic centimetres, and in girls to 2200.

Boys have a larger lung capacity than girls from the period of puberty onwards, but from the 9th to the 13th year the lung capacity of the two is almost identical, and prior to the 9th year the comparison is much in favour of the girls. The observations, however, have not been on so extended a scale as to warrant their being implicitly relied on. One peculiar feature worthy of attention is the small chest expansion of the Australian boys measured compared with that of European boys. In Ashby's and Wright's "Diseases of Children," the average capacity of boys from 5 to 7 years is given as 900 cubic centimetres, compared with 690 observed in Sydney; from 8 to 10 years, 1300 cubic centimetres, compared with 820; from 11 to 12 years, 1800 cubic centimetres, compared with 1440; and from 13 to 14 years, 2200 cubic centimetres, compared with 1800. The chest circumference and lung expansion for each age observed are as given in the accompanying table. The lung-expansion is the mean of three observations for each child.

Chest and Lung Capacity.

Age.	Chest Circumference.		Lung Expansion.	
	Males.	Females.	Males.	Females.
Years.	Inches.	Inches.	Cub. C'metres.	Cub. C'metres.
5½	21·0	21·6	620	820
6	21·2	22·1	690	840
6½	21·7	22·5	730	900
7	21·9	23·0	760	990
7½	22·0	23·2	790	1050
8	22·4	23·5	800	1050
8½	22·9	23·5	860	1050
9	23·1	23·5	990	1070
9½	23·2	23·5	1110	1160
10	23·4	23·6	1180	1240
10½	23·8	23·8	1250	1290
11	24·3	24·2	1350	1370
11½	24·7	24·6	1440	1440
12	25·1	25·1	1540	1540
12½	25·4	26·8	1630	1630
13	25·7	27·2	1720	1720
13½	26·0	28·0	1800	1720
14	26·5	28·2	1950	1720
14½	27·2	28·9	2140	1870
15	27·8	29·6	2290	2000
15½	28·3	29·7	2400	2090
16	29·0	29·6	2550	2145
16½	29·7	29·8	2680	2200

Hand-Grasp.

The strength of hand-grasp was taken for all children. It is found that there is a rapid increase of power after the age of 13½ years. This is, of course, a natural result following from the manual work and exercise undertaken by children after attaining the age stated. Hand-grasp, however, is not an important observation. It bears no relation to mental ability or even to general health and growth; it depends very largely upon sociological condition; and high registration of grasp is often associated with mental dulness or scholastic backwardness. Children who are forced to do manual work out of school hours, or who are compelled occasionally to absent themselves from school to assist their parents in earning their livelihood, are apt to acquire manual strength, and to lack mental development. More interesting is a comparison of the strength of the two hands.

Taking all the children examined, at no age does the average strength of the left hand exceed that of the right. Up to eight years of age there is, however, very little difference in the strength of the hands; but after that age children begin to show a decidedly greater strength in one hand than in the other.

Taking 1000 cases of boys over 5 years of age, the right hand is the stronger in 597 instances, the hands are equal in 122, and the left is superior in 181.

Lower Extremities.

The lower extremities of boys present no great peculiarity of growth. The average length for each age is shown in the table herein inserted, and it will be seen that there is very little difference in the proportions which the thigh, leg, and foot, bear to one another. For the eleven years covered by the observations the length of the thigh is 55·6 per cent. of the length of the whole lower extremity, and the leg 44·2 per cent. The foot is 30·7 per cent. of the length of the thigh and leg. Up to 8 years of age the growth of the lower extremity is rather slow, between 8 and 15 years it is more rapid, but after the 15th year the growth continues, but at a diminished rate, until the adult size is reached.

A comparison of the length of the lower extremities of Australian boys with those of British birth would be extremely interesting. As already noted, the Australian child is the taller, and it is alleged that the main cause of this greater relative height arises from a difference in the length of the thighs, the Australian being reputed to have the longer thigh. To settle the matter satisfactorily the measurements would need to be extended beyond the age of 16½ years, the limit of these tables, as important changes take place in males after that age has been passed.

Lengths of Superior and Lower Extremities.

Age.	Superior Extremity.			Lower Extremity.		
	Upper Arm.	Forearm.	Hand.	Thigh.	Leg.	Foot.
Years.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
5½	8·43	6·06	5·04	11·93	9·45	6·73
6	8·66	6·18	5·12	12·20	9·69	6·89
6½	8·70	6·38	5·20	12·44	9·72	7·05
7	8·82	6 42	5·31	12·64	9·84	7·13
7½	9·02	6·57	5·39	12·76	10·00	7·20
8	9·25	6·57	5·43	12·99	10·28	7·40
8½	9·57	6·69	5·47	13·39	10·55	7·60
9	9·69	6·69	5·51	13·78	10·75	7·76
9½	9·80	6·81	5·55	14·13	11·14	7·91
10	10·04	7·05	5·59	14·45	11·38	8·03
10½	10·16	7·20	5·67	14·65	11·65	8·19
11	10 31	7·40	5·83	15·04	12·01	8·35
11½	10·55	7·60	5·98	15·47	12·32	8·54
12	10·87	7·72	6·06	15·75	12·60	8·58
12½	11·10	7·87	6·18	16·18	12·99	8·74
13	11·18	8·07	6·26	16·54	13·23	8·90
13½	11 34	8·27	6·38	16·89	13·35	9·02
14	11·61	8·43	6·57	17·24	13·62	9·21
14½	11·89	8·66	6·81	17·72	14·09	9·45
15	12·17	8·82	6·81	18·11	14·37	9·53
15½	12·20	8·90	6·85	18·23	14·37	9·57
16	12·32	9·02	6·97	18·46	14·53	9·65
16½	12·60	9·25	7·09	19·13	15·00	9·69

The superior extremity grows proportionately in its three parts (upper arm, forearm, and hand) until adult age is attained—the upper arm being 43·7, the forearm 31·5, and the hand 24·8 per cent. of the total length. The rate of growth is also fairly regular, though there is a slight retardation at about age 15.

The leg and thigh of the girls do not grow proportionately as in boys. The thigh in boys averages 55·8 per cent. of the whole of the lower extremity; in girls it is only 52·3 per cent. at age 5½ years, gradually increasing, until at age 12 it has reached 54·9 per cent., which is the maximum proportion; in subsequent years it decreases, and at 16 years the proportion has again fallen to 52·2 per cent. From 5½ years until 12 the thigh grows more quickly than the leg; from age 12 to age 14 the two parts of the lower extremity grow proportionately; but after 14 the thigh ceases to grow, and the leg grows very little; the increase of stature made by girls after that year is almost entirely in the trunk. The following are the lengths of the lower extremity of girls at the respective ages stated:—

Lower Extremities, Girls.

Age.	Thigh.	Leg.
Years.	Inches.	Inches.
5½	10·5	9·6
6	11·1	9·6
6½	11·4	9·9
7	11·7	10·3
7½	11·8	10·6
8	12·0	10·8
8½	12·3	10·9
9	12·8	11·1
9½	13·4	11·5
10	13·6	11·8
10½	13·9	11·9
11	14·4	12·2
11½	15·2	12 5
12	15·4	12·7
12½	15·7	12·9
13	15·8	13·2
13½	16·0	13·2
14	16·2	13·4
14½	16·2	14·6
15	16·2	14·6
15½	16·2	14·7
16	16·2	14·8

Pelvic Measurements.

A description of the pelvic measurements has already been given. The following table gives the actual measurements of boys. The figures present much the same features of growth as those of other parts of the body. From 5½ to 8 years the growth is somewhat slow, and at 8 years there is a marked retardation in all the measurements; from the 8th year to the 10th year there is a rapid increase in the rate of growth. After the tenth year, the measurements do not increase so rapidly as in the years immediately preceding, but the growth is regular until the adult size is attained.

The interspinous breadth appears to slacken in its growth about age 15½, but the number of boys measured was not sufficiently large to enable the point to be satisfactorily determined.

Pelvic Measurements, Boys.

Age.	Intertrochanteric Breadth.	Intercristal Breadth.	Interspinous Breadth.	Conjugate Diameter.
Years.	Inches.	Inches.	Inches.	Inches.
5½	7·46	6·94	6·38	4·57
6	7·54	7·01	6·42	4·65
6½	7·72	7·17	6·46	4·74
7	7·87	7·32	6·61	4·82
7½	7·95	7·36	6·65	4·90
8	8·05	7·40	6·67	4·98
8½	8·19	7·60	6·75	5·06
9	8·41	7·89	6·93	5·24
9½	8·68	8·11	7·11	5·46
10	8·84	8·19	7·17	5·62
10½	8·91	8·25	7·24	5·66
11	9·07	8·39	7·32	5·71
11½	9·23	8·50	7·37	5·79
12	9·37	8·62	7·48	5·88
12½	9·53	8·78	7·64	5·97
13	9·72	8·94	7·72	6·06
13½	9·92	9·09	7·87	6·18
14	10·14	9·25	8·06	6·30
14½	10·43	9·43	8·21	6·48
15	10·79	9·67	8·39	6·60
15½	11·02	9·84	8·54	6·75
16	11·24	10·02	8·60	6·87
16½	11·46	10·28	8·62	6·95

The pelvic measurements of girls are naturally more interesting and present greater peculiarities than those of boys. The intertrochanteric, intercristal, and interspinous breadth, present much the same features of development. In each case the growth is quicker, and the measurement larger at each age, than in boys. The intertrochanteric breadth shows a rapid and regular increase up to 12½ years—from this stage there is a sudden development, the measurement increasing three-quarters of an inch in six months. From the 13th year the rate of increase originally experienced is maintained, and at 16½ years the development of the pelvis still continues. The external conjugate diameter is less in girls than in boys, the greatest difference being found between the 9th and 11½ years. After age 11½ the conjugate diameter of girls rapidly increases, and at the 15th year the measurements of boys and girls are much the same. The following is a statement of the four pelvic measurements for girls at the ages stated hereunder:—

Pelvic Measurements, Girls.

Age.	Intertrochanteric Breadth.	Intercristal Breadth.	Interspinous Breadth.	Conjugate Diameter.
Years.	Inches.	Inches.	Inches.	Inches
5½	7·52	7·04	6·60	4·44
6	7·98	7·16	6·68	4·50
6½	8·14	7·36	6·80	4·66
7	8·24	7·50	6·92	4·80
7½	8·28	7·64	6·96	4·86
8	8·48	7·82	7·04	4·89
8½	8·64	7·92	7·16	4·98
9	8·72	8·00	7·29	5·06
9½	8·92	8·09	7·44	5·16
10	9·16	8·24	7·64	5·24
10½	9·32	8·36	7·84	5·32
11	9·54	8·54	7·96	5·38
11½	9·80	8·76	8·08	5·56
12	9·96	8·88	8·26	5·80
12½	10·14	9·10	8·48	5·98
13	10·88	9·46	8·64	6·04
13½	11·06	9·66	8·68	6·16
14	11·20	9·84	8·84	6 34
14½	11·28	10·00	9·00	6·48
15	11·54	10·20	9·18	6·60
15½	11·92	10·49	9·50	6·72
16	12·20	10·68	9·60	6·80

In dealing with the information obtained through measurement and observation of the school children, I have avoided the discussion of congenital abnormalities, and of defects induced by unfavourable conditions of school life. Such discussion, indeed, is quite foreign to the immediate purposes of this paper, the chief objects of which are—firstly, to draw attention to the urgent necessity of child measurement and the good to be expected therefrom; and secondly, to make a slight contribution towards the determination of the Australian type.

Some of the measurements taken may appear more curious than useful. Taken by themselves, no doubt, such is the case. Value will be given to them by the work of future investigators. They form what will be the beginning of an extended series of measurements on a large scale, and their chief importance will arise from their position in the series. So far the measurements have not been so complete as the subject demands, or as it is my intention yet to make them. Moreover, only city children, and only a comparatively few children from a single city, have been examined. After information with regard to town children has been collected, there yet remain to be examined the children of the bush; and possibly the bush child may differ essentially in his characteristics from the child whose sky is mapped by roofs and chimneys. Even among the bush children themselves, there may be typical differences. Climate and associations set their mark on the human family.

"As the soil is, so the hearts of men,"

and the child of the plains may be of one type, the child of the uplands of another, and the one born and reared in the rich moist regions of the Eastern sea-board may develop into a type differing greatly from both.

THE ABSOLUTE DEPENDENCE OF AGRICULTURAL PROGRESS UPON EXPERIMENTS, AND SUGGESTIONS IN REGARD TO SOME DIRECTIONS IN WHICH EXPERIMENTAL WORK SHOULD BE DONE FOR THE AGRICULTURE OF AUSTRALIA.

By W. M. FARRAR, M.A.

(Wheat Experimentalist Department of Agriculture, New South Wales.)

It will be well to begin by explaining what is meant by "agricultural progress" in this short discussion. The word "agricultural" is confined to its proper meaning; and the "progress" which is meant is to come from improvements in the cultivation of the soil, and be in the direction of causing it to furnish to crops more of the plant-food it contains. That substantial, and possibly very great, improvements can be made in this direction, I think probable. Improvements of this kind scarcely appear to have been attempted until late years. They seem to have been regarded as impracticable; but from the knowledge we have now gained of the nature of the soil and of the forces, physical, chemical, and biological, upon which its fertility depends so largely, the time has now come, I think, for taking in hand this line of work in the manner in which, from its importance, it deserves to be taken up. Those of our scientific workers who have been engaged upon the practical application in the field of scientific knowledge to agriculture, and the increase of crop-yields by its use, seem to have confined themselves too much to the subject of hand-feeding crops with manures. This subject has been much studied; and, in relation to our knowledge of the nutrition of plants, very likely pretty exhaustively. I think we ought to leave this groove, at any rate for a time, and attack the subject *in the field* from the side I am proposing; and I hope in this paper to succeed in placing before you some ideas in regard to the manner in which this should be done.

The conditions, for which the necessity of improvements of this character is always before me, are those of the semi-arid and arid portions of Australia, and what I shall say on the subject will have reference to these conditions in particular. In those parts of Australia, remoteness from the commercial centres on the coast, the high freight-charges of the railways, the dryness of the soil, and the uncertainty whether there will be moisture enough to make chemical manures available for the crops they are applied to, make artificial fertilizers to be used at too great a disadvantage. But it is of almost, if not quite equal, importance, that the improvement of agriculture in the direction I am indicating should be taken in hand in the same manner the world over.

The soil, I need scarcely remind you, " is by no means the inert thing it appears to be. It is not a passive jumble of rock-dust, out of which air and water extract the food of vegetation. It is not simply a stage on which the plant performs the drama of growth. It is, on the contrary, in itself the theatre of ceaseless activities—the seat of perpetual and complicated changes."* The soil, as regards its components, is of most varied and complicated constitution. Not only does it contain a large number of chemical elements, but these elements occur in it in widely differing proportions and in many different combinations. The soil is of most complex constitution, and there is scarcely a single soil in regard to which we are not still, to a very large extent, ignorant of the manner in which the elements of which it is made up are associated and combined; while the introduction into it of a fresh substance, or an increase or diminution of the quantity of a substance which is already in it, or the action of a fresh force, or an increase or diminution of any of the forces which are already acting on it, may be the cause of wide-reaching changes in it. Any of these, because of the apparently simple chemical changes they produce directly, may be the cause of a whole cycle of fresh changes. The causes of disturbance are so manifold, that it is doubtful if anything approaching a state of chemical equilibrium is ever reached in a soil—in a fertile soil, at any rate. The temperature of the soil, like that of the atmosphere, is constantly changing; and a rise during the day may lead to certain chemical actions, and a fall at night to counter-actions. A shower of rain, or the acid juices of plants growing in it, may dissolve out certain substances from a mineral ingredient of the soil, and this may lead to a long series of changes in its other constituents. The decay of organic substances may set free acids or gases, or lead to the formation of fresh substances, which cause disturbances of chemical relations. These incessant changes and their complexity make it to be that we are to a very

* From Johnson's "How Crops Feed."

large extent ignorant of the state of a soil at any given moment; and this ignorance, from the nature of the case, we are hardly likely ever to dispel, although research will almost certainly enable us to reduce it very considerably. As a large proportion of the constituents of a soil are either potential plant-foods—that is to say, substances which, although unable in their present condition to feed plants, are capable of being changed into forms which plants can take in and assimilate—or are useful as well in other respects, because they perform functions by means of which they contribute indirectly to the formation of assimilable plant-foods, this state of chemical unrest or instability in the soil is the means by which it is kept supplied with assimilable plant-foods. The more complex, in fact, a soil is in its constitution, and the more exposed to forces which disturb its chemical equilibrium, and the greater the activity of these forces, the greater, *ceteris paribus*, is its capacity for feeding plants likely to be. Nor are the activities in a soil chemical alone. It is the theatre of other activities as well. It contains living organisms; and the bacteria with which it often teems, and can be made to teem, contribute largely to the formation of assimilable plant-foods in it—directly by the production of assimilable nitrogenous food; and less directly by helping to break up organic substances into other substances which cause chemical changes in it.

The agricultural progress I have in view in the title of this paper, is the making of such improvements in our methods of tilling and managing the soil as will enable us to increase, and, if possible, give direction to the activity of the chemical and biological (bacterial) forces which are incessantly at work in it, and cause them to change potential plant-foods into available forms in greater abundance than they do by means of our present methods. I do not venture to predict how much progress can be made in this direction; but it seems to me that as comparatively little effort of a systematic character, so far as I know, has been made in the field with this object in view, and that as the soil is known to be in general well supplied with potential plant-foods—sometimes within eight inches of the surface with enough for some hundreds of crops—it would be a far more philosophical course to make it our aim to learn how to make the greatest possible use of these potential plant-foods, than to devote our energies almost exclusively, as until lately we have been doing in our field-experiments, to the study of hand-feeding our crops with manures. I do not for a moment think that we shall ever be able to dispense altogether with manures, but I do think that the potential plant-foods which are already in the soil can be made to contribute far more largely, and that they should be made to contribute as much as possible, to the nourishment of our crops; and that eventually, under ordinary conditions and for ordinary, as distinguished from intensive, farming, it will only be found to be necessary to hand-feed crops with such plant-foods as the soil is naturally, or may become by cropping, insufficiently provided with, or as particular crops require in special abundance.

I have pointed out that the turning of potential plant-foods into available and assimilable forms is accomplished by the chemical, physical, and biological activities which are incessantly going on in the soil, and have expressed an opinion that available plant-foods can be produced in increased quantities by increasing and stimulating these activities. I will now go on to show that by taking proper measures we have a reasonable expectation of being able to do this.

The factors which are the most important for the creation of a state of chemical activity or unrest in a soil, and we are able to influence, are—

(1.) *Its physical condition.*—The soil should be in good tilth; that is to say, its condition should be made to be such that it is sufficiently open for air and water to enter freely, and close enough to be able to retain and, in the drought-liable interior of Australia especially, hold until crops have made use of it, as much as possible of the rain-water which falls upon it, as well as be favourable for the movement of moisture in it by capillary attraction. The putting of land into a condition of good tilth is a matter of good and thorough cultivation, and of management suitable to its character. To enable it to take in and store as much water as possible (a matter of very great importance in the interior of Australia), the cultivation should be as deep as possible, and sub-soiling had recourse to for this purpose. This is a point to which I shall recur.

(2.) *The presence in it of organic matters from dead plants.*—This is the main disturbing agency which causes the chemical activity in soils, to which they owe so much of their fertility.

Without such matters in them, the changes which air, moisture, and variations of temperature could make would be of comparatively little importance; and soils which are unprovided with them are, for the continued growth of crops, to all intents and purposes, barren. These substances are practically never in a state of stability. They are always making more or less rapid progress towards decomposition, and their presence in the soil is the direct or indirect cause of changes taking place in it incessantly. If these substances are moist and warm, and air, with the bacterial organisms it contains, has free access to them, their decay is rapid; but slower as the access of air becomes, after a certain point, less. If the temperature be too low (and that is probably never the case in the interior of Australia), or if moisture or air be entirely absent, decomposition ceases. Whether the destructive changes which these substances undergo be rapid or slow, substances are formed from them which react on the mineral constituents of the soil, and bring about decompositions and fresh combinations amongst them, with the result that mineral potential plant-foods are incessantly being changed into forms which plants can take in and assimilate.

These dead vegetable substances also bring into the soil nitrogen in inert combinations for the nitrifying bacteria, which are in it, to change into assimilable plant-food. Not the least valuable of the products of the decay within the soil of vegetable substances is humic acid. This, which is a relatively stable substance, plays a part of no little importance in the soil. It releases some of the most valuable of the plant-foods from insoluble combinations, and uniting with them, forms double humates. These substances are relatively insoluble, and are therefore not liable to be washed out of the soil; while the state of chemical union in which they exist is such that they do not offer very great resistance to decomposition. Plants are able to break up these double humates, and appropriate the plant-food elements they contain; and in doing so set free their humic acid, which, by releasing fresh plant-food elements from insoluble combinations and combining with them, forms double humates again, to be broken up anew, and have their plant-food elements again appropriated by plants. Humic acid in this way acts as a carrier to crop-plants of some of the most valuable plant-foods from potential forms, and on this account is a very important ingredient of soils; and, provided they do not contain enough of it to make them sour, contributes greatly to their fertility. There are, again, reasons of another character for dead vegetable matters forming an important constituent of soils. Their presence in it is of great importance to its physical condition. In the partially-decayed form of humus they increase its water-retaining qualities; they also modify its texture, and make it to be more easily put into a condition of good tilth.

Vegetable substances can be added conveniently and with ease to soils which are deficient in them. We can supply them as green manure, or ploughing in the parts of crop-plants which are not required for other uses. Weeds usually provide us with them in considerable quantity; and in this respect do us yeoman service. In our climate, stubbles are too valuable to be burnt off, and ought to be ploughed in; although the slowness with which they usually decay makes them to be much inferior to more succulent substances. The close dependence of the soil for its fertility on the dead vegetable matter it contains points to the probability that the increase of the chemical and bacterial activities, upon which depends the increase of its fertility that we are seeking, will be obtained more than in any other way by our directing attention to this one of its constituents; and an examination into the effects which follow from the manner of its disposition in the soil may lead to additional light being thrown on this subject.

(3.) It may be that we shall learn how, either by particular methods of treatment or by the addition of certain substances, to give direction to, as well as increase the chemical activity amongst, the constituents of the soil. If we could learn, for instance, how to make soluble some of the insoluble silica in the soil, we might promote the formation of zeolitic substances, which are valuable for reasons of the same character as are the double humates. As some of the ingredients of soils are important, rather for the part they play in promoting chemical changes than because of any value they possess as plant-foods, it is possible that an exhaustive study of them may show us how best to make use of them, and that some soils may have their fertility permanently increased by adding to their natural content of some of these substances, either by applying them as manures, or by giving the soil such treatment as leads to their production in it.

We have seen that in taking in hand this task, we have a comparatively unworked field before us; that the soil is of most complicated constitution, and that its composition is constantly changing, mainly in the amount of vegetable matter it contains; that the physical conditions (and particularly of temperature and moisture) to which it is exposed are also continually changing, and that in consequence chemical changes of a most complicated and obscure character are taking place in it incessantly, and that it is to these changes that the release in small quantities of assimilable plant-foods from unavailable (potential) forms, which is constantly going on in a fertile soil, is due; also, that not only are we to a large extent ignorant of the nature of these changes, but unable even to tell what the combinations are in which the constituent elements of a soil exist in it. We have also seen that we have good grounds for thinking that we may increase the activity of the forces to which the release of available plant-foods is due, by attending to the tilth of the soil and its content of vegetable matter, and not improbably by adding to it suitable substances, or by special treatment which favours their production in it. With these data before us, it remains to consider how we ought to set to work in order to secure our end.

As our knowledge of the changes in the soil which follow from any steps we may take in cultivating it, especially if in taking such steps we leave the well-trodden path of established practice, is so imperfect, it is plain that we are very far from being in a position to say what specific course of treatment will give us the results we are seeking. It is true, indeed, that our knowledge of the principles on which the results of practice are founded may furnish us with valuable guidance, and is likely to prevent us from proceeding on lines which can only lead to failure; but more than that we cannot expect from it. The only plan which remains is the old one of actual experimental trial—of trial and error: we must make the best use we can of our knowledge of principles for planning our experiments, and when they fail, for finding out the causes of our failures, which we must go on eliminating until we have succeeded. Instead of depending, in fact, as we seem to have been doing hitherto, for progress in the solution of our problem on such light as studies of the soil in the laboratory, made by a few independent specialists, may throw on matters connected with the subject, the time has now come, I think, for attacking the problem directly in the field, and making its solution the immediate object of systematic and continuous work, and of comparative experiments. Our laboratory investigations in connection with the soil ought, I think, no longer to be of an abstract character, and entirely detached from or only remotely connected with our problem, but be made in direct connection with it, and for the express purpose of throwing light on or helping us over difficulties as they are met with in our experimental efforts to solve it. By following this course, each discovery made in the laboratory, instead of remaining for an indefinite length of time of probably little practical value, will be likely to receive at once its most important practical application, and be the means of helping on a step forward the solution of this, the most important problem of agricultural practice. This method of solving our problem is, of course, likely to prove a long one and difficult; but it is the most practical and the most certain of success, if success be not absolutely unattainable. It is, in fact, the well-beaten path to progress. In this case, the gain which success would bring is important enough to cause the effort to be well worth making, however small the chance may be.

It may be, and it is quite likely, that success will not be due to any one striking discovery, but rather to the more exact knowledge which the making of systematic experiments will give us of the effects of different methods of cultivation. Even if the measure of success we meet with be only moderate, while such success will be valuable for itself, the experiments by means of which it is gained, from being comparative, will have great value independently, on account of the greater and broader knowledge of agricultural operations, and on account of the collection of experimental facts they will leave us possessed of. We are now in a far better position to take in hand this problem than we ever were before in the world's history. Not only is our knowledge of the nature of the processes upon which the fertility of the soil depends greater and more exact than it ever was before, but in the national experiment-farms which are now to be found in almost every civilized country, and in the staff of scientific workers who are attached to them, we are already equipped for the undertaking, which ought, I think, to engage the attention of every national experimental farm, and be made a standing investigation. We, in Australia, ought certainly to take it in hand; and it is to be hoped that the proper function of experiment-farms has now become recognised sufficiently generally for this to be done at once.

I shall now proceed to point out some directions in which experimental work is urgently needed for the farming of the dry interior of our country:—

(1.) *Subsoiling.*—The practice of subsoiling has long been recommended by agricultural writers, but for some reason it has failed to secure more than very occasional adoption. At present its use appears to be confined almost entirely to the preparation of land for vineyards and orchards. When we hear, as we occasionally do, of its being tried on the farm, the results are sometimes reported to have been good, but about as often disappointing, or even undesirable. As a matter of fact, we know no more about the practice now than we did thirty years ago, except, perhaps, that it is less often successful than we used to suppose. There can be no manner of doubt that on account of its loosening it to a greater depth, subsoiling increases greatly the capacity of the soil for storing the water of rainfalls. This alone is so important an advantage for our interior, that we cannot afford to neglect to make subsoiling the subject of special experimental study, and of systematic trials in different soils and subsoils. It may be that the adventages of the operation do not always appear at once, and that under some conditions it appears at first to do more harm than good, and that its good effects are not seen until later on; until, probably, some such change has taken place in the subsoil as its having come to contain a sufficient quantity of the dead roots of plants; or it may be that in some cases the process has to be repeated before its good effects are yielded, or that the subsoil ought only to be encroached upon gradually. The condition, again, of the subsoil cannot but be an important factor in determining the success or failure of the operation. It goes without saying, for instance, that a clayey subsoil ought not to be stirred when it is wet. One kind of subsoil is likely to require one kind of treatment, and another another. When so great an advantage as enabling the soil to take in more water is attached to the practice, we ought certainly to ascertain what the conditions are under which it is successful, as well as what can be done to make it successful under other conditions. For a study of this important subject to be at all satisfactory, it is necessary for the experiments to be comparative, and that they should be made in many different kinds of soils and subsoils.

(2.) *The disposition of dead vegetable matter in the soil.*—That this should be made the subject of experimental investigation has been suggested to me as well by the apparent importance of the subject, as by the fact that the different methods of ploughing which are practised in India and England dispose of the surface vegetation so differently; and that while our climate more nearly resembles that of India, in our practice we follow the English method. The Indian plough, which has stood the test of very long usage, and has probably been in use from time immemorial, is furnished with nothing of the nature of a mouldboard, and makes no attempt to cover the vegetation and crop-residues which are on the surface. It leaves them where it finds them, or at the most covers a very small proportion of them, and then only lightly. The result is that practically none of the crop-residues or weeds which are on the surface go to add to the humus content of the soil. They simply remain on the surface until they are burnt up (oxidised) by exposure to the sun and air, or are blown away. It is hardly surprising, therefore, that the agricultural soils of India have been found to be relatively very poor in humus. It may, however, be in favour of the Indian system, that it disturbs so little the dead roots which are left in the soil. The vegetable matter, which, when the land is in a state of nature is left on the surface, undoubtedly does much good while it lasts by acting as a mulch; while its exposure to the sun and air causes it to decay (be oxidised or burnt up) far more quickly, and far more quickly to yield substances which, carried down by water into the soil, help on the changes by means of which plant-foods are released from potential combinations, than would be the case if it were buried. Whether the Indian method of leaving the surface vegetable matters where they are, or the English system of humefying them by burying them and distributing them throughout the soil to the depth of about seven inches, is the better in the climate of our interior should, I think, be ascertained by a series of exhaustive comparative experiments. It may be found that a compromise between the English and Indian systems, by means of which the vegetable matter on the surface is only buried deeply enough to partially humefy it, and is afterwards kept near the surface, while the soil underneath is stirred to a much greater depth, will prove to be better than either; for if we succeed in making the upper three inches of the soil to be rich enough in humus and partially humified substances to be sufficiently open to prevent the surface from caking, or to act in some degree as a mulch, we shall make the rain-water we receive to go much further than it does at present. I hope, shortly, to be able to initiate some experiments for the purpose of determining these points. This investigation may prove to be closely connected with the problem of inducing the soil to give up to crops more of its natural potential fertility.

(3.) *Comparative trials of the common turn-over and rotary disc ploughs.*—Experiments are needed in connection with another matter. Within the last few years the rotary disc plough has come into use, and from the smallness of the cost of its ploughing the land, is likely to receive wide adoption. As in its method of cultivating the soil, and especially in its manner of disposing of the vegetable substances which are on the surface, it differs entirely from the turn-over plough, comparative experiments ought to be made for the purpose of ascertaining the effects which follow from the continued use of each of these ploughs, as well on the plant-food ingredients of the soil as on the crop-yields and their permanence. It is possible that instead of using either plough exclusively, the two used in conjunction may be found to give better results than either by itself; and if this be the case, we ought to find out in what manner they can be made to best supplement each other. I am inclined to expect good results from a system of covering the stubbles immediately after the harvest with a many-furrow stubble plough, followed after an interval of a few months by a rotary disc plough for stirring the soil deeply.

SOME ASPECTS OF TASMANIAN FORESTRY.

By H. J. Colbourn, Holder of the Special Forestry Certificate of the Institute of Surveyors, London, and Life Member by Examination of the Royal Agricultural Society of England.

In his report for the year 1898 upon the "Forests of Tasmania: Their Conservation and Future Management," the late Mr. G. R. Perrin made the following statement:—"The condition of Tasmanian forests is infinitely worse to-day than it was at the date of my report in 1886 and 1887. Another decade of waste, of private monopoly, of fierce bush-fires, of neglect by the Government to check the damage to public property, must ultimately result in disaster to the industries and thousands of people dependent upon the timber resources of the Colony." He further pointed out the fact that available timber is getting scarcer year by year in the contiguous Australasian States, which he estimated would become exhausted of their timber supplies within 20 years, unless recuperative measures are adopted; also, that large markets for timber were opening out in other parts of the world, in consequence of which opportunities would be afforded for ensuring a much more rapid depletion of the forests of Tasmania than has hitherto been the case. It is highly probable, therefore, that this, combined with the reckless waste heretofore rampant, will eventually seriously menace the development of the mining industry of the country (from lack of timber for woodwork-construction in connection with the mines), if steps are not taken for the more careful economisation of the existing forests, and the reproduction of the devastated ones upon land unfit from its nature or position for other purposes than timber-growing.

In the three years which have elapsed since Mr. Perrin's report was published, a steady revival of industrial commerce has taken place in most parts of the world, affecting British, and, consequently, Australasian interests. This revival appears to be influencing the timber trade considerably, and in all probability, especially when the South African war is terminated, the Tasmanian timber industry will assume proportions of greatly increased magnitude, more particularly, it is anticipated, in the production of railway sleepers, of which a considerable number have recently been exported to South Africa. Such a time is therefore a very appropriate one for calling attention to the subject of the forestry of the country, and to point out some of the leading factors which must be taken into consideration in formulating any scheme of forest conservation at all likely to meet with success.

To go minutely into the details of forest management would make my paper unnecessarily long, and serve no useful purpose upon the present occasion. I will therefore confine myself, as far as possible, to a few of the leading features of the subject, which may be considered, so to speak, from one point of view, since from their mutual interdependence they cannot well be dissociated.

I will speak in the first place of some of the chief principles, the understanding of which is necessary for the carrying out of any successful scheme of forest management. One of these, and that a cardinal one, is the preservation of the leafy canopy of the forest, and I would now say a few words explanatory of what this involves.

Forest trees make little demand, in comparison with farm crops, upon the resources of the soil, provided the leaves which periodically fall from them are allowed to decay upon the spot, thereby contributing to that accumulation of partially-decomposed vegetable matter which, as it gradually becomes mingled with the soil through the action of earthworms and other natural agencies, goes by the name of humus. This humus is a valuable reserve of plant-food, containing, as it does, all that enters into the composition of the tree or plant from which it has been derived. Unless present in excess, as sometimes happens in cold and humid localities, the amount of it to be found in the soil, at any time, may be taken as a fair criterion of its fertility. In agricultural language, a soil possessing an abundant supply of humus would be said to be in good heart or condition. Apart, however, from its power to contribute to plant-nutrition, humus exercises physical influences which are probably of even greater importance. I allude to the great capacity it possesses for absorbing and retaining moisture and improving the mechanical texture of soils. Access of sunshine and air to the soil, however, accelerate the decomposition of its humus, and so much so, indeed, that a soil denuded of its surface vegetation, and fully exposed to atmospheric action, very quickly gets into a sterile condition, or at least is liable to suffer severely from the effects of drought.

The maintenance, therefore, of the continuity of the leafy canopy of a forest is a matter of first-class importance, in order that the ground beneath may be duly shaded and protected from the injurious effects of too great an access of sunlight and air-currents.

There is yet another reason why an accumulation of humus in the surface-soil, and the close occupation of the latter by vegetation, are important considerations; and this is concerned with the greater power land so protected possesses of withstanding the denuding effects of heavy and continuous rain. Soil charged with humus within the limits of the latter's absorbent and retaining capacity holds back the water, which would otherwise rush down headlong to find its level, carrying everything portable with it. The roots of trees, and other forms of vegetative life, have a further tendency to retard the devastating effects of running water, and to regulate its outflow upon tracts of country lying at lower levels, and therefore liable to suffer from floods.

Land destitute of vegetation upon hill-slopes is always exposed to the danger of having its surface stripped off; and this once done, its capacity to sustain the higher forms of vegetation cannot be restored except at an expense that could not, in all probability, be incurred in a new country.

The soil and climate of Tasmania lend themselves, over a great deal of the country, to the production of trees of large size and excellent quality; but land equal to the production of heavy timber is usually capable of being used advantageously for agricultural purposes; and such land, not being of relatively extensive area in Tasmania, will no doubt eventually be cleared off and devoted to cultivation. A great extent of the country, however, owing to its steepness and rocky nature, or from the loose, sandy texture of its surface-soil, is quite incapable of being devoted profitably to agriculture, and could with advantage be permanently occupied by timber, which, if not attaining the large dimensions in demand at the present time, would probably pay well for conservation a few years hence.

By the prevention of fires, the restriction of cutting operations within proper limits, and the sowing of vacant patches of ground, the leafy canopy of land of this class will, as far as possible, be preserved, and consequently its fertility maintained, if not augmented. The great expense and risk involved in attempting to reafforest land once deprived of its original arboreal vegetation makes it very desirable that restrictions should be put upon the sale of Government lands which, when cleared, would prove unfit for agricultural purposes. Such land is liable to be taken up for its timber and afterwards abandoned when this is worked out. If, in the meantime, no steps are taken to effect the regeneration of the area devastated, it will in a few years become utterly unfit for the support of anything but useless scrub.

Upon all Government land appropriate to be set apart for permanent forest reserves, but which is being denuded of its timber for sawmill purposes, some steps should be taken to ensure reproduction; otherwise, as soon as any portion of the soil becomes unduly exposed to the action of the sun and wind, deterioration sets in, and the process of restoration is yearly rendered more difficult of accomplishment.

Natural seeding, and the springing up of suckers, will often do much in the way of regeneration; but too frequently useless shrubs and rank weeds spring up, which, although affording protection to the ground, nevertheless would be better replaced by prospective timber-trees.

Much good might be accomplished by the systematic seeding of the patches of land left clear upon the removal of timber to the mills, especially if the leaves and branches of the fallen logs could be promptly burnt out of the way in a manner to be considered further on in my observations upon forest fires. After disposing of the rubbish from the areas vacant of timber, the cleared patches of ground might be surface-chipped with an appropriate implement, and then sown down with the seed of trees suitable for the soil and situation.

Taking into consideration the great liability of all Tasmanian bush country to suffer from fires, patches or belts of European hardwood trees would doubtless prove valuable interspersed amongst the more inflammable kind, as a means for checking the progress of any fire which might be started. Conifers could be more easily sown, and would establish themselves in the circumstances I have mentioned; but they are even more liable to destruction by fire than the native trees. The larch, however, might be used, as being, from the nature of its foliage, less inflammable than other trees of the coniferous order. An experiment upon the lines indicated in some typical locality would cost little, and its success or otherwise could be speedily demonstrated, and practical evidence obtained as a guide to further operations on a larger scale.

The system of forest management alluded to in the foregoing is called the "method of selection," and is the one necessarily practised at the outset in countries which are being freshly opened up, and consists for the most part in exploiting the best timber, and leaving the process of renovation to natural agents.

Where, however, forest supervision is practised, as in India, efforts are made to fill in the vacant spaces of ground somewhat upon the lines I have indicated. The chief objection to the "selection method" is that it leads to irregularity of the leafy canopy, and consequently to exposure of large portions of the soil to injurious atmospheric influences. It is not to be compared in general utility with the so-called "compartment" system of management, by which a forest is worked out in sections, these being at the same time restocked by seeding or by the planting of young trees of uniform size. Such a system necessitates the adoption of the practice of periodically thinning out the young trees as they attain a certain size; and this operation, which requires more skill and judgment to carry out properly than any other in the whole range of forestry, can only safely be undertaken by trained men.

This question of thinning raises another point in connection with forest management, which requires to be considered.

We have seen that it is highly desirable that forest land should be amply stocked with timber, both with the view of maintaining soil fertility and restricting the denuding effects of rain.

It is further necessary that such a degree of proximity should exist between the trees that light is so far excluded from the lower parts of their stems that the growth of side branches is discouraged, and a clean bole or trunk produced, thus adding to the commercial value of the wood, which is then more likely to be free from knots, besides cutting-out to a greater length.

Under natural conditions, and where direct sowing has been practised, the forest if left alone tends to thin itself, because the young trees start growth under unequal conditions, and the taller and stronger plants overgrow those which are weaker. On the other hand, when trees of equal size are planted artificially, thinning becomes absolutely necessary, or they will eventually spoil one another through overcrowding.

By means of judicious thinning carried out at the right time, the growth of the trees composing a forest is greatly assisted, and their full development accelerated by many years; a conclusion we might well arrive at when considering that trees crowded together too closely retard each other's growth, and when allowed too much space develop branches instead of trunk.

I have spoken of the necessity for skilled labour in connection with forest-thinning, and to make this sort of work pay its way, it would be desirable that some market should exist for the disposal of material cut out in this way.

Some sale might be found for well-grown stakes and poles, but much of the produce which in Europe and many other parts of the world would find a ready sale as firewood, would in Tasmania have to be burnt on the ground out of the way.

I have recently been considering the feasibility of charcoal-burning being taken up in Tasmania on a large scale in connection with the mining industry. Charcoal has been used for ages for the purpose of reducing metallic ores, and in view of the augmented price of coal, and the scarcity of the latter in this country, it occurred to me that charcoal might be advantageously prepared from the vast quantities of wood at present left to rot upon the ground.

I lately addressed inquiries upon this subject to several prominent mining managers, and to Branch Boards of Agriculture. The replies received are in a certain degree contradictory: some speaking in favour of charcoal, others not.

In view of the great importance that would attach to any practicable scheme for utilising, in a large way, the waste wood of the forests of this country, and possibly supplying the smelting works with a suitable fuel at moderate cost, I think that the question of charcoal-burning deserves further inquiry and investigation. To make an industry of this sort pay, however, it would have to be undertaken by men who fully understand the process of manufacture, such as the Italians, who, I understand, are employed to burn charcoal extensively in Australia.

Companies of men working systematically, and equipped with the means for readily cutting up and preparing wood, and afterwards converting it into charcoal, might go from one locality to another, and rapidly rid the country of the dead gum-trees, which at present encumber the ground, and make the landscape hideous. Also, they might use up the rough, scrubby, and mis-shapen trees of the bush which would never, if allowed to remain, grow into really good timber.

It is hardly necessary to emphasise the fact that men skilled in any branch of work can turn out their particular product at a far cheaper rate than could those only qualified to deal with it in a rough and ready way, such as the ordinary settler.

Forest Fires.

I now come to the consideration of the best means for the prevention or suppression of forest fires, and I do this more with the view of inviting discussion on this most important subject, rather than because I have any observations that are particularly novel or fresh to offer upon it.

In a "Report on the Forests of Canada," the Honourable H. G. Joy says:—

"We can cope with waste and pillage in our forests, they are but the work of man, but we are terribly helpless against fire. It is in every country the greatest enemy of the forests, especially the pine forest, on account of its resinous and inflammable nature. It is ubiquitous; you find it exercising its ravages wherever nature has planted its grand virgin forests; in North America, destroying the beautiful white pine; and at the antipodes, in New Zealand, sweeping away the noble kawrie pine; through India, the Russian Empire, Sweden, and Norway, it throws around the globe a girdle of lurid flames, only broken by the great oceans."

The foregoing paragraph points in eloquent terms to the terrible agent which is fast sweeping away the great forests of the earth, leaving to a by no means remote posterity the task of solving the problem of how a healthy or satisfactory existence can be maintained by the animal organism in a world deprived in such a large degree of the chief means, hitherto provided by nature for maintaining the normal purity of the atmosphere. This consideration, taken together with possible injurious climatic changes, and the great inconvenience and misery that must arise should a real scarcity of wood, for the purposes of combustion, or building, supervene, ought to cause an increased attention to be paid by those interested in the welfare of the community to the important subject of the prevention of forest fires.

As it is, I believe, generally conceded that forest fires are, in the first place brought about by carelessness or design on the part of settlers and others, legal enactments made so effective as to be deterrent should produce much good. The difficulty, of course, is to obtain convictions on account of the reluctance of people to lay information against offenders, and also often from the difficulty experienced in finding out who the latter really are. Hough's "Report on Forestry" for the United States contains many apparently useful suggestions, and I now venture to put forward some of these—

(1.) The appointment of men to act temporarily during the dangerous months as fire-police or inspectors.

(2.) The appointment of a special fire-commissioner in each township with power to act under authority of the law; such person to be provided with maps of the district, and to be empowered to call out such assistance at any time as may be necessary for the putting out of any fire which may have been started.

(3.) The taxation of a district in which a serious fire has occurred at a fixed sum per acre; the money realised to go towards the keeping up in the locality of the means for fire-prevention. This plan would make every one owning land in the district interested in suppressing fires.

(4.) The entire exclusion from settlement of all timber land not well adapted for agricultural purposes.

Alluding to the careless conduct of settlers with reference to fires Mr. Hough says:—

"There appears to be no mode of overcoming these vicious habits, but a proper public opinion, and it is suggested as a matter for serious consideration that some instruction be given in our normal schools, and from those going out from these as teachers in the public schools of the country, with reference to the great importance of the careful use of fire, and the great responsibility that may result from carelessness or accident therein.

"This mode of inculcating ideas of the duty of the citizen to society is well understood and often practised in Europe, and in this we may do well to follow their example. It is only a few years since the Minister of Public Instruction in France issued a series of circulars tending to suppress the practice of wantonly destroying the birds, because great injuries were resulting to agriculture from the multiplication of noxious insects that had followed from this destruction to excess. We have in mind at least one instance in which the responsibility with regard to fires has thus been made a subject of instruction in the schools, and with excellent results."

The following regulations with regard to camp and other fires prevail in Ontario, Canada:—

"Every person who shall between the first day of April and the first day of November (northern hemisphere) make or start within such fire-district, a fire in the forest, or at a distance of less than half a mile therefrom, or upon any island, for cooking, obtaining warmth, or for any industrial purpose, shall—

"(1.) Select a locality in the neighbourhood in which there is the smallest quantity of vegetable matter, deadwood, branches, &c.

"(2.) Clear the place in which he is about to light the fire by removing all vegetable matter, dead trees, branches, brushwood, and dry leaves from the soil within a radius of ten feet from the fire.

"(3.) Exercise and observe every reasonable precaution to prevent such fire from spreading, and carefully extinguish the same before quitting the place."

If some regulations of this kind were in force, it would not be a difficult matter for an officer acting as inspector to visit camps and ascertain if they were being carried out properly.

The planting of lines or belts of hardwood deciduous trees, makes an excellent barrier to the progress of fire from forests composed of more inflammable trees.

The formation of cleared fire-paths 20-feet wide is practised in India, but these are found hardly wide enough to act as effectual barriers in windy weather, though in ordinary circumstances they act as useful checks.

The planting of a grass called Panicum spectabile is also carried out in India. It is said to grow to a height of 3 or 4 feet, and to flourish in the hottest and driest situations, remaining always green and succulent, so that no fires will pass over it.

Stone walls, barriers of earth, ditches, and ploughed belts, are all capable of doing a great deal to prevent the spread of fires.

With reference to the methods employed by settlers in burning up the wood upon their clearing, Mr. Hough says:—

"A frequent cause of disastrous fires in the woods is the mode of clearing land now generally followed by settlers. Of course, they must have recourse to fires in order to clear woodlands, but fire ought to be our servant, kept under continued control, not our master.

"Woodland can be cleared with comparatively little danger from fire, and be made ready to sow earlier than by the mode now generally in use (as I know from practical experience), if the settlers will only burn the shrubs, branches, leaves, and tops at once, as they cut them down. Light a good bright fire to start with, after having made a safe place for it, and then begin cutting away, and as you cut, throw upon the fire at once; children will help immensely with the light-stuff, and willingly too. The fire once well started, everything will burn up, the green wood and the sap running out, and the green leaves too, not only those of fir trees, but of every hardwood tree. As you throw in the branches the whole of the green leaves upon them catch fire simultaneously, with a sudden flash, and burn up with a crackling sound as if they had been steeped in grease.

"I have often done it, frequently in wet weather. We get rid immediately of all the light inflammable material, from which the greatest danger of bush fires is to be apprehended; the larger branches and trunks of trees, if you must burn them (which you ought not), present little danger of fire in dealing with them. When you get inconveniently distant from your first fire, you light a second one, and let your first one burn out. It is remarkable that those fires generally burn down to the ground more thoroughly than the carefully constructed piles that have been drying up for a whole year."

State Nursery.

The establishment of a State forest nursery has been suggested; and this, if started, would prove a valuable means for disseminating useful exotic trees all over the country, as well as for the growth of evergreens for shelter planting and other purposes.

The encouragement of tree-planting for shelter is highly important in districts which have been denuded of their native woodlands. Stock are kept warmer during inclement weather, and crops are less liable to suffer from wind and frost, when suitably protected by trees.

Also, the embellishment of homesteads with ornamental trees, apart from the pleasure conferred, must really, in many cases, be looked upon as a remunerative investment, for properties beautified in this way are always, other things being equal, more saleable.

Numerous kinds of trees likely to be of great economic value in the future might be raised, and plantations afterwards formed of them in appropriate situations; or they might be distributed over the country amongst those who would be disposed to utilise them.

There is apparently no reason why the silkworm industry should not be developed and fostered by this means in many localities. The white mulberry, upon the leaves of which the silkworm feeds, is easily grown, and thrives in dry, hilly situations, where little else can be produced. There is plenty and to spare of such land in Tasmania; and if it could be devoted to sericoculture, the profit that might arise from it would, in comparison, probably be infinitely greater than at present. Moreover, it is not a thing that would necessitate waiting long years before an ample return could be realised, as is the case in most kinds of tree-planting, because the mulberry would quickly grow to the dimensions requisite for furnishing a crop of leaves. Many families at present in poor circumstances might doubtless add to their incomes by the production of raw silk, the operations connected with which involve no great amount of technical knowledge. In a country like Tasmania, where conditions mostly favour the small culture system, any branch of industry which may be made to work in with the latter ought to be encouraged; but there is no doubt, also, that silk-raising would pay on the larger scale if tried.

With reference to new varities of fruit-trees, these cannot at present be legally imported by private individuals; but there appears to be no reason why they should not be brought into the country by the Government, if a State nursery existed, where they could be planted under such conditions that the introduction or propagation of further insect or fungus pests by their means could be absolutely prevented.

The cork oak is a tree which would probably turn out to be of great economic value in future years if extensively planted, since cork is stated to be getting more and more scarce, and no really efficient substitute for it has been yet found. The vigorous condition of the young cork-trees to be seen at the present time growing in the Hobart Botanical Gardens shows that the cork oak is adapted for the soil and climate of the warmer parts of Tasmania. But cork of good quality could not be obtained for about 33 years, so that the planting of this tree on any extensive scale cannot be expected on the part of private individuals. At the same time, the first stripping of cork-bark takes place in about 15 years, and the result of this, and the one made some 8 or 10 years later, are of some use for economic purposes, such as tanning or possibly fruit-packing. The adaptability of the cork-tree to grow in dry, hilly situations should make it an object of attention in Tasmania, where so much of that class of land abounds of little use for the purposes of cultivation, and yielding scanty pasturage, if any.

The planting of nut-producing trees in this country deserves more attention than it has yet received. The tendency of trees of European origin when grown in Tasmania seems to be to bear an exuberance of seed. This may be due to some climatic influence acting upon the general organisation of the plant and increasing its fecundity; but in the case of the nut-trees of which I propose to speak, another factor may be at work, namely, the high winds which prevail so much in this country; for, as the trees in question are anenomphilous or wind-fertilised, naturally the distribution of their pollen must be affected by high winds, especially those of a dry character; and it is in this connection worthy of notice that we are liable to drying north-west gales in the spring of the year when these trees are in flower.

The nut-trees to which I more particularly refer are the walnut, Spanish chestnut, filbert, and hazel. The two first-named would be many years coming into bearing, but their highly ornamehtal appearance and the valuable nature of their timber should be inducements for planting them in favourable situations. The filbert and hazel come into bearing in a comparatively short period, viz., from six to eight years, and when fully matured, in ten or twelve years, may be expected to produce 20 cwts. or more of nuts per acre.

It is unnecessary to extend the list of trees and shrubs which might be successfully raised and distributed throughout the country. Seeds might be obtained from all parts of the temperate world, and the adaptability of the trees raised from them to flourish in this country be put to the proof in a very few years.

CAUSES OF VARIATION IN THE PERCENTAGES OF WATER IN BUTTER.

By G. Sutherland Thomson, N.D.D., &c., Government Dairy Instructor, South Australia.

The subject of water in butter and the fixing of a standard is now before a Commission in Great Britain. With a precautionary measure about to be enforced, it is very gratifying to find that the Australian product has won the reputation of being free from excess of water, and reports show that the percentages are below those of leading export countries. The differences in the degree of moisture in butter placed on the London market from Denmark, Canada, America, and Ireland are very pronounced. The latter country would appear to favour the manufacture of a moist product, as much as 25 per cent. of water having been found in samples analysed. In Denmark the average exceeds 13 per cent., and in Canada and America the percentages are equally high, while in Australia 12 per cent. is a good estimate of the proportion of water left in the factory-made article. But Australia may predict a drier consistency in her butter when pasteurisation becomes universally adopted throughout the States, and when the dangers in churning and working are more closely studied and avoided by the able class of butter-makers which Australia is proud to possess. In the extensive and fine dairying-country of New Zealand, we are told that the dry texture of the butter is a marked feature in its value, and it will be accepted by practical and scientific men alike that the keeping properties of the product are extended by virtue of this great quality. How reasonable it appears to us in these days of scientific dairying, that the more effectual are our methods of prevention against the invasion of destructive germ-life, the more enhancing will the quality of our butter be; and the extended keeping-properties and commanding price will make a combination worthy of our efforts. It is therefore to the interests of the dairying industry of Australia to supply the British consumer with a dry, choice flavoured butter, and that the water used in its manufacture should be previously purified by filtration.

Before proceeding with the principal subject of my paper, permit me to give a short criticism on the merits of the steel-trier.

Is the Butter-trier Reliable in Giving a Practical Guide to the Extent of Moisture in Butter?

For some time I have regarded the use of the steel trier as unreliable in providing a practical estimation of the extent of moisture in butter, and, after comparing its worth with accurate analytical tests, my suspicion has been justified. In support of my contention we have evidence in the results of important tests published in the Australian States, in which one finds an instance of excessive moisture being confronted with an average percentage of water in a sample of butter examined. In such a case as this the trier had certainly been deceptive, as was proved by the analyses. Further proof was observed in a report issued by a foreign journal, giving the percentages of water in butter from different countries, and it remarked that a sample of dry consistency proved to contain over 13 per cent. of moisture. The same may be said of the Danish butter; and, to show conclusively the weakness of the trier, the following table of practical tests and analyses of South Australian butter is given:—

No. of Sample.	Percentage of Water Found.	Indications of Moisture on Trier.	Consistency or Texture.
1..........	9·0	Very dry	Greasy, overworked.
2..........	12·5	Very moist	
3..........	10·9	Very moist	
4..........	14·1	Very dry	
5..........	10·1	Moist	Greasy, overworked.
6..........	11·0	Moist	
7..........	11·8	Dry	
8..........	11·5	Very moist	
9..........	11·5	Moist	
10..........	11·4	Dry	
11..........	11·5	Dry	Greasy, overworked.
12..........	10·5	Very moist	
13..........	11·2	Dry	
14..........	11·3	Dry	
15..........	10·1	Dry	Greasy, overworked.
16..........	10·2	Dry	Greasy, overworked.
17..........	12·2	Very moist	
18..........	13·2	Dry	
19..........	11·4	Very moist	
20..........	12·3	Fairly dry	
21..........	13·3	Moist	
22..........	10·4	Dry	Greasy, overworked.
23..........	10·0	Moist	

No. 4 shows a high percentage of water, with a very dry appearance to the trier; but this was a sample of unsalted butter. The above peculiarity will be considered further in this paper.

Experiments to Determine the Causes of Variation in the Percentages of Moisture.

For this purpose 21 boxes of butter were prepared, and throughout the process of manufacture, from the separation of the milk until the finished article was packed, great care and attention were devoted to obtain correct results.

In taking the samples of butter for analysis, all necessary precautions were adopted, and the percentages of water in each case represent an average of three determinations conducted by the writer.

Test 1.

In the first test six boxes were manufactured, the main object being to ascertain the effects of temperature and salting on the degree of moisture.

The following table gives the course of preparation of the butter:—

	Box No. 1.	Box No. 2.	Box No. 3.	Box No. 4.	Box No. 5.	Box No. 6.
Temperature—						
Temperature of cream when churned	54° F.	58° F.	56° F.	56° F.	56° F.	56° F.
Acidity of cream	5·8	5·8	5·9	5·9	5·9	5·9
Minutes in churning	24	20	22	23	23	23
First washing, 5 galls.	Water	Water	Water	Water	Water	Water
Second washing	Brine	Brine	Water	Water	Brine	Brine
Salting—						
Pounds of salt to 5 galls. water	1	1	—	—	3	5½
Pounds of salt to 100 lbs. butter	2½	2½	5	2½	*Nil*	*Nil*
First working, minutes	1¾	1¾	1¾	1¾	1¾	1¾
Second working, mins.	1¾	1¾	1¾	1¾	1¾	1¾
Time between working, hours	17	17	17	17	17	17
Weight of cream	40	40	40	40	40	40

Water Analyses:

The following are the percentages of water found in the six boxes:—

No. 1, 11·1 per cent. } Difference due to temperature
No. 2, 12·5 per cent. } of cream churned.
No. 3, 10·5 per cent. }
No. 4, 12·7 per cent. } Difference due to salting.
No. 5, 13·4 per cent. }
No. 6, 14·6 per cent. }

In working the samples the speed of the roller was 45 revolutions per minute, and the salt, where used, was added immediately after starting to work the butter the first time. The temperature of the unsalted water for washing the butter-grains was at the same degree for each churning.

For convenience in offering an explanation of the above, I have divided the table with two headings, viz., "Temperature" and "Salting." Let us consider the first.

Temperature.—In each box of butter, excepting Nos. 1 and 2, the temperature of churning was the same, 56° deg. F. Observe the difference in water-percentage of sample No. 2, which was churned at 4 degrees higher temperature than No. 1; other conditions being exactly the same from first to last in the production of the butter. It is to be expected when cream is churned at a high temperature that the oily consistency of the butter will afford a good resting-place for the particles of water, and so well divided will the moisture be that the influence of working will increase the incorporation of the water to a finer state of division and distribution, thus making it impossible for the worker to accomplish its requirements. The equipment of our factories in the way of refrigeration will minimise the losses that would be otherwise sustained, but I am convinced that cream which has been overheated will produce a sample of butter delicate in texture even when refrigeration is adopted in cooling the cream before churning, and chilling the water for washing the butter-grains.

Salting.—It is an authenticated belief that the extent of salt added to butter influences the amount of water left in the product. But there is a good deal to be determined as to the extent of the variations caused by the quantity of the salt used. For example, when a comparison is made in this direction, it will be ascertained that a sweet salted butter will possess more moisture than a medium salted article, but less than unsalted butter, while the heavily salted product will yield the greatest of all.

In turning to the analysis of No. 3 box in test 1, it will be seen that the proportion of water was less than No. 4. This can be attributed to the double quantity of salt taking up the moisture better; but had more than 5 lbs. been added, a higher percentage than 12·7, would have been retained in the butter. In expectation of this variation, a quantity of cream was churned and the butter divided into three lots. One was salted at the rate of 5 per cent.; the other, 7 per cent.; and the third, 10 per cent. Each received one working throughout the process of manufacture, and upon analysis 5 lbs. salt left 15·4 per cent., 7 lbs. 17·9 per cent., and 10 lbs. 18·8 per cent., of water in the butter.

In consideration of the differences between unsalted and salted, 6 boxes of butter were produced from separate quantities of cream. To one box from each lot of cream 3½ per cent. of salt was added, while the other three boxes were worked without the addition of any salt. Every care and attention was given to the churning of the cream, and handling of the butter on the worker.

The following is the result—

	Unsalted Butter. Percentage of Water.	Salted Butter. Percentage of Water.
No. 1	13·2	11·8
2	14·2	11·4
3	14·1	12·3

The above figures show that the unsalted butter contained a marked increase in moisture; and such a difference is not discernible by the application of the trier, but the very opposite indications are given. In making a practical examination of these 6 boxes, I found that the unsalted butter in each case showed a dry appearance on the trier, while the other boxes were more or less moist.

In the table of water analysis and trier tests appear an illustration of the above where one sample of butter (No. 4) proved to contain 14·1 per cent. of water, while it gave no token of moisture, but, on the other hand, was very dry. It thus appears that butter, in the absence of salt, cannot yield its moisture to the good influences of the worker; but in the presence of an average percentage of salt, the water gathers in drops throughout the body of the butter, and escapes from the worker in company with a percentage of the dissolved preservative. By reason of the salt gathering the water together, and the possibilities of it becoming locked up in badly distributed proportions, the excessive moisture exhibited by the trier in "dry" butter may be accounted for. Again, when excess of salt, and particularly some brands, is added, the water of crystallisation must assume a considerable proportion, and before working is concluded the separation of the moisture will have become a matter of impossibility.

We will return to the table of analysis of test 1, and ascertain what influence the brine has exerted on the extent of moisture.

It will be noticeable that an increase of $2\frac{1}{2}$ lbs. of salt in the brine of No. 6 box, has given 1·2 per cent. more water, and the $5\frac{1}{2}$ lbs. of dissolved salt has yielded an increase of 3·5 per cent. of water over No. 1, in which $2\frac{1}{2}$ lbs. of dry salt was added, and 1lb. dissolved in the water. No. 5 box with 3 per cent. of salt to the 5 gallons of water, gives 2.3 per cent. more water than No. 1, and 2·9 in excess of No. 3; which was salted at the rate of 5 per cent.

In this particular experiment, where 5 per cent. of dry salt was the maximum quantity used, and $5\frac{1}{2}$ lbs. the maximum added to the brine, there is convincing evidence given in the result to prove that brine possesses a greater influence in increasing the water-percentage of butter.

Test 2.

The butter-worker.—The treatment of butter on the worker is so important a matter that a saving of money can be made by careful and skilful management. In manipulating the appliance successfully, the operator studies the solidity and texture of the butter as soon as the granules are formed in the churn. But this should not be sufficient to satisfy the factory-manager. He must take into consideration the temperature of the room, the probable moisture that the butter contains—and both judgment and skill are required to leave a sufficient percentage of water in the manufactured product without causing damage to the fats and keeping properties of the butter.

In the first pages of this article dealing with the percentages of water in export butter, the reader will observe, in five samples, that a low degree of moisture is accompanied by a greasiness of texture. In most cases this defect was found in consignments of milled butter, and it is reasonable to attribute the dryness of the product to the addition of a little extra salt, together with more working; and this is further strengthened by the knowledge that milled butter is often the product of dry, over-ripened cream.

In carrying out test 2, all conditions in the manufacture of the butter were exactly the same, the only difference being in the working as enumerated below .

	Box 7.	Box 8.	Box 9.	Box 10.
First working in minutes	$2\frac{1}{2}$	$2\frac{1}{2}$	Worked once for the same time as the two workings of box 7, and at the same speed of roller.	Worked once for the same time as the two workings of box 8, and at the same speed of roller.
Second working, in minutes	$1\frac{1}{2}$	$1\frac{1}{2}$		
Revolutions of roller, in minutes	45	19		
Hours between working	17	17		

Percentages of Water:

No. 7, 12·0; No. 8, 11·5; No. 9, 13·5; No. 10, 11·3.

The above percentages of water go to show that the decreased speed of roller favoured a freer escape of moisture. Sample 7, with a roller speed of 45 revolutions per minute, and two workings, of two and a half and one and a half minutes respectively, gives 12 per cent. water; and sample 9, with one working of the same time (four minutes), and of the same speed, leaves 13·5 per cent. of water in the butter; while the slow working of boxes 8 and 10 for an equal number of minutes to 7 and 9 produce a much drier article. All along I have been opposed to fast working, and I would suggest to factory managers and their assistants the necessity for closer attention to this important factor in butter-making. No. 9 illustrates in a striking manner that water becomes locked up in the body of butter when it is exposed too long to the influence of a quick moving roller.

Test 3.—Butter Grains and Drainage in Churn.

Test 3 was undertaken to ascertain what effect the sizes of butter grains in the churn would have on the dryness of the butter, and the influence of draining in the churn, and also salting.

Altogether, eight lots of butter were made. The first four were treated as follows:—

	Box 11.	Box 12.	Box 13.	Box 14.
Size of Grains	rice	peas	rice	peas

Boxes 11 and 12—Brine in churn, $1\frac{1}{4}$ lbs. salt to 5 galls. water; dry salt, $3\frac{1}{2}$ per cent.

Boxes 13 and 14—No brine; washed twice; dry salt, 3½ per cent.

Equal quantities of water were used for washing the butter. The butter was given thirteen minutes to drain in the four lots, and the time of working was two minutes for the first and two minutes for the second, while the speed of the roller was kept at the same throughout. Fourteen hours between working was allowed.

The temperature of the cream was 50° F.; acidity, 5·8. Temperature of washing water was similar, and the time of churning varied very little. The same percentage of fat (0·1) was found in the buttermilk from each churning.

Percentages of Water:

Box 11, 12·2; box 12, 12·2; box 13, 12·5; box 14, 12·3.

According to the above analyses there is practically no difference obtained by churning into grains of small and large size, and the slight difference in salting has been insufficient to cause a rise or fall in moisture.

Drainage in Churn.—In the second four boxes the chief features in manufacture were as follows:—

	Box 15.	Box 16.	Box 17.	Box 18
Size of grains............	pin heads	pin heads	peas	peas
Time of draining, in minutes	20	20	4	4

All other conditions were exactly the same.

Percentages of Water:

No. 15, 11 8; No. 16, 11·4; No. 17, 14·5; No. 18, 15·4.

Nos. 15 and 16 favour a distinctly drier butter than 17 and 18, and this undoubtedly arises from the longer period given to the drainage of the water from the butter grains. Where four minutes has been allowed the percentages of water have risen much above the average.

Before concluding, allow we to refer to an important factor in the solidity and dryness of butter. I allude to the feeding of milking-stock. In exhaustive trials which I conducted on the feeding of cows with different rations, it was determined by analyses of the butter produced, that the quality of the rations fed to the cows, and the season of the year, exerted an influence on the solidity of the fats and water-carrying properties of the butter.

The following gives the analysis conducted by Mr. G. A. Goyder, F.C.S., School of Mines, Adelaide, of ten samples of butter made from the test-cows in March last year, when the animals were solely dependent on dry rations and withered herbage.

	Water. Per cent.	Fat. Per cent.
No. 1	10·54	86·12
No. 2	10·37	85·69
No. 3	6·68	90·59
No. 4	7·07	90·49
No. 5	7·13	89·27
No. 6	7·58	89·68
No. 7	7·26	89·11
No. 8	8·36	87·68
No. 9	9·40	88·07
No. 10	9·05	88·07

What Influences the Water Percentages in Butter.

1. Feed and season of year.
2. Temperature of cream.
3. Drainage of butter grains in churn.
4. Ripeness and age of cream.
5. Temperature of washing water.
6. Temperature of churning-room.
7. Strength of brine used.
8. Quantity of dry salt added to butter.
9. Speed of roller and time in working.
10. Kind of roller used and worker.
11. Quality of salt.

CULTIVATION OF THE APPLE.

By Sydney Shoobridge, "Clydesdale," Glenorchy, Tasmania.

In preparing a paper on the above for this meeting, the writer cannot well be expected to touch upon every detail which will be met with in the course of an orchardist's career, and he is also conscious of its many imperfections; yet, after several years' experience, it is hoped that a general outline is given of what one must be prepared to undertake if a decision to embark in apple culture is decided upon. The writer trusts that the discussion to follow will also bear upon points for which space could not be allotted in this paper.

The first consideration in fruit-growing is

The Selection of the Soil and Situation.

In Tasmania almost any soil is suitable for this purpose, from the lightest soil to the heaviest clay. Where possible, an eastern aspect is preferable to any other, for many reasons. First, because of the morning sun; and, second, because it is generally sheltered from the strong north and north-westerly winds. In all cases where the soil is not naturally drained, it should be done artificially, either with tiles, or brush, or stone, to a depth of not less than 3 feet. This is most important, as the trees will not thrive where the water lays for more than a few hours. I should like to lay special stress upon this matter, as it is not given nearly enough consideration by intending planters. Varieties of fruit, such as the French Crab, Sturmer, and Stone Pippin, require more moisture than most kinds, and this should be taken into consideration when selecting soil and situation. Again, the Cleopatra, King Pippin, Cox's Orange Pippin, and others of the earlier varieties, can manage with a lighter rainfall, as well as soil, to come to perfection.

Selection of Varieties.

These, to the ordinary grower, should be, I think, limited to about eight different kinds, viz.—Dessert: Ribston Pippin, Cleopatra, Cox's Orange Pippin, Aromatic Pearmain, Scarlet, Nonpareil, and King of the Pippins. For Culinary purposes: French Crab, Sturmer Pippin. There are several hundred other varieties, many of which do well in Tasmania. At the same time, from a practical and also commercial standpoint, the varieties abovementioned give the best results in Tasmania, owing to our comparatively low rainfall and strong westerly winds in the summer and autumn months. In selecting varieties careful consideration should be given that the stocks are of the best blight-proof sorts, such as the Northern Spy or Winter Majetin. In some districts, however, the blight-proof stocks do not do as well as the ordinary ones, partly, I think, owing to the artificial richness of the soil the stock is raised in as compared with the soil of its permanent location. Again, it should always be borne in mind that trees grafted on blight-proof stocks do not come into bearing as soon as ordinary ones, yet, at the same time, they last longer, and are more satisfactory to the grower. In selecting new and early kinds in other parts of the globe, many people in Tasmania are much disappointed with the results. The chief reason for this is, I think, they overlook the fact that climate is a far-reaching factor in successful fruit culture.

Preparation of Land and Planting.

The land should be ploughed in the late summer, and again in the autumn, scarified, and, if rough, a disc harrow should be used to break the clods, so as to bring the land into thoroughly good order. Too much attention cannot be given to this, as the benefit derived from good cultivation cannot be overestimated in the later growth of the trees. Before planting in poor land, it is as well to put some compost round the roots, as it gives the trees a better chance of free growth from the beginning which is very desirable. The roots of the young trees should be cut with a sharp knife all round, as it throws vigour into them. From six to eight inches is quite deep enough, and the roots should be carefully spread out after any tap roots which may be present have been removed, as they only strengthen one particular part of the tree, which is most undesirable, the chief aim being to feed the tree in every direction. Planting should be done not later than June or July, and the soil placed lightly round the roots, and then pressed firmly about the collar of the tree, by this means enabling it to benefit by the later winter rains, and make a good start in the following spring, as the roots begin to throw out fibres long before the stem shows any sign of growth. The trees should be placed about eighteen feet apart, and this leaves ample room for cultivation. It is good practice to plant the different varieties together, thus saving labour in picking.

Pruning.

The first year the tree should be pruned with the buds outwards, to form the tree as soon as possible, which should be accomplished in the first five years. The ideal tree in Tasmania should be formed on the lines of an inverted umbrella, and should the same, from whatever cause, be weakly, it is advisable to remove most of the spurs and fruit buds, the main object being to produce at the outset a vigorous tree, and not fruit, which will come later on. The reason for training the tree after the fashion of an inverted umbrella is to secure the maximum amount of sunshine and atmospheric circulation, thus producing large and well-coloured apples. Root pruning is not sufficiently practised in Tasmania. This can be done in winter with a sharp spade, and care should be taken not to bruise the roots in any way which would render them liable to become a nidus for blight or other disease. The object in this branch of an orchardist's work is to sever the main roots, thus producing lateral ones and small feeders. Severe pruning and bud pruning have, as yet, been little practised in this State, but in different parts of America the results have been most successful. The method is to disbud in the winter, pruning all lower buds to about two feet from the ground in dwarf trees, and thin all fruits buds to one or, at the most, two, with the result of a much finer class of fruit from less blossom and a marked resistance to late frosts. Bud pruning must not be done promiscuously, as certain varieties do not require it, notably the Cleopatra, the tendency being to drive them to wood; but in the case of the Scarlet Nonpariel, King of the Pippins, French Crab, and Sturmer Pippin, which are most prolific bearers, and inclined to bear small-sized fruit, you can, by this method, produce apples of large size and good colour.

Cultivation and Irrigation.

Most of the ploughing and digging should be done in the autumn. The ground should be throughly moved to a depth of one foot, so that the sun and air can thoroughly pulverise the soil. Land with a large percentage of clay cannot be dug too roughly, as long as it is thoroughly moved, the winter frosts being powerful disintegrators. Light soil should be thoroughly broken down, otherwise it will remain in hard clods. Throughout the summer the land should be kept thoroughly stirred and all weeds destroyed, this being best accomplished with a light

American scarifier and disc harrow; but on no account should this operation take place when the soil is wet.

Irrigation should begin in December, and great care taken not to let the water lie. The great secret in irrigating is to keep the fruit growing, as then it will fill out and thoroughly mature. If the fruit is allowed to stop growing, and then watered, it will not keep, hence the impression that watered fruit will not keep. In parts of America winter irrigation is practised. It has been tried in Tasmania, but the results are doubtful.

Manuring.

In manuring for a given object, it is necessary to know the composition of the matured product for a guide as to what should be applied. The following represents the mineral composition of the apple:—

Potash	35 · 66 per cent.
Soda...	26 · 09 per cent.
Magnesia	8 · 75 per cent.
Lime...	4 · 08 per cent.
Iron	1 · 40 per cent.
Phosphoric Acid	13 · 69 per cent.
Sulphuric Acid	6 · 09 per cent.
Silicic Acid...	4 · 32 per cent.

An analysis of the soil will reveal the presence of all or any of the above being in abundance or deficient, but too much cannot be taken for granted if the former condition prevails, as it is more a question of availability rather than actual quantity. Lime is one of the best materials that can be used, although not strictly a manure in its action. It sets free the chemical constituents of the soil, and promotes a crumbly structure, making the land easy to work. It should be lightly worked into the soil in the autumn. Farmyard manure, when obtainable, will aid in the maintenance of the humus in the soil, as well as add to fertility. The ploughing-in of leguminous crops is another method of keeping up the supply of humus, as well as nitrogen. The application or such fertilisers as phosphates and nitrates will, in great measure, depend for success upon the discrimination of the grower in regard to the condition of the soil and the trees. Potash is, of all manures, one of the most important for fruit growing. Its high percentage in the composition of the apple, as well as its tendency to render the foliage immune from insect depredations, have made this mineral very popular amongst fruitgrowers. The presence of lime in the soil for the best results when using potash for fruit trees is being better appreciated in this State.

Diseases of the Apple and Treatment.

Apple growing, or, for the matter of that, any fruit culture, is not simply a matter of planting the trees and cultivating the land. Were this the case under our existing favourable conditions, there would not be much profit in the business. Destructive agents, both insect and fungoid, claim a large annual share of the orchardist's product. At the same time, it must be recognised that if every apple which set matured, prices would be considerably reduced in seasons of heavy yields. The ideal orchard is one which produces annually a good average crop of the finest marketable apples. Fruit pests not only destroy a large quantity of fruit, but they largely reduce the value of what is marketed by an indirect influence on the vitality of the tree. The only course open to a grower is to endeavour to control the pests by artificial means, and thin out the fruit when heavy yields occur. Whilst in this State we are still free from some of the worst pests to be met with, yet the following will be found of quite sufficient magnitude and destructive power to absorb the orchardist's attention when present.

The Codlin Moth (*Carpocapsa Pomonella*).

In favourable seasons the above is a very troublesome pest, and yet the adoption of the several methods prompted by a knowledge of its life history and recent experiments will materially curtail its destructiveness. Banding the trunks of the trees in the spring and picking the infected fruit—a provision of the Legislature in this State—is an effective course of procedure, if concerted action could be secured; but experience shows that too much cannot be relied on in this respect, owing to the apathy of small fruitgrowers. It, therefore, devolves upon the progressive orchardist to adopt the more advanced method of using arsenical sprays. Many will be found in works on horticulture, as also the method of application; but some little tenacity of purpose on the part of the user must be cultivated to overcome the vagaries of climate, as rain, following on spraying, if in any quantity, necessitates a repetition of the operation.

Black Spot (*Fusicladium dendriticum*)

Is, perhaps, the most formidable enemy to apple growers in those parts of the State where the climatic conditions favour its development. The writer, however, is glad to learn of the success attending the use of the Bordeaux mixture in the repression of this fungus. Several scale pests, notably the mussel scale (*Mytilaspis pomorum*), have to be reckoned with, but where remedial measures have been attempted satisfactory results have been secured. I regret that want of space forbids even a passing reference to several other minor pests.

Gathering and Storage.

Fruit should not be gathered until it is full grown, well coloured, and the pips turning black. This is as it should be picked, not as is often the case in Tasmania, when it is picked before properly mature, owing to the early shipment of apples to London. These early shipments, causing growers to fill alloted space with immature fruit, are the chief reason for the complaints that the fruit in the commencement of the season at home is shrivelled, not coloured, &c. We cannot, therefore, hope to compete satisfactorily in the two first boats with our neighours in South Australia and Victoria, owing to their fruit maturing at least a fortnight earlier than that grown in Tasmania. At the same time, taking the London season all through, our returns compare quite as well as those received by shippers from the mainland. To cite one instance. I know a certain grower in Tasmania whose shipments of never less than 2000 cases in any one year have averaged nine shillings, f.o.b., Hobart, for the last four years. It would be well at this juncture to emphasise the fact that too much care cannot be given to the grading and packing of all fruit, whether for shipment to England or inter-State markets.

Apples for storage should not be picked until the pips are quite black. The fruit has then an oily feeling, and should be placed in a store with an even temperature and thorough ventilation, and should not be touched until required for shipment.

Marketing the Fruit..

In the present state of .the trade this is the most important, as well as the most difficult, matter in connection with fruit growing. Taking the English market first, one agent should be selected to receive the fruit, which should be sound, well-coloured, and graded. Each grower now by law must, have a registered brand, and should ship none but first-class fruit under it, as in a few years the brand will sell the fruit. This applies with equal force to all markets. It is advisable to either sell all your fruit in Tasmania or ship all; if part is shipped and part sold neither seller nor buyer is satisfied. I have tried both plans and say unhesitatingly it is bad policy to adopt half measures. Trial shipments by growers to fresh markets in a small way is becoming desirable, owing to the ever-increasing production and competition from all parts of the world.

Care should always be taken to have a clean, white case, without any stains, as the more attractive the package the better price the fruit realises. In shipping to England the best paper should be used, as cheap paper allows the moisture from one decaying apple to spread to another, causing further damage. When procurable, wood-wool should be used on the top and bottom of the apples, as it acts as a pad, and keeps the fruit from undue pressure; if not procurable, paper shavings are a fair substitute.

EXPERIMENTS IN RUST AND STINKING SMUT IN WHEAT DURING 1901.

By D. McAlpine, Pathologist, Victoria.

[*Abstract.*]

Rust in Wheat Experiments.

Since 1890, there have been continuous experiments in Victoria on the above subject. The main object had been to devise measures whereby the ravages due to rust may be materially diminished, and this object has been to a certain extent secured by means of selection and crossing of wheats. Port Fairy, a district favourable for the development of wheat had been selected for the experiments. An account of the experiments followed. The course adopted in testing varieties for their rust resistance was to sow the seed at first in small quantities, say, from 20 to 50 grains, in what were called single seed plots. Seeds of each variety were sown by hand in rows, 18 inches apart, and 6 inches between each seed in the row. Then, if considered worthy of further trial, they were again sown in medium sized plots, after careful selection, and finally grown on a large scale in big or field plots. When a variety was found to promise well, and possessed the necessary rust resistance, it was selected for further trial. The best ears of the plant were saved, and the tips and butts were removed. The large, well-nourished grains towards the middle were selected for next year's sowing. Variety tests were carried out in different districts, to determine their suitability and how far resistance to rust in one locality held for a different set of conditions in another locality. The process of careful seed collection had been going on for a number of years, and the result was a number of improved varieties, which were gradually being introduced into general cultivation. The work of cross-breeding had been undertaken in New South Wales. "Queen's Jubilee" was one of those crosses. As it was the premier wheat of the season, as far as yield was concerned (42 bushels per acre), he had given it an appropriate name. It was the following cross (Leaks and Hornblende), and Ward's White and Tourmaline. It was comparatively early, heading on September 28, and ripe on November 7. It was evident that the two great factors in combating the wheat rust in Australia were selection and crossing. In growing a number of varieties in certain areas liable to rust, there were usually some which were comparatively free, although none were absolutely rust-proof; and by selecting the cleanest plants year after year, ultimately a rust-resistant variety might be secured for that district. But that quality and rust resistance might be, and often is, associated with other qualities which rendered wheat undesirable. Cross-breeding would then step in, and new kinds might be made, which would combine the desirable qualities with the indispensable rust-resistance. A process of vigorous selection would be required to fix the characters of those improved wheats, and the varieties thus obtained could be tested in different districts, for they might prove rust resisting and prolific in one locality, and fail in one or both of those characters in another.

Results of Treatment for Bunt, or Stinking Smut.

Experiments were directed during the past season to the three principal substances which were known to destroy the bunt spores, and their relative effects on the germination of the grain were noted. These were: Sulphate of copper, corrosive sublimate, and formalin. The results of the treatment were:—

	Grains sown.	Grains germinated.	Per cent. of germination.	Per cent. of Bunty Plan
Bluestone, 1 lb. to 5 gallons	1000	459	46	0
Corrosive sublimate, 1 in 1000	1000	712	71	0
Check Plot	1000	960	96	95
Formalin, 1 in 500, dipped for 10 minutes	1000	621	62	0
Formalin, 1 in 1000, dipped for 10 minutes	1000	692	69	0

SCALES FOR COUNTING CARDS IN BULK.

By J. J. Fenton.

CARD-PUNCHING MACHINE FOR STATISTICAL PURPOSES.

By J. J. Fenton.

COST: REAL AND APPARENT.

By A. J. Ogilvy.

THE EAST END AND THE SOCIAL SETTLEMENT.

By W. Jethro Brown.

SECTION H.

ENGINEERING AND ARCHITECTURE.

PRESIDENTIAL ADDRESS.

By PERCY OAKDEN, A.R.I.B.A., President of the Royal Victorian Institute of Architects.

THE RELATION OF ARCHITECTURE TO ENGINEERING.

MANY writers have essayed definitions of architecture and engineering, and some have attempted to draw very definite distinctions between the two professions. One author—Fergusson—goes so far as to publish parallel illustrations of a building in different stages of ornateness, professing to discriminate where engineering ends and architecture begins. But neither architects nor engineers, I think, would care to subscribe to his limitations.

Without wearying you with quotations, I would here like to read an extract from Gwilt which, I think, gives the key to the discovery of the purpose and origin of both professions.—" Protection from the inclemency of the seasons was the mother of architecture. Of little account at its birth, it rose into light and life with the civilisation of mankind; and, proportionately as security, peace, and good order were established, it became not less than its sisters, painting and sculpture, one method of transmitting to posterity the degree of importance to which a nation had attained, and the moral value of that nation amongst the kingdoms of the earth." This idea has been more tersely put by another great writer.—" All architecture is but a *glorified roof*," and I would here expand that idea by saying that practically both architecture and engineering take their use from the desire of mankind to dwell, or to assemble for various purposes, under a roof—a glorified roof. If there is a distinction between us, it would be that the emphasis with you, my brethren of the engineering professions, would be on the word " roof "; with us architects, on the word " glorified."

Taking, then, this as our starting point, that the gregarious instincts of our race demand opportunities for dwelling and assembling for various purposes under one roof, in one building, or group of buildings, let us consider for a moment some of the requirements of a modern city, or modern great building (which is a city in miniature), and see how the lives, health, comfort, and even the morality of a community are in our hands.

We may group these requirements under the following heads:—

1. *Capacity.*—The adequacy of the accommodation for the purposes to be served.
2. *Cost.*—Economy of materials and labour—
   A.—In construction;
   B.—In management and maintenance.
3. *Access.*—
   A.—From without: by road, rail, tram, water, &c.;
   B.—From within: by stairs, elevators, &c.
4. *Communication.*—
   A.—From without: postal, telegraph, telephone, despatch tube, speaking tube, bell, semaphore, &c.;
   B.—From within: ditto.
5. *Health.*—Sanitation in all its branches; lighting, heating, ventilation, water-supply, drainage, &c.
6.—*Comfort.*—Suitability of purpose, and provision in detail for fulfilling all the demands which will be made upon it with a minimum of strain or inconvenience.
7. *Safety.*—
   A.—Safety in construction: stability;
   B.—Safety in working: provisions against fire, panic, &c., and for efficiency of management.
8. *Beauty.*—Both externally and internally—
   A.—Of form;
   B.—Of color;
   C.—Of material, as far as is consistent with cost.

1. *Capacity.*—The quite recent developments of science and the extension of the uses of iron and steel have enabled the demands upon capacity to be met on a greater scale than formerly. Spaces may be, and are, now roofed over in one span which could not have been so treated in any former age. The gregarious instincts of mankind can therefore be indulged in to a greater extent than ever before, and provision has to be made for the assembling

and dispensing of greater numbers, putting exceptional demands upon all the requirements of the building.

2. *Cost.*—It should be scarcely necessary for me to say that, consistently with the proper attainment of its objects, our aim is necessarily to attain those objects with the greatest economy, but I take the opportunity of making this statement here publicly on behalf of both professions, because we are often so misunderstood and suspected of an unworthy ambition to glorify ourselves and save ourselves time and thought at the expense of our clients. It is often forgotten that we have to look for true economy under the two heads of "first cost" and subsequent "wear and tear and cost of working," and that what may seem a saving in first cost may be absolutely a loss when the reduction in durability and the increased cost of maintenance and working are considered.

3. *Access.*—It would swell this paper beyond all proper limit were I to more than glance at the requirements which may be included under even the first subdivision of this heading, "access from without," but I will just refer to them in order to justify my contention that all engineering, as well as all architecture, centres round the idea of the "glorified roof." The road, the rail, the tramway, the waterway, the various agencies for propulsion and traction—wind, water, steam, electricity—all are feeding agencies which become necessary to the existence of the modern city or great building.

And so with access from within, *re* from one part of the edifice to another. The lofty building of the present day would be an impossibility but for the use of the modern elevator, both for passengers and goods. I do not know what papers are going to be contributed to our section this Session, but it would be interesting to have one on the comparative merits of the various forms of elevators now competing for public favour, more especially a dispassionate comparison between the hydraulic and the electric types.

I have referred here to lofty buildings. In passing, let me say here, that the instinct of imitation is sometimes liable to make us overlook the different conditions which prevail in different communities. The restricted area of a certain business portion of New York, confined by rivers on either side, has rendered the 10 to 25-storey building a necessity there; but it by no means follows that where lateral extension is possible any such growth skywards is advisable. If equal pains and money be expended in providing means of horizontal transmission as are absorbed by the nautical elevators, a city, or section of a city, may be just as concentrated and compact with less lofty buildings, even though it covers three times the acreage, and it must certainly be healthier and safer for its inhabitants.

4. *Communication.*—Both from without and within. I have already briefly enumerated the long list of scientific inventions which have been enrolled for practical use in improving our means of inter-communication, and will not recapitulate. I would, however, like to say that the greatest demand put now upon science under this head is for a satisfactory treatment of the accoustic difficulty. How to ensure perfect accoustics in every part of a new hall is a problem not yet properly solved.

5. *Health.*—It scarcely needs stating that a large building accommodating its hundreds of inmates should possess an arterial system as perfect as (but probably more complex, because subject to more varying demands than) that even of the body. Its supplies of air, water, food, warmth, and its means for the discharge of the nitrated and waste products, are as essential to the well-being of its inmates; and any failure of these is likely to be as fatal to those inmates as are failures of the corresponding organs to fulfil their parts in the human frame divine.

We have much to accomplish in these directions yet, S. and G., before sanitary science can be considered to have attained perfection, and I am looking with great interest to the proceedings of Section H. in this Session. But it seems to me that these two sections overlap each other, and that the practical carrying out of the hygienic conditions which may be determined in Section H. as necessary to enable us to dwell, assemble, and worship under the glorified roof can only be effected under one section—I.

6. *Comfort.*—This is almost a necessary sequence of the former subdivision, and I will not dwell upon it, except just to say that the first object of all design should be "suitability of purpose." Much design which is beautiful in itself has failed to fulfil the required condition of comfort because of some fancied necessity to adhere to the details of some particular school or style. Let me also point out that under this heading you will see again how wide is the application of the "glorified roof" conception. To perfect the appointments under this roof demands are made practically upon every useful art and science, as well as on the fine arts.

7. *Safety.*—I have not arranged this list of requirements in any order of relative importance, otherwise I should

necessarily have taken "safety" much earlier. We have to consider—

A.—Safety in construction—Stability; and
B.—Safety in management.

Under A. (Stability) we come to what constitutes a considerable divergence in practice between the architect and the engineer. The latter can generally calculate the actual stresses which will be put upon each part of his work with tolerable certainty, and disposes his material accordingly. The former has to make very much greater allowance for the various, and often careless, ways in which his structure may be used, or misused, and for the needs which may arise for making alterations in its subdivision from time to time. With the architect, too, a certain excess of weight and mass is often necessary, both for stability and appearance.

B. (Safety in Management.)—Here, again, the contrast in our two branches of practice comes out. No one dreams of letting a skilled piece of engineering or mechanism take care of itself (probably the law would not allow him to do so); but in too many instances the architect has to reckon upon the building, once finished, being thenceforth neglected and left to take care of itself.

I might add here, as a third division, "safety from violence," but I will refer to that later under "military engineering."

8. *Beauty.*—My placing this requirement last does not mean that I consider it a less absolute necessity than the rest. The desire for beauty in form, color, and material is one which requires satisfying as much as any other human want. Moreover, beauty in the works of man's hand may be accompanied by expression, and may serve a much higher purpose than merely to please the eye. Who can fail to realise this when contemplating some of the great religious edifices of Christendom, or the tombs of the mighty dead, long past? As regards architecture, the need for more or less attention to beauty of design is pretty well conceded, but I wish in this address to extend that demand more universally.

It has been well said that an ugly building is offensive, mainly from its absolute inherent expression of the selfishness of its owner and designer in refusing to give to the world some adequate *quid pro quo* for the beauties of nature—the charm of horizon and sky—which it intercepts, and of which, consequently, it deprives the community.

Rightly designed, every building should enhance the beauty of the locality in which it is placed; not detract from it.

Yet, while this principle is almost universally admitted concerning buildings generally, it is too often ignored with regard to other works of a strictly utilitarian character; hence, we see in the same street great efforts made to improve the architectural effect of the street side by side with telegraph posts and other features in which an utter absence of all attempt at beauty is displayed.

I wish to lay down here the doctrine that there is a moral obligation upon the owner and designer of any structure, or architectural or engineering work, not to mar the beautiful face of nature, which is God's gift to all mankind.

Even though it involves the sacrifice of a little profit, or the incurring of a little extra expenditure, and consequent abstinence from indulgence in some other direction, is there any reason why the factory, the foundry, the railroad, the bridge, the canal, &c., should not be made objects which harmonise with and enhance the beauty of a scene, instead of so frequently doing the reverse?

The steam-mill has pretty well banished the old wind-mill, and all but susperseded the water-mill—and rightly so, because of its greater efficiency and continuity of working—and the railroad, with its sterner and straighter lines, has necessarily taken precedence of the old winding coach road; but there is no reason why all these should not fulfil the condition above laid down.

The extension of this doctrine also opens up the question of the consumption of smoke. That the smoke from our chimneys and engines represents a sad waste from an economic point of view has long been recognised, but perhaps sufficient emphasis has not hitherto been laid upon the moral obligation which rests upon us to seek some method by which we may avoid the blackening and defacement of our heritage which is continually going on.

The wonderful strides of science within the last century have so vastly increased our powers of construction, and

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NOTE.—When I wrote this address we had not listened to the admirable inaugural address of the President of our Association, else would I have inserted as a prelude to this part of my subject his remarks on the function of beauty in the works of nature. Let me quote them here :—"We all recognise what science has done for civilisation; but how did the scientific study of nature begin?—and why is it carried on? It is the wonderful and the beautiful in nature which are, and always will be, the moving forces of pure science. Without the beauty and wonderful complexity of natural objects, man would never have risen above the level of an intelligent beast."

(may I say it?) of devastation, that this obligation upon the obliterator of the beauties of nature assumes larger proportions than it did in the past. Take mining, for instance: it may be conceded that the first effect of a rush of diggers to a new field was to pretty well devastate it; but of the multitude of workers, some generally came to stay, and the district, stripped of its original face, soon assumed a new, and often picturesque, dress from its varied occupants; but now, with giant nozzle and hydraulic elevator, a few men can direct operations which will devastate in a few days a larger strip of ground than hundreds would formerly treat in as many weeks. Is there not to be an obligation on us to make some amends to the earth that has thus been made to yield the treasure at the expense of her fair face?—or is all this to be left to nature and time?

My paper will not be complete without some reference to the following:—

1. *Marine Architecture.*—The modern vessel is but a floating hotel or floating city, and its architecture and engineering are subject to very much the same laws as those we have just reviewed—with this difference, that the elements of safety and efficiency, both in design and construction and in management, assume predominant proportions. Fortunately, these seem to go hand-in-hand with beauty of form, for it is difficult to conceive of a vessel appropriately designed for her purpose which does not necessarily become more or less a thing of beauty.

But the accessories of maritime architecture! The wharf! The crane! The shed! Is there any reason why the first view of a city when landing on the wharves should so often be an uninviting one?

Let me not be misunderstood. I am not pleading for effeminacy. There are different kinds of beauty in nature—from the lilies of the field and of the valley to the rugged gorge and frowning cliff—and the beauty of the fountain square must be another thing from that of the foundry, the poppet-head, or the landing-wharf; but some beauty each should have, and that one distinctly its own.

2. *Military Engineering.*—Even this revolves round the central idea of the "glorified roof." All our works of art and science which we have produced with so much thought and toil would be liable to be destroyed or taken from us but for the defence and protection of our naval and military forces. Let us not forget the debt we owe them. Then, too, both architecture and engineering owe much to the developments of military works for offence and defence. Many of our most beautiful architectural forms had their

origin in the military architecture of the Middle Ages—now, of course, obsolete for military purposes, owing to the changes which have taken place in the weapons of warfare, but still intrinsically beautiful—and many of the highest inventions and adaptations of engineering science have been achieved in the effort to meet military requirements.

3. *Aërial Architecture.*—I may seem to anticipate, but in these days scientific curiosities so soon become entrained for practical use that, with wireless telegraphy and the aërial machine "in the air," so to speak, it surely is justifiable to say that in the near future we shall have entirely new problems in design and construction to face.

What the air-ship of the future is to be—and what forms her arrival and departure stations, or the receiving stations for wireless telegraphy, are to take, are as yet unsolved problems; but more than ever will such structures need to be governed by the laws I have laid down, since more than ever, probably, will they intrude themselves upon the public view, and intercept the view of earth, and sky, and sea.

I cannot conclude my paper without making some reference to the projected Federal Capital of Australia. The various points to be considered in the planning and erecting of an ideal city were so thoroughly discussed at the Congress of Architects, Engineers, and Surveyors, held in Melbourne in May last, that I will not take up your time by the recapitulation; suffice it to say, that the opportunity will be a unique one for avoiding the errors and difficulties which nearly all existing cities that have been laid out, or have grown up, before some of our late inventions of science and art were applicable, have to contend.

A Memorial was addressed by that Congress to the Prime Minister of the Commonwealth asking that, before the site is finally chosen, the advice of a committee of experts—architects, engineers, surveyors, and medical men—should be taken. As yet no very favourable response to this request has been received. Let us hope that considerations of party politics will not be allowed to outweigh this most important proposal.

Perhaps this section, with the weight of the whole Science Association behind it, may see fit to take the matter up, and urge the adoption of the suggestion made by the May Congress.

ARCHES.

By B. A. Smith, M.C.E.

At the last meeting of the Association the writer contributed a Paper on Circular Arches; a slight modification of the method followed in that paper enables us to obtain the formal solution for the general case, in which the intrados is any given curve. The method is applied in the present paper to obtain the solution for an Elliptic Arch under a uniform partial load with an additional concentrated load at the end of the partial load.

The assumptions usually made in engineering text-books as to the position of the "line of pressure" are discarded, and instead we merely express the conditions that the ends of the arch are fixed in position and direction, and that at the point below the end of the partial load the arch remains unbroken, *i.e.*, the displacements of two points beside one another (one in each segment) at the end of the partial load are the same, and the tangents to the two segments at this point remain in the same straight line. The pressure at each point is assumed to be normal to the arch ring and the notation is the same as in the former paper.

Considering the equilibrium of a small element PQ of the arch ring we have

$$\frac{dT}{d\psi} + L = 0 \qquad (1)$$

$$\frac{dL}{d\psi} - T - \frac{w}{\kappa} = 0 \qquad (2)$$

$$\frac{dM}{d\psi} - \frac{L}{\kappa} = 0 \qquad (3)$$

where T, L, M are the tension shear and bending moment at P

w is the normal pressure at P due to the load,

κ is the curvature at P,

and ψ is the inclination of the tangent at P to the horizon.

We have since the bending moment is proportional to the change of curvature

$$\frac{M}{EI} = -\kappa^2\left(\frac{\delta^2 u}{\delta\psi^2} + u\right) - \kappa\frac{\delta\kappa}{\delta\psi}.\left(\frac{\delta u}{\delta\psi} - v\right) \quad (4)$$

$$T = E \times 2t \times f = 2Et \times \kappa\left(u + \frac{\delta v}{\delta\psi}\right) \quad (5)$$

where $2t$ is the thickness of the arch ring at P (not necessarily uniform) and f is the elongation of the element at P.

$I = \frac{2}{3}t^3$
E = Young's *modulus* for the material
u = normal displacement, outwards, at P
v = tangential displacement towards the right at P.

From (4) and (5) calling $z = \frac{\delta^2 v}{\delta\psi} + v$ we have

$$\frac{M}{EI\kappa} = \frac{\delta}{\delta\psi}(\kappa z) - \frac{1}{2E}\left\{\frac{\delta}{\delta\psi}.\kappa\frac{\delta}{\delta\psi}\left(\frac{T}{\kappa t}\right) - \frac{T}{t}\right\} \quad (7)$$

From (1) & (2) eliminating L we have

$$\frac{\delta^2 T}{\delta\psi^2} + T = -\frac{\omega}{\kappa} \quad (8)$$

A Particular Integral of this is (Forsyth, Diffl. Equations, pp. 86–7)

$$To = f(\psi) = \cos\psi\int\frac{d\psi}{\cos^2\psi}\int\left(-\frac{w}{\kappa}\right)\cos\psi\,.\,d\psi \quad (9)$$

So that the complete solution is (A and B being arbitrary constants)

$$T = A\cos\psi + B\sin\psi + f(\psi) \quad (10)$$

From (1) & (10) $L = A\sin\psi - B\cos\psi - f'(\psi)$ (11)

From (3) & (11) $M = \int\frac{L}{\kappa}d\psi$

$$= A\int\sin\psi\, ds - B\int\cos\psi\, ds - \int f'(\psi)\, ds + C$$

or, $M = -Ay - Bx + C - \int f'(\psi)\, ds$ (12)

From (7) & (12)

$$\kappa z = \int \frac{M}{EI} . ds + \frac{1}{2E} \left\{ \kappa \frac{\delta}{\delta\psi} \left(\frac{T}{\kappa t} \right) + \int \frac{T d\psi}{t} \right\} + D \quad (13)$$

$$= F(\psi) \quad \text{a known function of } \psi.$$

D being the arbitrary constant of integration

$$\text{or } \kappa \left(\frac{\delta^2 v}{\delta\psi^2} + v \right) = F(\psi) \quad (14)$$

of which the complete solution is

$$v = R \cos\psi + S \sin\psi + \cos\psi \int \frac{d\psi}{\cos^2\psi} . \int \frac{F(\psi)}{\kappa} . d\psi \quad (15)$$

u is then known from (5) & (10)

u, v, are thus known throughout ; the 6 arbitrary constants are determined by the end conditions at each abutment.

$$u = v = \frac{\delta u}{\delta\psi} = 0 \quad (16)$$

which furnish six equations for the arbitrary constants.

This is the formal solution of the problem.

To apply this to the elliptic arch of uniform thickness, observe that we have

$$w = g\rho(h-y) \quad (17)$$

where ρ is the height from the major axis to the roadway (or to an imaginary line representing the partial load treated as of the same density as the filling above the arch) ρ is the density of the material,

and $\kappa = \frac{b}{a^2} \Delta^{-3}$ where $\Delta = \sqrt{1 - e^2 \text{si}^2 \phi}$ and ϕ is the eccentric angle of P measured from the minor axis

Hence $$f(\psi) = \frac{g\rho b}{\Delta}\left(\tfrac{1}{2}\, b\, \phi \sin\phi - b\right) \tag{18}$$

a, b are the semi-axes of the ellipse which forms the centre line of the arch ring

$$f'(\psi) =$$

$$-\frac{g\rho a}{\Delta}\left[\tfrac{1}{2}\, b\, \phi \cos\phi + \tfrac{1}{2}\, b \sin\phi\, \Delta^2 - he^2 \sin\phi \cos\phi\right] \tag{19}$$

$$\int f'(\psi)\, ds = \frac{1}{g\rho a^2}$$

$$\left[\tfrac{1}{2} b\phi \sin\phi + \tfrac{1}{3} be^2 \cos\phi + \tfrac{1}{6} be^2 \sin^2\phi \cos\phi + \tfrac{1}{2} he^2 \cos^2\phi\right] \tag{20}$$

where $e^2 = \dfrac{a^2 - b^2}{a^2}$ and observe that $ds = a\,\Delta . d\phi$

$$\int \frac{M}{EI} .\ ds = \frac{a}{EI} . \int M . \Delta . d\phi \tag{21}$$

$$= \frac{a}{EI}\left[\begin{array}{l} -\tfrac{1}{2} Ab\left\{\Delta \sin\phi + \dfrac{1}{e} \sin^{-1}(e \sin\phi)\right\} \\ +\tfrac{1}{2} Ba\left\{\Delta \cos\phi + \dfrac{1-e^2}{e} \log(\Delta + e\cos\phi)\right\} \\ + C \times E(\phi) \\ - g\rho a^2 \left[\begin{array}{l} \tfrac{1}{2} b . G(\phi) + \tfrac{1}{6} be^2 (\Delta \sin\phi + \\ \dfrac{1}{e} \sin^{-1} \overline{e \sin\phi}) + \dfrac{b}{48}\left\{\dfrac{1}{e} \sin^{-1}(e \sin\phi)\right. \\ \left. - \sin\phi(1 - 2e^2 \sin^2\phi)\Delta\right\} + \tfrac{1}{6} he^2 \\ \left\{\Delta \sin\phi \cos\phi + \left(1 - \dfrac{1}{e^2}\right) F(\phi)\right. \\ \left. + \left(1 + \dfrac{1}{e^2}\right) E(\phi)\right\} \end{array}\right] \end{array}\right]$$

where $F(\phi)$ $E(\phi)$ are Legendre's Elliptic Integrals of the

First and Second kind, and $G(\phi) = \int \phi \sin\phi \,.\, \Delta \,.\, d\phi$

$$\kappa \frac{\delta}{\delta\psi}\left(\frac{T}{\kappa}\right) = \frac{\delta T}{\delta\psi} - \frac{T}{\kappa} \cdot \frac{\delta\kappa}{\delta\psi} = \frac{\delta T}{\delta\psi} - T \times \frac{3ae^2}{b} . \sin\phi\cos\phi$$

$$= -A\sin\psi + B\cos\psi - T \times \frac{3ae^2}{b} . \sin\phi\cos\phi \qquad (22)$$

$$\int T\delta\psi = A\sin\psi - B\cos\psi + \frac{b}{a}\int \frac{g\rho b}{\Delta}\left(\tfrac{1}{2}b\phi\sin\phi - h\right)\frac{d\phi}{\Delta^2}$$

$$= A\sin\psi - B\cos\psi + \frac{g\rho b^2}{2e}\left\{-\frac{\phi\cos\phi}{\Delta} + \frac{1}{e}\sin^{-1}(e\sin)\phi\right\} (23)$$

substituting in (14) we have

$$\kappa\left(\frac{\delta^2 v}{\delta\psi^2} + v\right) =$$

$$\frac{a}{EI}\left[\begin{array}{l} -\tfrac{1}{2}Ab\left\{\Delta\sin\phi + \frac{1}{e}\sin^{-1}(e\sin\phi\right\} \\ +\tfrac{1}{2}Ba\left\{\Delta\cos\phi + \frac{1-e^2}{e^2}\log(\Delta + e\cos\phi)\right\} \\ + C\times E(\phi) \\ -g\rho a^2\left[\begin{array}{l} \tfrac{1}{2}bG(\phi) + \\ \tfrac{1}{6}be^2\left\{\Delta\sin\phi + \frac{1}{e}\sin^{-1}(e\sin\phi)\right\} + \\ \frac{b}{48}\left\{\frac{1}{e}\sin^{-1}(e\sin\phi)\right. \\ \qquad\qquad \left. -\Delta\sin\phi(1 - 2e^2\sin^2\phi)\right\} \\ +\tfrac{1}{6}he^2\left\{\Delta\sin\phi\cos\phi\right. \\ \qquad \left. + \left(1 - \frac{1}{e^2}\right)F(\phi) + \left(1 + \frac{1}{e^2}\right)E(\phi)\right\} \end{array}\right] \end{array}\right]$$

$$+\frac{1}{2Et}\left[\begin{array}{l}\frac{g\rho b^2}{2e}\left(\frac{-\phi\cos\phi}{\Delta}+\frac{1}{e}\sin^{-1}(e\sin\phi)\right)\\ \qquad\qquad +g\rho ah\left(\frac{e^2\sin\phi\cos\phi}{\Delta}-E(\phi)\right)\\ -\frac{3ae^2}{b}\sin\phi\cos\phi\left\{\frac{A\cos\phi}{\Delta}+B.\frac{b}{a}.\frac{\sin\phi}{\Delta}\right.\\ \qquad\qquad \left.+\frac{g\rho b}{\Delta}\left(\tfrac{1}{2}b\phi\sin\phi-h\right)\right\}\end{array}\right]$$

$$+D \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad (24)$$

The complete solution of (24) is

$$v = R\cos\psi + S\sin\psi + I \qquad (25)$$

where R, S are arbitrary constants and I is a particular integral of (24) the elements of which, corresponding to each term on the right of (24) are given in the table below—these are obtained by successive applications of the method used for obtaining the particular integral of (8) observing that we have identically

$$\cos\psi\int\frac{d\psi}{\cos^2\psi}\int\frac{\Psi}{\kappa}\cos\psi\,d\psi = \frac{b\cos\phi}{\Delta}\int\frac{d\phi}{\cos^2\phi}\int\Psi\cos\phi\,.\,d\phi \quad (26)$$

Term.	Corresponding element of Particular Integral.
$\Delta\sin\phi$	$\frac{b}{3}\left[\left\{\frac{1}{\Delta e^2}-\left(\frac{1}{e^2}-1\right)\right\}\sin\phi+\left\{\left(1-\frac{1}{e^2}\right)F-\left(2-\frac{1}{e^2}\right)E\right\}\frac{\cos\phi}{\Delta}\right]$
$\sin^{-1}(e\sin\phi)$	$\frac{b}{\Delta e}\left[e\sin^{-1}(e\sin\phi)+\left\{(1-e^2)F-E\right\}\cos\phi+(\Delta-1)\sin\phi\right]$
$\Lambda\cos\phi$	$\frac{b}{3\Delta}\left[\left\{\left(1-\frac{1}{e^2}\right)F+\left(1+\frac{1}{e^2}\right)E\right\}\sin\phi+\frac{\Delta-1}{e2}.\cos\phi\right]$
$\log(\Delta+e\cos\phi)$	$\frac{b}{\Delta e}\left[e\log(\Delta+e\cos\phi)+(1-\Delta)\cos\phi+(F-E)\sin\phi\right]$

$E(\phi)$	$\frac{b}{2\Delta e}\Big[2Ee - \cos\phi\sin^{-1}(e\sin\phi) + (1-e^2)\sin\phi\log(\Delta+e\cos\phi)\Big]$
$(G\phi)$	$\frac{b}{\Delta}\Big[\sin\phi\,.\,H(\phi) - \cos\phi\, K(\phi)\Big]$
$\Delta\sin^3\phi$	$-\frac{b}{15\Delta e^4}\Big[\Big\{2(1-e^2)(1+2e^2)F + (8e^4-3e^2-2)E\Big\}\cos\phi - \Delta e^4\sin\phi\cos^2\phi + \sin\phi\Big\{(1-e^2)(2+3e^2)\Delta - 2\Big\}\Big]$
$\Delta\sin\phi\cos\phi$	$\frac{b}{8\Delta e^2}\Big[\frac{(1-e^2)^2}{e}\sin\phi\log(\Delta+e\cos\phi) - \frac{1}{e}\cos\phi\sin^{-1}(e\sin\phi) - \Delta e^2\sin\phi\cos\phi + \frac{1}{2}e\sin\phi\Big]$
$F(\phi)$	$\frac{b}{\Delta}\Big[F + \frac{1}{e}\sin\phi\log(\Delta+e\cos\phi) - \frac{1}{e}\cos\phi\sin^{-1}(e\sin\phi)\Big]$
$\frac{\sin\phi}{\Delta}$	$-\frac{b}{\Delta e^2}\Big[(F-E)\cos\phi + (\Delta-1)\sin\phi\Big]$
$\frac{\cos\phi}{\Delta}$	$\frac{b}{\Delta e^2}\Big[\Big\{E-(1-e^2)F\Big\}\sin\phi + (\Delta-1)\cos\phi\Big]$
$\frac{\phi\cos\phi}{\Delta}$	$\frac{b}{\Delta e^2}\Big[\cos\phi\Big\{\phi\tan\phi\,(E-\overline{1-e^2}\,F) - E + \phi\,.\,\Delta\Big\} - \Big\{E_1-(1-e^2)F_1\Big\}\sin\phi\Big]$
$\frac{\sin\phi\cos\phi}{\Delta}$	$\frac{b}{2\Delta e^2}\Big[\frac{1-e^2}{e}\sin\phi\log(\Delta+e\cos\phi) + \frac{1}{2}e\sin\phi - \frac{1}{e}\cos\phi\sin^{-1}(e\sin\phi)\Big]$

$$\frac{\sin\phi\cos^2\phi}{\Delta} \qquad \frac{b}{3e^4}\left[\left\{2(1-e^2)F-(2-e^2)E\right\}\frac{\cos\phi}{\Delta} + 2(1-e^2)\sin\phi\right]$$

$$\frac{\sin^2\phi\cos\phi}{\Delta} \qquad \frac{b}{3e^4}\left[\left\{-2(1-e^2)F+(2-e^2)E\right\}\frac{\sin\phi}{\Delta} + 2\cos\phi\right]$$

$$\frac{\phi\sin^2\phi\cos\phi}{\Delta} \qquad \frac{b}{3e^2}\left[\phi\left\{2\left(-1+\frac{1}{e^2}\right)\cos\phi + \left\{\left(2-\frac{2}{e^2}\right)F+\left(-1+\frac{2}{e^2}\right)E\right\}\frac{\sin\phi}{\Delta}\right\} - \frac{1-e^2}{3e^2}\cdot\sin\phi - \frac{1-e^2}{3e^2}\cdot F\frac{\cos\phi}{\Delta} + \frac{e^2-5}{3e^2}E\cdot\frac{\cos\phi}{\phi} + \left\{-2\left(1-\frac{1}{e^2}\right)F_1 + \left(1-\frac{2}{e^2}\right)E^1\right\}\frac{\sin\phi}{\Delta}\right]$$

where

$$H(\phi) = \int G(\phi)\cos\phi\, d\phi$$

$$K(\phi) = \int G(\phi)\sin\phi\, d\phi$$

$$E_1 = \int E(\phi)\, d\phi$$

$$F_1 = \int (F\phi)\, d\phi$$

{The obvious abbreviation E, F instead of $E(\phi)$ $F(\phi)$ is used above.}

The functions G, E_1 F_1 have not yet been tabulated. Tables are in course of preparation, and will be submitted as an appendix to the present paper.

To determine the constants we have, considering the point C at the end of the partial load—

For equilibrium of the forces and couple

$$\left.\begin{aligned} T_2 &= T_1 - W\sin\psi \\ L_2 &= L_1 + W\cos\psi \\ M_2 &= M_1 \end{aligned}\right\} \quad . \quad (27)$$

again since the arch ring is continuous and unbroken at C

$$v_2 = v_1$$
$$u_2 = u_1$$
$$\frac{du_2}{d\psi} = \frac{\delta u_1}{\delta \psi}$$

or which are equivalent

$$\left.\begin{array}{l} v_2 = v_1 \\ \frac{dv_2}{d\psi} = \frac{dv_1}{d\psi} \\ Z_2 = Z_1 \end{array}\right\} \quad (28)$$

(27) and (28) are six equations, by means of which the constants A_2 B_2 — of the second segment can be expressed in terms of those of the first.

To determine the remaining six constants we have

$$u = v = \frac{\delta u}{\delta \psi} = 0$$

at each end of the arch

$$i.e. \quad v = \frac{\delta v}{\delta \psi} = Z = 0 \quad (29)$$

at each end of the arch

(29) gives six equations for the six unknown constants. The case of the circular arch in the former paper follows at once from the present solution by putting $e = 0$

CHAINS.

The links are supposed elliptical and of uniform section. Considering half a link with ends fixed in direction at right angles to the applied force, and supposing radius of bar of which links are formed is small compared with a or b, as in the paper on arches and using the same notation

we have $w = v$ so that $f(\psi) = 0$ and equation (10) (11) (12) become

$$T = A \cos \psi + B \sin \psi \quad (1)$$
$$L = A \sin \psi - B \cos \psi \quad (2)$$
$$M = - Ay - B\,x + C \quad (3)$$

hence (13) becomes

$$\kappa z = \frac{1}{EI}\int(-Ay - Bx + C)ds + \frac{1}{EH}\left[\int T d\psi + \frac{1}{\kappa}\frac{\delta}{\delta\psi}\cdot\frac{T}{\kappa}\right] + D$$

$$\text{or } \kappa z = -\frac{Aab}{2EI}\left\{\Delta\sin\phi + \frac{1}{e}\sin^{-1}(e\sin\phi)\right\} + \frac{Ba^2}{2EI}\left\{\Delta\cos\phi + \frac{1-e^2}{e}\log(\Delta + e\cos\phi)\right\} + \frac{C}{EI}\times s + \frac{1}{EH}\left[(A\sin\psi - B\cos\psi) + \kappa\frac{\delta}{\delta\psi}\cdot\frac{T}{\kappa}\right] + D \quad (4)$$

From symmetry $T_{\psi} = T_{-\psi}$

hence $B = 0$

Again since $L_{\frac{\pi}{2}} = \frac{W}{2} \therefore A = \frac{W}{2}$

and since the tangential displacement vanishes at A and B, and the tangent is fixed in direction at these points

$$\therefore v = \frac{\delta u}{\delta\psi} = \frac{\delta v}{\delta\psi^2} = z = 0 \qquad \text{at } A \text{ and } B.$$

giving two equations for C and D,

we have $u = \frac{T}{EH\kappa} - \frac{\delta v}{\delta\psi}$

$$\therefore \frac{\delta u}{\delta\psi} = \frac{1}{EH}\frac{\delta}{\delta\psi}\cdot\left(\frac{T}{\kappa}\right) - \frac{\delta v}{\delta\psi^2}$$

hence when $\psi = 0$ or $\frac{\pi}{2}$ we have remembering $\frac{\delta u}{\delta\psi} = 0$

$$z = \frac{\delta v}{\delta\psi^2} + v = \frac{1}{EH}\frac{\delta}{\delta\psi}\left(\frac{T}{\kappa}\right)$$

$$\therefore \kappa z = \cdot\frac{\kappa}{EH}\cdot\frac{\delta}{\delta\psi}\cdot\left(\frac{T}{\kappa}\right)$$

hence from (4) we have when $\psi = 0$ or $\frac{\pi}{2}$

$$-\frac{Aab}{E2I}\cdot\left\{\Delta\sin\phi + \frac{1}{e}\sin^{-1}(e\sin\phi)\right\} + \frac{W}{2EI}\cdot\sin\psi + \frac{C}{EI}\cdot s + D = 0$$

Hence $D = 0$ and

$$C = \frac{W}{\Delta l} \left\{ b^2 + \frac{ab}{e} \sin^{-1} e - \frac{c^2}{2} \right\} .$$

where c is the radius of the bar of which the link is formed and l is the length of a quadrant of the ellipse but since c is supposed small compared with a and b we may neglect c^2 compared with b^2 and ab and we have

$$C = \frac{W}{\Delta l} \left\{ b^2 + \frac{ab}{e} \sin^{-1} e \right\} \qquad (5)$$

The constants are now all known and we have

$$\left. \begin{aligned} T &= \frac{W}{2} \cos \psi \\ L &= \frac{W}{2} \sin \psi \\ M &= -\frac{W}{2} y + \frac{W}{4l} \left\{ b^2 + \frac{ab}{e} \sin^{-1} e \right\} \end{aligned} \right\} (6)$$

The following table gives the bending moment at A and B for 2 or 3 cases :—

$\frac{b}{a}$	$\frac{M_A}{Wa}$	$\frac{M_B}{Wa}$
1	·318	— ·182
$\frac{1}{2}$	·175	— ·075
$\frac{1}{3}$	·120	— ·047

To find the maximum stress observe that we have

$$M = \frac{\pi}{4} \cdot Ef_1 \times c^3$$

$$F_1 = Ef_1$$

$$\therefore M = \frac{\pi}{4} \cdot F_1 c^3$$

$$\text{or } F_1 = \frac{4}{\pi} \cdot \frac{M}{c^3}$$

e.g. $a = 2''$

$b = 1''$

$c = \frac{1}{4}''$

$$F_A = \frac{4}{\pi} \times \frac{M_A}{c^3} = \frac{4}{\pi} \times \frac{\cdot 175 \times W \times 2}{(\frac{1}{4})^3} = 28\ W$$

$$F_B = \frac{4}{\pi} \cdot \frac{M_B}{c^3} + \frac{1}{2} W = 12\ W + \frac{1}{2}\ W.$$

We observe that the stresses due to the tension and shear are very small compared with the bending stresses, and that the stresses at the point *A* become, relatively to those at *B*, more intense as the links become more oval.

We may note that no inferences are to be drawn from the above work as to the actual method of failure of links—the work is supposed to apply only within the elastic limit of the material, and although it is a safe guide to design when the stresses are kept within the elastic limit, care must be taken not to attempt to apply it to cases of failure of chains. The testing machine, on the other hand, can inform us as to the limiting load a given chain will carry, but gives us no idea of the magnitude of the stresses in the material.

ON THE PREVENTION OF DAMAGE BY FLOODS IN RIVERS.

By C. Napier Bell, M. Inst. C.E.

Having lately been engaged by the New South Wales Public Works Department to report on the floods of the Hunter River, my attention was turned to a general consideration of the subject of damage by floods, and how best to guard against them.

What I have to say on the subject will, no doubt, appear to be restricted within a narrow range, as I have no means at hand to study what has been said on the question by others, and therefore I can only give my own limited experience and ideas on the subject.

Although there is nothing new in it, I must take my chance of boring those who have studied the phenomena of floods in rivers, by giving here some facts which most people know, but which must be set forth as a preface to a consideration of subsequent details. Thus the characters of floods vary from the most erratic and incomprehensible phenomena in small rivers, to the grand uniformity with the seasons in great rivers, and between the extremes it is impossible to find any distinct boundary which may divide the simple from the complex.

Every great river has hundreds of tributaries, in each of which the floods are subject to no known law, as every passing thunder-shower may gorge the smaller branches with floods, and every rain-storm will cause floods in some of the larger; but the parent rivers, like the Amazon, the Parana, the Nile, or the Ganges, rise inch by inch for months, keep stationary for awhile, and as slowly subside. There is a grandeur and solemnity about the floods of great rivers which have at all times impressed not only civilised observers, but even more so the timid, superstitious savages, who, looking at the yellow turbid waters steadily rising during parching hot weather and cloudless skies, and being unable to imagine the cause, satisfy their wonder by attributing the rising flood to the "Water God," who is pouring it out of caverns in the mountains.

The simplest example of this phenomenon—that is, the effect of the erratic floods of all its tributaries on the flood of the parent river—may be studied in a large lake, such as the Lake of Nicaragua, where I passed many days of my youth. Into this lake dozens of rivers enter, some coming from the mountains, some from the plains. Receiving floods at very various times, the lake remains unaffected until the rainy season, when from the end of May it slowly rises until it has attained its full height; and not until the end of July does it begin slowly to fall. A case on a smaller scale may show the action of erratic floods reduced to regularity; thus the Brunner Lake, in New Zealand, is a sheet of water of about 18,000 acres, and receives two small rivers, and many creeks, taking their drainage from neighbouring mountains. The outlet of the lake is by the Arnold, a most beautiful river, free from floods and all disturbances. The two rivers and the creeks which flow into the Lake Brunner are subject to terrific floods, but the effect is merely to raise the lake a foot or two; the outlet River Arnold is correspondingly raised a foot or two, and the steady flow continues till the floods are over. This is the same effect in another form of the floods of the various tributaries on a great parent river like the Nile.

The effects of floods in rivers are subject also to the conditions of the rivers. If they descend from steep mountainous country into great plains, the plains are liable to suffer severely from floods, and all the more as the rivers are usually very crooked on alluvial plains—in fact, from the nature of things they cannot be otherwise; the softness of the soil forming the banks is the measure of the swiftness of the current that can flow between them with the least amount of change from erosion; therefore, the softer the alluvial soil of the plain the more crooked will the river be that flows through it. In the Hunter River of New South Wales I noticed a strange phenomenon in a part of the river where the twists and turns through the alluvial plains were unusually numerous. The general fall of the plains was about one in two thousand, but the fall of the river along its winding course was only one in nine thousand. When a flood commenced to reach this part of the river, the winding and twisting part slowly filled up, slightly increasing its sluggish current as the depth increased. As soon, however, as the flood rose somewhat above the banks, so that the plain became inundated, the river-channel ceased to act, or rather it flowed the wrong way; because in those loops and bends in which the flow was usually against the general fall of the plains, as soon as the flood overflowed the banks, the inclination of the surface of the water in such bends was directed towards the general fall of the valley, and the water being higher on the down-stream end than on the up-stream end; then had no option but to flow the wrong way; so that the river with its winding course ceased to act, as all the reaches overflowed at their higher loops, the long reaches having now a surface-gradient of 1 in 2000; therefore, the flow could not follow the course of the river, which would give a gradient of only 1 in 9000.

The effects of floods are also greatly influenced by the depth of the river; and the difference in depth of rivers is difficult to understand. Thus, the Amazon, Parana, Yangtse, are very deep; but the Mississippi, Ganges, Hoangho, Volga, are shallow. The cause cannot be the geology of the countries which the rivers flow through, because rivers like the Amazon and Mississippi flow through every sort and condition of country, neither can the extent of level plains through which the lower parts flow be the cause. The Mississippi flows through extensive plains, and so does the Parana. The same thing is also seen in Tasmania, where the lower 18 miles of the Gordon is about 100 feet deep; and the King and Pieman rivers are very deep at their lower parts. Some parts of the Amazon are 500-feet deep below sea-level, while the mouth is over extensive shoals only 12 or 18 feet deep.

As regards the effect of depth on the floods—taking the case in China, the deep Yangtse causes no trouble, although it rises about 50 feet in spring and summer, while the shallow Hoangho is called "China's Sorrow," and in 1887, 1,600,000 people were drowned by a flood in it; and again in 1901, immense numbers of people and cattle were drowned by the bursting of the banks by floods. The City of Glasgow was afflicted with floods long ago, but since the deepening of the Clyde no floods ever affect the town.

As stated above, the nature of the banks is generally the measure of the crookedness of the river; and of course the crookedness of the stream aggravates the destructive effects of the floods. The river cannot be permanently straightened unless the banks are artifically protected, which is generally impracticable, from the magnitude of the work involved. But if the river is straightened and prevented from eating away its banks, it will at once commence to attack its bottom, which action is generally beneficial in every way, as tending to abate the height and shorten the duration of floods.

In the course of the operations to improve the Mississippi, the river is said to have been shortened about 260 miles by cutting through bends, the tendency of which is, of course, to cause more trouble from the erosion of the banks. I have known cases where towns and villages situated below great bends in rivers have strongly objected to the bends being straightened for fear that they would be injuriously affected by the increased height of the floods. It may be shown, however, that although the bends may delay the approach of the flood, they cannot diminish the quantity, so that straightening them would have no injurious effect below. Straightening bends in rivers is, therefore, altogether beneficial, provided the expense to be incurred to protect the banks is kept in view.

If a river is so small that the work of training it through its length can be done, then it is often possible to greatly change in the character of the river, and with it the effects of floods. By protecting the banks, forming proper curves, and training the channel to a calculated expanding width downwards, the formation of shoals and banks may be prevented, and the river so assisted to increase its depth that the current may become nearly uniform throughout, and, if it has sufficient velocity to scour away its deposits, the channel may permanently maintain its depth, and so greatly diminish the bad effect of floods.

This training of rivers is, however, generally done on tidal rivers, like the Seine between Havre and Rouen; but, if done intelligently, almost any part of a river may be advantageously trained; the uncertainty in the results, if any, lies in the uncertainty as to the material contained in its deposits, because the training that may be effectual in fine sand may not succeed in coarse sand, still less in gravel.

As the deposits in rivers are one of the chief causes of the damage by floods, it is essential to ascertain if possible the causes of them, and whether they can be removed, partially or wholly. Of course, the beds of rivers are extremely irregular, varying with the hardness of the soils or rocks over which they pass; but such irregularities are not of the nature of deposits, which is the subject under discussion. The deposits in a river consist of the material worn away from the watershed, deposited in the rivers on its journey down to the sea, which it reaches sooner or later, except such part as is used up to make new land. The length of time taken for the journey to the sea varies according to the material; fine silt and mud may reach the sea in a single freshet, sand takes longer, gravel longer still; while boulders may take centuries, and in some rivers may never reach the sea in that form; also, in many rivers, especially the large ones, gravel and coarse sand may not reach the sea for ages, being used up in raising the bed of the river and making new land, or being reduced by wear and tear to smaller materials.

Although a river-bed may be encumbered by many great banks of deposits all the way to its mouth, yet it displays much uniformity from year to year, and only careful measurements may show any changes; yet the deposits are constantly travelling, and like the strange phenomenon of drifting beaches, there is no apparent change, because the material removed is balanced by the supply.

Although the deposits are constantly travelling along its bed, yet every river has reaches and channels in which the depth and width do not vary perhaps for centuries; from which it may be inferred that there are positions and conditions of flow which are not affected by any deposits, whether in great or small quantities; and in seeking to improve a river with the view of abating the effect of floods and maintaining its bed in the improved condition one naturally seeks to imitate the good points found to exist in the river as it is. This would not be so difficult were it not for the reverse curves in every river, and the great irregularities in the widths. Irregular width can of course be dealt with, but reverse curves, called "cross-overs" by the Americans, have always proved to be difficult to deal with, especially in large rivers. Any one can see where the difficulty lies, and that it is a matter of comparison. For instance, the channel of a river flowing round a curve may be 40 feet deep, but the same stream flowing in a straight line may not give a channel more than 10 feet deep. In the space between two reverse curves the river is flowing in a straight line, and any attempt to train this part would tend to block up the river, and therefore cannot be done.

The German engineers have found in their practice, or one of them has asserted as an axiom, that by intelligent study and observation, the natural or even the artificial axis of the current can be ascertained at any part of a river, and that any improvements, such as dredging, if done in this axis, will be permanently maintained by the river.

This seems likely to be true, because we see that the river has in various places natural channels which are permanent and never vary in width or depth, but I can conceive the difficulty of deciding upon an axis of currents along which all artificial channels will be permanent, seeing that the least alteration in the bed or banks may start changes which would tend to entirely alter the conditions. I have seen costly dredging entirely obliterated through being wrongly placed as regards the currents, and other dredged channels, presumably properly placed, which are good to this day; a good example of this latter may be seen in the new cut recently made from the great middle channel of the Fitzroy River into the fine basin of Broadmouth, which it was predicted would silt up as fast as excavated; but the current has taken to it properly, and it seems quite permanent.

This is not beside the question under discussion, because any improvement in the channel of a river will mitigate the effect of the floods, and in some cases may be all that is required to be done.

Another, and possibly the most common method of avoiding the damage caused by floods, is to raise dykes or embankments along the banks of sufficient height to prevent the floods overtopping them. If this is done on a large scale, it is often followed by effects which are generally overlooked at the time, but are sure to be felt in the future.

The valley of a river seldom offers evidence of any sudden or violent changes; but most valleys do undergo changes, which become evident if careful observation is continued for sufficient length of time; and the most usual change is found to be that the bed of the river slowly rises by the deposits brought down from the mountains. If the river is left in its natural state this effect may remain unnoticed for ages, because the flat meadow land bordering the river is raised also by the yearly deposits left in it by the floods. The amount of this raising may vary greatly, but as a rule it corresponds roughly to the rate at which the river-bed rises. Now the river-bed rises according to the rate at which the heavier material of its deposits creeps down towards the sea, and however slow in most cases, this advance is ceaseless as long as the relative level of sea and land remains the same. In most rivers the deposits carried to the sea slowly advance the shore-line, which has the same effect in raising the river-bed. In the case of a river like the Amazon, unnumbered centuries may elapse before the heavy material of its upper waters approaches the sea, but in small rivers, like those of New Zealand, the process is sufficiently evident in a reasonable number of years. Of course, the coarser and heavier the material comprising the deposits of the bed of the river, the steeper will be the slope of the bed. Thus, in the Amazon and Parana the heavy deposits are still thousands of miles from the sea. The bed of these rivers has therefore as yet no slope; it is on the contrary scooped out by the current to great depths. In the Mississippi and Hoangho the heavy deposits are approaching the mouth, and the river-bed is shallow, rising yearly. In some of the New Zealand rivers the heavy deposits have long ago reached the sea, and consequently the slope of the beds is at the rate of 30 to 60 feet per mile, and when heavy gravels begin to come down, the slope may be still steeper. In a state of nature the changes in bed and banks of rivers are very slow, but when the country is inhabited the changes which take place are sometimes alarmingly rapid, and in a few years I have seen the entire character of a river altered by changes brought about by cultivation and clearing of the country.

But if embankments, or "levees," as the Americans call them, are built to keep the adjacent lands from being flooded, the bed of the river continues to rise, but the land is prevented from doing so, and sooner or later serious consequences follow. In Holland, I saw much land which was a considerable depth below the ordinary level of the river, and seemed to be in a very risky position. Engineers of the Dutch Waaterstad told me that some of the embankments were as old as the time of the Romans, and it had been calculated that if they had not been erected the adjacent land would now be 15 feet higher than it is by reason of the yearly deposits which would have been left on it. The Americans have had great trouble with their levees on the banks of the Mississippi; the experience of them in China has been terribly disastrous; and the River Po in Italy, and some of the Japanese rivers, are cocked up high above the plains—so much so, that in Japan some of the railways have to pass under the rivers.

In these cases, if it had been possible to imitate Egypt, the land could have risen proportionately with the river-bed, and all would have been well. Even as it is, I have often thought that people are too eager to embank their lands and keep out the floods; they ignore the value of the manure with which the floods yearly enrich the soil, and before many years they find that they must provide manures at a great annual cost. The future effects of embanking the rivers naturally find no place in their thoughts.

Embanking to keep out floods is rendered all the more risky, because the height of the floods is necessarily raised by the process, and all the alleviations found in natural conditions in the inundating of great flats and marshes are denied to the river confined by embankments. There is only one compensating advantage, which is that the river is made deeper and steeper by the embankments, which has the effect of scouring out its bed and so enlarging the water-way; but this has little effect, considering the immense extent to which the water-way is curtailed by the embankments. Notwithstanding the risks and inconveniences attending this method, it will always be the most popular, and many thousand lives of men and cattle will continually be sacrificed to it.

We may next consider a system of abating floods, which always finds heaps of advocates, who are almost invariably wrong as to their ideas of obtaining relief in this way.

In numerous instances, I have known people strongly urging that diversions or by-washes should be cut to relieve the floods. Their contention usually is, that if only the "top few feet of the flood could be cut off, all would be well." Unless they are conversant with hydraulics, and such people never are, it is almost impossible to convince them that the "top of the flood" is at the bottom, not at the top; if it were possible to drain off the bottom, the top of the flood would give no trouble; just as in the sea, if you wish to kill a wave, you much obstruct the bottom of it—the top will then do no harm. Thus, a deputation wished to get relief from the floods of a river in Queensland. They urged that a by-wash should be made 200 feet wide and 8 feet deep, which they said would take the top off the flood, and be all they wanted; but they were surprised when it was shown that if the bye-wash were made the whole width of the river, viz., 500 feet, and 8 feet deep, it would only lower the flood about 18 inches.

Other projects of this nature are to make diversions to take away one-third or one-half of the flood-water, under the impression that the floods will then be greatly relieved. But in the long run no relief can usually be had in this way, for no benefit can be expected except on the assumption that the floods carry no sediment, which is seldom or never the case; and for this reason, if there is to be any diversion, or shortening, or straight-cuts, it must be of the whole river.

On this subject, a friend of mine, a highly scientific and experienced engineer, in a lecture delivered at Shanghai in 1888, remarks:—"When the Chinese have been troubled with floods in their rivers, they have always been too ready to cut extra channels to carry off the surplus waters. This is, as a rule, the exact opposite of what should be done. The extra channel lowers the velocity, the river deposits more silt, the bed rises, and the level of floods becomes worse than ever." Also, Mr. Gustav Dyer, speaking of the work of the Mississippi Flood Commissioners, says:—"Outlets in any form, whether waste weirs, reservoirs, or water-ways connected directly with the sea, all come under the same head and require the same treatment; each part of the volume of which the main channel is temporarily relieved will require a proportionate expenditure for construction and maintenance, and the object in view will fail of accomplishment. The Mississippi Commission has accordingly striven to raise the levees and dredge the channels, and concentrating the scour by groins so as to get uniform velocity." Both these authorities deprecate tampering with the main-channel of the river with the view of relieving floods; in fact, the practice of the Mississippi Commission to raise levees, and at the same time clear out and improve the river-channel, is about the best thing that can be done; but to cut by-washes, outlets, or relief-channels, is certain to produce very injurious changes in the regimen of the river. Fortunately, these attempts to relieve floods are seldom permanent; sooner or later the river either takes entire charge of the relief-channel or silts it up; but if the relief-channel can be, and is maintained, then the main river suffers by silting up in just the same proportion as the quantity of water that is taken from it by the diversion. The people of Rockhampton lay great stress on the fact that they are protected from the height of floods in the Fitzroy River by an overflow above the town, which they say cuts off many feet of the height of floods. The overflow is of great width, but I have seen no calculations to show how much the height of floods is reduced by it; but the damaging effect on the bed of the river below it which usually follows such diversions is now not evident, as the bed is all rocks, as far as Rockhampton, and below the town the water of the overflow returns into the river through many creeks and channels.

As the most likely way of controlling the floods of a river seems to be to improve its channel, it is important to consider what forces and influences are opposed to such works.

Very few, if any, rivers are able to contain their own floods within their banks at all parts of their course. This is due to many causes, such as different height of the banks, varying width of the river, differences in the hardness of the strata composing the banks and bottom, differences in the gradients of the river, and, as a result of all these, the inability of the river to dispose of its own sediments.

As the front of a flood travels faster than its rear, it is usually found that a flood coming down a river carries its sediments before it, and this action in time would clear out the river-bed; but the rear of the flood is more sluggish, the sediments trailing along with it are soon left stranded, and the shoals and sand-banks, after being partly stripped by the first of the flood, are replenished by it as it subsides. This suggests the question, whether the river annually delivers to the sea the same quantity of sediment that is put into it by its tributaries; and it seems highly probable that in most, if not all, cases, it does not; the observed rising of the bed, and the silting up of adjacent lands, are proofs that to such extent at least the river does not take as much to sea as it receives.

There are many places in most rivers where defined deep channels are found which all sediments pass over without any effect, for in such parts sand-banks are not accumulated. Here the velocity of the current keeps the bed clear; and one would think, that if this condition of things could be brought about over all parts of the river, then there would be no deposits, and flooding of the country would be avoided. But the existence of deposits indicates that the necessary velocity is not to be found at all parts of the river, and to procure it artificially by training-walls and levees requires that the flat gradients of the river shall be made steeper, which would have the effect of raising the entire river above the adjacent land. Such a proceeding is equivalent to raising the banks by levees, and involves great risk of accident, and in the long run becomes ineffectual from the gradual flattening of the gradient of the river-bed, caused partly by the deposits pushing the shore-line further out to sea, partly by the retention of all heavier and coarser sediments, which gradually raise the river-bed in spite of the scouring action. Grand examples of this kind of action are seen in many of the rivers of New Zealand, where steep mountain slopes of, say, two to one end abruptly in a wide river-bed of shingle. There can be no doubt that these mountain slopes are continued below the river-bed, and end in original rock-bound river-banks, hundreds of feet below the present flat, shingly river-bed. But the shingle, sand, and boulders have pushed the sea-beach twenty to thirty miles further out to sea, thus flattening the gradient to such an extent that the present river-bed is raised hundreds of feet above its original rock-bound ravine, in which it may have flowed hundreds of thousands of years ago. Thus, the magnitude and the diversity of effects brought about prevent all our efforts to control the floods in this way.

Although the inclination of the bed of the river is not the same as that of the surface of the water at all parts and in all states of flood, yet it is of course the measure of the average inclination of the surface. Now from this it is inferred that the character of the material of which the river-bed is composed determines the inclination of the bed and of the average surface-inclination.

Thus, near the mouth of a great river the sediments may be mud or soft sand, and at such parts they are so easily scoured that the inclination of the bed may have no reference whatever to the inclination of the surface of the river; that is, the river may be very deep while its mouth may be very shallow. But as we ascend the river, we find the sediments getting heavier and coarser, and the inclination of the bed approaching more to that of the surface of the water, until we reach the state of things found in many New Zealand rivers, where the sediments being shingle and heavy boulders the inclination of both bed and surface of the river may be from 40 to 60 feet a mile. Yet even with such heavy sediments, the river is continually raising its bed, until being elevated above the surrounding country, it suddenly breaks through into lower ground and commences raising it; so that the strange phenomenon is seen over a hundred miles of plains with a uniform slope towards the sea of from 20 feet a mile near the sea to 60 feet a mile near the foot of the mountains.

In a case of this kind there are two factors which govern the inclination of the plains and the river, one being the weight of the sediments or deposits, and the other the size and volume of the river; accordingly, we find the slope of the plains from sea to mountain with a steep fall, and getting gradually flatter towards the sea. But we also find that the larger rivers, where they come out of the mountains on to the plains, flow in deeper beds than the smaller rivers, the latter not having the weight and body of water to cut down the heavy shingle which the larger rivers have. Thus, given the weight of the deposits and the size of the river, the inclination is fixed; and a fine example of this was seen in the Otira River, in New Zealand, where during a great storm a vast "shingle slide," as it is called, slipped from the lofty mountain-side bodily into the river. The flood distributed this shingle for many miles down the river, raising the bed from a foot or two to about 20 feet in the gorge of the Otira, where two bridges 20 feet high were buried in the shingle.

This raised bed was all removed after a few years, and the usual slope restored, and if it were not that it left a big boulder perched on a point of rock, the coach-drivers would have difficulty in persuading tourists about the great shingle slide.

But the character of the rocks of the mountains determines the nature of the sediments in the rivers, and this determines the slope of the river-bed. Thus, the rivers of New Zealand may be sloped 60 to 100 feet per mile, while on the Colorado River in North America the rocks are ground down, and are carried away to such an extent that the river-beds are sloped only a few feet per mile, and are six to ten thousand feet deep.

The above shows the difficulties that will be met with in trying to mitigate floods by deepening the river-bed. Nevertheless, it has been done successfully in parts of many rivers, and its effectiveness, it seems to me, depends on the character of the deposits as compared to the volume of the river; thus, where the river is so great, and the deposits so fine, that the river is of great depth, the problem is solved naturally; where the deposits are heavy, and the river small, there it is impossible to permanently deepen the whole or even part of the bed; and in cases intermediate between these extremes the bed may be deepened permanently by carefully selecting the position and direction of the deepening, and assisting the operation by judicious training of the banks within stone embankments. Of course, if the bed is deepened, in a corresponding degree the effect of floods will be mitigated, because lowering the bed is equivalent to raising the banks. A notable example of relieving floods by lowering the river-bed and straightening its channel was seen in the great flood in the Yarra, in April 1901, which in consequence of this beneficial kind of treatment did no damage at all, although the flood was greater than any since 1863, each previous flood having caused great damage. But there is necessarily a limit to a partial improvement of a river-bottom—which is that the beneficial effect will only extend to the next important change of grade in the surface-inclination either above or below the improvement; thus, the part under treatment may have a general inclination of one in five thousand, but above it may be a long stretch of one in three thousand, and below it a long stretch of one in twelve thousand, and these will not necessarily receive any benefit from the floods being lowered in the intermediate part.

Some 20 years ago there was much discussion about abating floods by retaining them in reservoirs of sufficient dimensions. I think the French engineers were those who took most interest in this question; but I noticed that they never had the courage to put it in practice. In 1878 the late Mr. H. P. Higginson and I were instructed by the New Zealand Government to investigate a proposal to abate the disastrous effects of the floods of the Taieri River in this manner. We found an excellent site for a dam, and calculated the height it would require to be to contain the waters of a great flood.

In this case there were two branches of nearly equal size, and the problem was to hold back the flood in one until the other had time to discharge its flood. This of course is quite feasible and probably safe enough if one could have a time-table of floods, but on looking up the records we found the floods were so uncertain in their times, and so devoid of any kind of regularity, that how to deal with a flood when one had caught it in a reservoir was the most puzzling part of the question.

Subsequently I investigated, for the New South Wales Government, the same question as regards the floods of the Hunter River, and shortly after that Col. Pennycuik, R.E., dealt with the same subject in respect to the floods in the Brisbane River. It is significant of the uncertainty of treating floods in this way that we arrived at opposite conclusions in regard to it, and necessarily, from my point of view, I hold that the Colonel ignored or made light of difficulties which I consider formidable.

In the Hunter the drainage area of the flood to be stopped is greater than the Brisbane, and consequently the capacity of the proposed flood reservoirs was correspondingly greater than that proposed by Col. Pennycuik for the Brisbane River; in fact, the flood reservoir proposed to hold up the floods of the Hunter would have held the unheard of quantity of 40,000,000,000 cubic feet or 250,000,000,000 gallons, which was reckoned to be somewhere about the quantity brought down in a flood by the Hunter and its principal tributary, the Goulburn, from 5230 square miles of watershed.

The proposal was to stop back the water in a great flood, and to use it for irrigation at other times. The dam to hold this vast quantity of water was to be below the junction of the Hunter and Goulburn, 130 feet high, with eight sluices

40 feet above the river-bed. In a great flood 23,000 acres of about the finest land in New South Wales would be submerged, and, according to evidence by settlers, would be rendered nearly useless by the silting up and killing of the finer grasses. The next objection was the terror expressed by the settlers of Singleton and Maitland at living below such a quantity of water with the dam only between them and drowning. Of course, an engineer need not take this into consideration, because he would possess the assurance that the dam ought, and must, not give away; but as regards those whom it concerns, they are sure to make their fears known. Then arises the question as to the permanence of the effects to be brought about by the dam. The Hunter river in flood brings down silt, and the Goulburn sand; and in great floods incredible quantities of drift timber come down both. It does not seem excessive to reckon that a smart flood brings down one-sixtieth of its volume of sand and silt; and on such a supposition, sixty great floods would fill up the reservoir with sand, silt, and drift timber. Although this could not happen because of the quantity which would be washed out through the sluices, still not only is it impossible to wash out anything like all the sediment that would be laid down by a great flood over 23,000 acres of the submerged land, but every smart fresh brings down sediment, and no year occurs in which there are not freshes, although great floods may only occur at long intervals. If any one suggests how is it that the reservoirs made to supply towns with water do not silt up, the answer is that they do so, but they are generally cases of large reservoirs filled by small streams. We are now, however, considering the case of a reservoir receiving a large river, and instances are not wanting of reservoirs filled to the top of the dams in a few years. Thus the Torrens River was dammed at Adelaide to form a lovely sheet of water in front of the City, but it is all silted up now to a foot or two deep; and the Kowhai River in New Zealand was dammed to raise the water for irrigating the plains, and in about 8 years it had filled up with shingle to the top of the dam. In both cases the sluices were buried, and would not work. Also, in *Nature* of the 13th June, 1901, one reads of a great dam in America which burst, causing great damage; but it was noticed that three-fifths of the total capacity of the reservoir was filled up with sand and silt brought down by the river in four and a half years. It may be asked, if a reservoir like this is not permanent.

what will happen to the Nile, now being dammed at Assuan? The answer is, that it is more than likely that in a number of years the reservoirs formed by the dam will be silted up to about the level of the sluices; but the sediments at this part of the river are most likely nothing but fine silt, and of this a much larger proportion can be washed out through the sluices than of the heavy sands and gravel found in the upper waters of the Hunter. But of course a fuller answer is, that in the flood reservoir of the Hunter it is the space that is wanted to hold back the flood, while the Nile dam is wanted to lift the flood water to the higher level required to irrigate land which the water could not reach without the dam, and there is no question here of holding back any water; in this sense, therefore, the Nile dam is permanent.

Now, to hold back a flood, one should have some idea of when it is coming, and in this respect Col. Pennycuik took for granted that the floods of the Brisbane are sure to happen in the rainy season, which is the summer in Queensland; and, as far as I know, floods do not happen there except in summer. Brisbane is very near the turning point, but as you go south the rains gradually change from summer rains in the north to winter rains in the south, and the records which I collected of the Hunter floods show that from 1856 to 1898 there were 35 great floods, eight of which were "Oldman" floods; that no Months of the year, except October, were without floods; that seven great floods came in pairs—that is, one closely following the other; that in 1870, from the middle of March to the middle of May, six floods followed each other, none of which waited till the previous one had subsided before it came on; that in 1861 there were five great floods between March and August; and that of 42 years observed, 27 years had no great floods, and of the 15 years with floods they had no regularity other than this classification—that 10 were summer floods, 17 winter floods, 2 were spring floods, and 6 were autumn floods.

To show the difficulties of dealing with floods in this way, I will quote from my report to the New South Wales Government on this subject: (p. 10). "I do not know how a flood stopped back in this reservoir would be disposed of. No one can tell what rainfall will cause a flood. There was a case here where 4 inches of rain in 24 hours did not raise the Hunter nor Goulburn more than a few feet, because the rain was preceded by nine months of drought, yet the 1893 flood, the greatest ever experienced, was, according to Mr. Price, caused by 4 inches of rain, the country being previously well soaked. But between such extremes there are many means, among which it would take a wise man to know which flood should be stopped, and which allowed to go down the river.

"Then it is known that floods frequently come in pairs. If the first to arrive is held back, it would have to be let out very quickly, so as not to have the second on top of it. If it were held up too long the second flood would find the reservoir with the first flood still in it, and when the second had passed over the dam the reservoir would have to be emptied, which would prolong the flooded condition of the river to an injurious length of time, seeing that while the river was thus kept bank high all adjacent lands would be waterlogged for want of drainage outlet. A case occurred in 1870, when six floods followed each other between the 5th March and the 25th of May. If each of these had been held up in the dam, and let out again, the lower river would have been bank high for nearly three months, and all land would have been waterlogged for that time.

"But the first flood reached its height at Singleton from the 11th to the 12th, and the second between the 18th and 19th, so that there was no time between these to let the first flood out of the dam before the second was on top of it. On the 16th the first flood had gone down greatly, and it is not unlikely, seeing the weather cleared up, the keeper of the dam would have opened the sluices; but immediately he did so, the second flood was coming, and he would have to shut the sluices forthwith, for if he did not he would blend the two floods into one. In like manner between the fourth and fifth floods of the series there was hardly time to empty the dam of the fourth before the fifth was at hand; and the fourth was the highest of them all.

"Now, under these circumstances, this reservoir would not have served its purpose; neither would it on the more frequent occasions when the floods follow each other at short intervals. In any case seeing how uncertain what rainfall will produce one, how careful the man must be who handles such a vast body of water, and how entirely new and experimental is such a method of regulating floods, I think it would be more prudent to let some other country try the experiment first, and see how it works."

I have shown above so many reasons against the possibility of controlling floods in rivers, that if the reasons are valid, the problem must be considered hopeless. But there is this to be said—the damage by floods arises from different causes, and it is reasonable to suppose that therefore no one universal remedy is feasible, nor that it is possible to protect every place which is exposed to damage. The most ancient remedy is still the most popular; that is, to protect flooded land by embankments. I have shown that there are great risks and great inconveniences attending this method, and from the rising of the river-bed it is not in the long run a permanent remedy. I have also remarked above, that lowering the river-bed is equivalent to raising the banks; therefore, in such places as are reasonably possible to protect from flood, it seems that a combination of the two methods would be the most likely to be successful; and where the river deposits alone constitute the bottom, recent improvements in dredging machines enable the bottom to be lowered at a cost hitherto undreamt of—thus the high power dredges now being used are said to dredge sand and silt, and deposit the spoil on the banks, at a cost of $1\frac{1}{2}d.$ per cubic yard.

In a district afflicted with floods, it is generally found that the adjacent river is very crooked, of greatly varying width, and obstructed with sand-banks and shoals. To treat such a river with the view of abating the damages from floods, the first thing should be to straighten it as much as possible, which will increase the declivity or slope; next to dredge a wide and deep channel through the shoals, always keeping this channel in the natural axis or run of the current; this will increase the velocity of the stream, so that with increased capacity of the waterway, and increased velocity of flow, the height of the flood will be reduced; but if this is not sufficient, then it must be supplemented by embanking the land.

In the eagerness to protect the land from floods, immediate relief and benefit is generally sought, to the exclusion of all other considerations, and it is difficult if not impossible to induce people to act with a view to the future instead of the present; besides which, action is generally first taken by individual sufferers trying to protect each his own holding, and it is not till after many failures by private people that the Government steps in to assist.

Some people are great sticklers for following what they call the laws of Nature. Nature, however, has no laws properly so called, but rather certain effects are sure to follow certain causes; the requirements of man are, however, often directly opposed to Nature and its ways; and if he is determined to have what he wants, Nature must often be resolutely set aside.

If we observe what Nature does in its treatment of a river and its floods, we shall notice, first of all, that the treatment varies greatly according to the soil, the character of the surface, the rainfall, and so on. Every river may be divided into two parts. In one part, namely, the upper part, the river is slowly cutting out and lowering its bed; and in this part the river is seldom obstructed by its own sediments. The other part is the lower part, and here the sediments are generally increasing, and slowly encroaching on the upper part; and it is commonly in the lower part that floods are troublesome. But Nature has one working rule which is used more than any other; in fact, she uses it wherever and whenever she can make it apply.

The object of this working rule is, first of all, to reduce the surface of the river and the surface of the land to a uniform inclination; and next to raise the land above the river, so that the floods can be contained within the banks. To be entirely successful it is necessary that the river should have to deal with material of more or less uniform consistency. But, as I mentioned above, the material of the river sediments continually varies, even though it may be ages before the change is perceptible, so that the river may never succeed in fixing a limit at which it can control its own floods. Yet everywhere one finds approximation to a complete solution of the problem; and then one observes that the floods have silted up the meadow lands until the greatest floods overflow only a very little; and this very little is more or less completely protected by the banks on the immediate edge of the river, which are always a few feet higher than the meadow land at the back.

It is evident that man cannot imitate this operation. To raise all the land above flood-level is out of the question; to raise the banks only in the form of levees is most commonly resorted to, but is often very dangerous.

But the natural operation just described above is in effect to raise the banks, and thus deepen the river, whereby the whole of the floods are contained within the banks, and the depth and impetus of the water is thus made sufficient to scour away the sediments as long as they do not change in weight and size.

How then are we to imitate this operation, and secure the same results? Evidently to deepen the bed is the safest course; but in most cases, this must be combined with raising the banks; and the nature of the bed and other local conditions must determine how much of the one and of the other should be done.

It is now clearly shown, after all this long discussion, how little can be done to protect land from effects of floods. It is shown that whatever is done is ineffectual in some respects, and not permanent in others: to seek to protect from floods is, in short, to seek for fixed conditions where nature insists on change, which in effect means a stand up fight between man and nature, wherein man is sure to get the worst of it, if not at once, at any rate in the long run. The discussion also seems most unprofitable, as it is impossible to reach any definite conclusions, and no rules can be laid down which may be relied on in every case. And so, after all this long consideration of the subject, all that has been achieved is to point out a few things to those who are looking for safe guidance in flood matters which should not be done, leaving what should be done to the good judgment of the sufferer from damage by floods.

ON A GRAPHIC METHOD OF DETERMINING THE CHANGE OF FORM OF FRAMED STRUCTURES UNDER STRESS.

By Professor W. C. Kernot, M.A., M.C.E.

[Plates.]

When a framed structure, such as, for example, the girder or truss of a roof or bridge, or a trestle-tower for carrying a railway viaduct or elevated water-tank, is loaded, its form is altered by the elastic deprivation of its various elements. In well-designed structures these elements are usually exposed to longitudinal thrusts and pulls, all bending actions being eliminated as far as possible. From these calculable thrusts and pulls, the cross-sectional areas, lengths, and direct modulus of elasticity of the material, the change in length of each element is easily determined. The problem that next presents itself is this—"Having given the change in length of the various elements, to determine the alteration in form of the whole structure." As such structures almost always consist of a series of triangles, this may be done by plane trigonometry. Taking the altered lengths of the sides of the triangles, the alteration in the angles may be computed, and then by a further calculation based on the alteration of both sides and angles, the movement of any point in the structure from its original position may be determined. The whole calculation involves but simple mathematics, but is very laborious, and consequently rarely attempted. To find a rapid and convenient mode of arriving at the same result within such limits of approximation as are needed for practical purposes appeared therefore desirable, and after some consideration the writer was led to adopt a graphic method suited for rapid and convenient use in the drawing office. Of this, as of other graphic operations now popular with engineers, it may be remarked that, while subject to small errors due to imperfections of draughtsmanship, such errors are of no practical moment, being under ordinary office conditions less in magnitude than the inevitable uncertainty in the computed stresses and modulus of elasticity of the material. The system is best illustrated by a series of examples, commencing with a very simple case, and proceeding thence to more complex ones.

Let *ABC* in Fig. 1 represent a bracket attached to a rigid wall, and loaded at *B*. It is required to find the magnitude and direction of the movement of *B* when the load

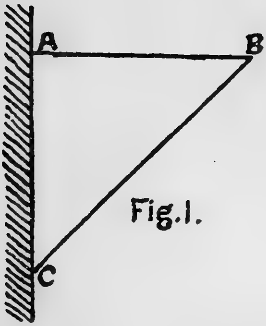


Fig. 1.

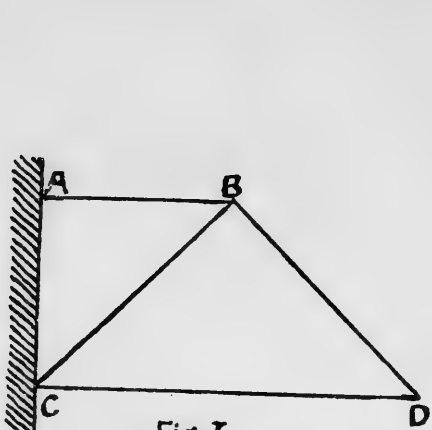


Fig. 3.

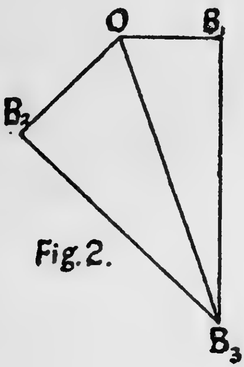


Fig. 2.

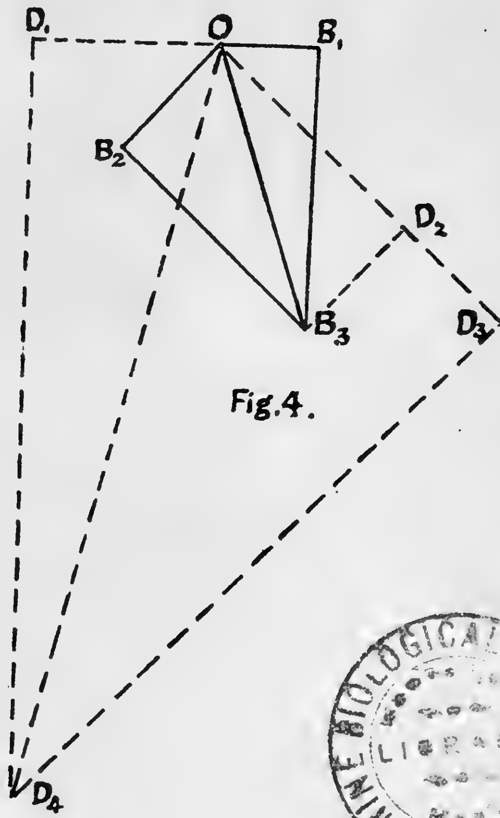
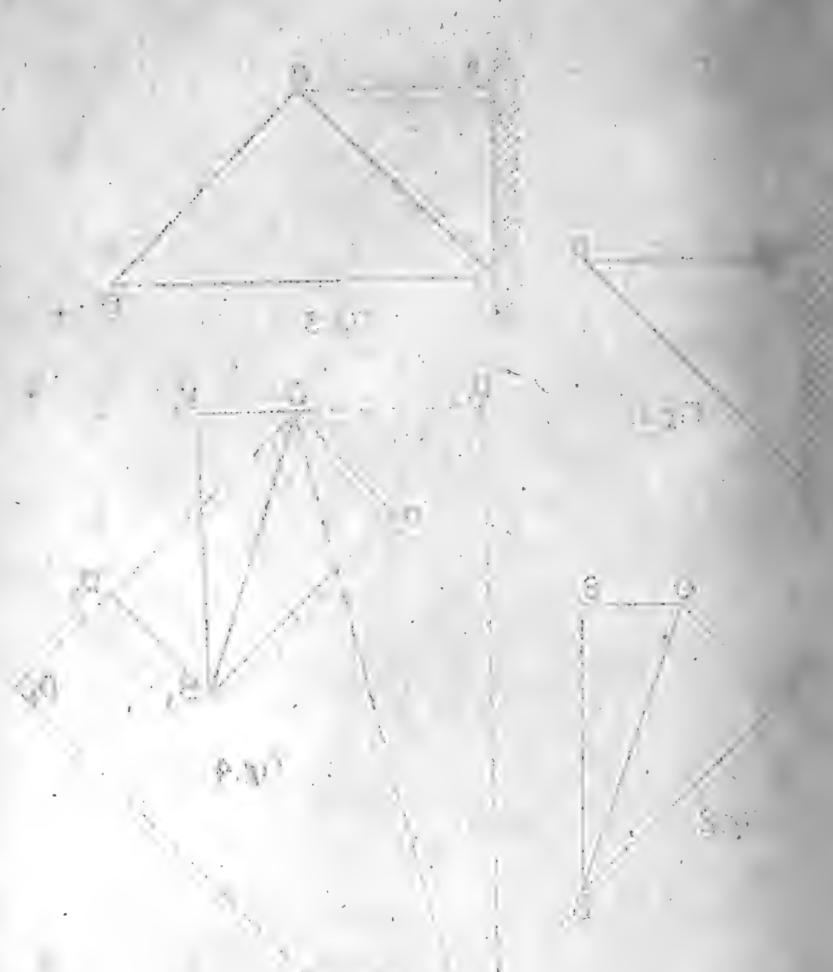


Fig. 4.



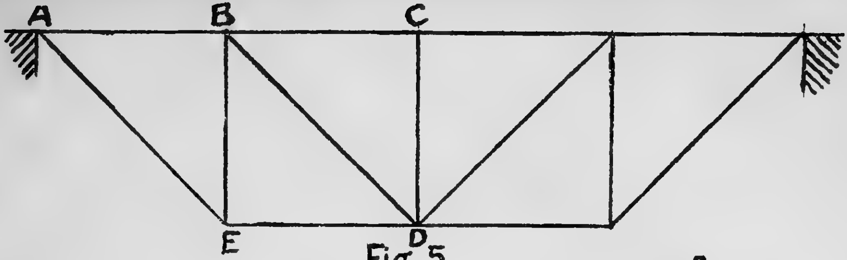


Fig. 5.

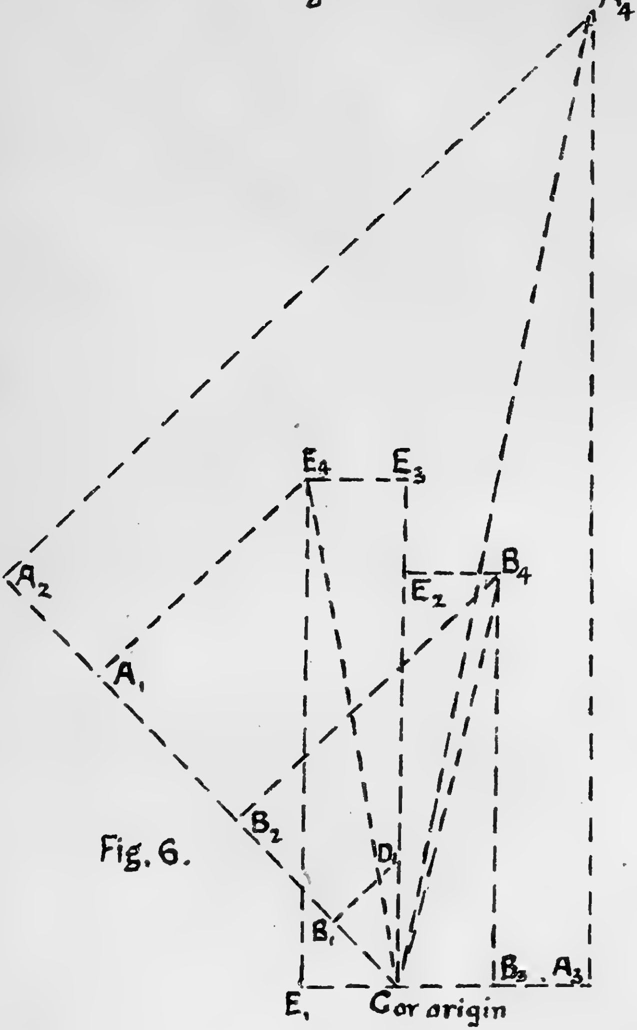


Fig. 6.

is applied or removed. To give definiteness to the discussion, let us assume AB to be 10 feet, BC 14 feet, ABC 45°, and the stress to be 5 tons per square inch on AB and ABC, and the direct modulus of elasticity of the material in either tension or compression 30,000,000 lbs. per square inch. The elongation of AB will then be $\frac{1}{2678}$ of its whole length, or $\frac{1}{268}$-foot or $\frac{1}{22}$-inch very nearly, and by a similar calculation the shortening of BC will be $\frac{1}{16}$-inch very nearly. Now, suppose that from A, as a centre, we draw a circle 10 feet plus $\frac{1}{22}$-inch radius, and from B one of 14 feet less $\frac{1}{16}$-inch radius, the intersection of these circles will give the new position of the point B. But practically this cannot be satisfactorily done, for on any ordinarily convenient scale, such as say 1 inch to 1 foot, the whole movement of B is so small that the slightest spring or yielding of the compasses used, or even the thickness of lines drawn by ordinary pencil or drawing-pen will be sufficient to entirely mask and overpower the dimension we seek to obtain. Even were we at great inconvenience to make a full-size drawing of the bracket, we could hardly, with the most scrupulous care, obtain more than an extremely rough approximation to the result sought. To carry out the operation satisfactorily, we need to do our plotting on a scale at least 10 times the full size of the structure; but this is out of the question, requiring in the present case a sheet of paper more than 100 feet square.

At this point comes in the artifice upon which the method depends. The arcs of circles used are in every instance excessively short compared with their radii—in the case at present postulated they are not much more than 1 inch long for radii of 100 and 140 feet respectively. Such short arcs may, with but infinitesimal and perfectly negligeable error, be replaced by straight lines perpendicular to the radii, and if this be done there is no need to draw but a very minute portion of the gigantic diagram previously referred to.

In Fig. 2 OB_1 represents to a scale of ten times the full size the elongation of AB in Fig. 1, and OB_2 to the same scale the shortening of BC. OB_3 is to the same scale the total movement of B when the load is imposed, and B_1B_3 the deflection of the structure, also magnified ten times. As a matter of fact, B_3 should be by an excessively minute amount lower and more to the left than shown, as B_1B_3 should have been an arc of 100 feet radius with its centre to the left, and B_2, B_2 one of 140 feet radius with its centre in the direction OB_2. But the error is imperceptible, being by calculation less than $\frac{1}{1000}$-inch, and therefore absolutely imperceptible on an ordinary drawing.

The extension of the method to more complex cases is comparatively easy. Let us suppose the bracket or cantilever in Fig. 1 extended by another triangle or panel as in Fig 3, and stressed to the same degree as before. Then, in Fig. 4, the part shown in full lines is identical with Fig. 2. OB_3 represents in magnitude and direction to the enlarged scale the movement of B. To find that of D we proceed as follows:—Draw OD_1 to represent the movement of D due to the shortening of DC, OD_2 its movement in the direction BO due to the motion of B from O to B_3, being the resolved part in that direction of the motion OB_3, and D_2D_3 the motion in the same direction due to the elongation of BD. Then, drawing the perpendiculars D_1D_4 and D_3D_4, we find D_4 and OD_4 is the total motion of D and D_1D_4, the deflection of the cantilever. D_1D_4 of course ought to be an arc of a circle of 200 feet radius, and D_3D_4 one of 140 feet radius, but the difference between them and the perpendicular is imperceptible under the conditions of ordinary draughtsmanship.

The extension of the system from cantilevers to ordinary trusses supported at the ends presents but little difficulty. It is merely necessary to treat each as a pair of cantilevers, regard the central point as fixed, and finding how much the ends move upward relative to it. This will give the deflection, which can then be compared with the actual measured deflection of the structure under its test load. The subjoined example will illustrate this, and the various steps are indicated by the lettering. C is taken as the reference point or origin.

In this diagram—

CD_1 = upward motion of D due to shortening of CD
CB_1 = motion of B due to motion CD_1
B_1B_2 = ditto lengthening of BD
CB_3 = ditto shortening of BC
CB_4 = resultant motion of B
CE_1 = motion of E due to lengthening of ED
CE_2 = ditto upward motion of B
E_2E_3 = ditto shortening of BE
CE_4 = resultant motion of E
CA_1 = motion of A due to motion CE_4
A_1A_2 = ditto lengthening of EA
CA_3 = ditto shortening of AC
CA_4 = resultant motion of A
A_3A_4 = Deflection of centre of truss when loaded to a scale 10 times full size.

In a similar way the deformations and deflections of various forms of roof and bridge frames may be worked out in a very few minutes by any one that has had a little practice in the system.

This system has been given in lectures and examinations for some time past at the Melbourne University, and the students appear to find no difficulty in following and applying it even in cases considerably more complex than those given above.

RURAL CHURCHES.

By A. North, F.R.V.I.A.

By nature, man is a copyist rather than an inventor, and in no science has he shown greater aptitude for imitation than in architecture.

The most pronounced and typical features which have tended to give fixity to any recognised architecture style, when traced to their original source, are found to be but the crude attempts of a copyist to reproduce a petrified repetition of more primitive modes of construction, or those natural features which were most intimately associated with the every-day wants of his existence.

Should we desire to verify the truth of this assumption, it will be necessary to search among the mists of a hoary antiquity. We must, in fact, go to the cradle of our civilisation both in time and place, for the dawns of civilisation and architecture are contemporaneous.

Since that time architecture has passed through many phases. It has successively adapted itself to the conditions of many forms of civilisation, to many diverse religious systems, and to the requirements of many extreme climates; but change from one type to another was slow, and almost imperceptible.

Little by little, one generation added to the knowledge possessed by its fathers, but always building on the foundation already laid. Sometimes, it is true, progress was more rapid than at others, and it must also be admitted, that like the progress of evolution in nature, there appeared those unavoidable periods of stagnation, and even retrogression.

We call those return waves by names which are synonymous to decline and decay, but they were in reality breathing spaces during which architecture stored up new vigour and vitality which enabled it to soar to heights never attained by any previous type.

Individual man seldom travelled far on any given path of progress. An original mind might initiate the transition to a new style, but the fixity and development of the type would be left for other men to perpetuate and embellish.

As civilisation spread, architectural culture was necessarily carried to climes dissimilar to those which had evolved the transported type; yet history teaches us that many generations of men lived and died before that exotic architecture breathed in sympathy with its new environments.

No man ever invented a new style of architecture, for the present is merely the result of the past.

What generic resemblance can the superficial observer see between the pessimistic gloom of an Egyptian temple, and the optimistic audacity of a mediæval cathedral? Yet that elegant cluster of Gothic shafts, with the finished beauty of its sculptured capitals, and the symmetrical sweeps of its cut base, is the lineal descendant of those bundles of Nile reeds, tied together at top and bottom for additional strength, which supported the primitive dwellings on the Nile banks, long before the stone architecture of Ancient Egypt was reduced to a science.

Why, it may be asked, has the development of architecture been so slow, whilst other arts and sciences have leaped forward as if by magic during these recent years of rapid progress? The reason surely is not far. Not only during the Middle Ages, but up to within very recent years the study of many sciences was looked upon as dangerous. Students were hampered, persecuted, and otherwise discouraged from pursuing the study of these forbidden subjects, because those in authority imagined that any weakening of the belief in accepted tradition, was equivalent to the severing of every bond which held society together.

The forbidden sciences thus unnaturally retarded in their progress were behind the spirit of the age, and their abnormal advance within recent years is but the result of suppressed development; not a true index to the permanent rapidity of their growth.

The practice of architecture on the other hand was never looked upon with suspicion. Among its professors are to be numbered some of the keenest intellects and most cultured thinkers of Ancient, Mediæval, and Modern times, Yet the men who left the most indelible marks of success on the sands of history are those who have most loyally striven to follow the traditions of their art, and who have shown themselves best fitted to utilise the accumulated knowledge and experience transmitted to them from past ages, amending their designs as fresh information was obtained, new wants felt, and the conditions of life changed.

This was a true upward evolution, gradual yet certain. It is self-evident that a science which has been consistently studied for the last 6000 years, will not be so sensitive to the thoughts of a new mind, to the touch of fresh fingers, as one whose very name cannot be found in a dictionary 60 years old.

Are we then to say that because architecture has received so much study in past ages, that nothing original now remains to be accomplished; that no opening exists for genius, that a modern architect must necessarily be a mere copyist?

Nothing could be further from the truth, and I would like to direct your attention to the condition of the average church buildings in the rural districts of this and the adjoining States, as evidence that the design and construction of these erections is as yet very far from perfection.

When the first colonists settled on these Southern shores, they found no indigenous architecture in these lands, on which to graft their ideas; consequently—like their domestic animals and cultivated plants—they brought with them just so much of the science and arts of Europe as would serve their needs.

These early colonists were not art-loving men; moreover, art was not a necessity to their existence. Their yearnings for the beautiful in architecture were not exacting, and so we need not be surprised that many of our earliest church buildings—even of pretentious dimensions—are scarcely capable of bearing serious art criticism.

It is only fair to bear in mind that at the time of the first European settlement in these States, not only architecture, but most of its allied arts, were undergoing one of these periods of stagnation or retrogression to which I have already referred.

As the early settlers came from England, it was only natural that they should select that style of church building with which they were familiar. In this they did well, for England not only contains better examples of rural church architecture than any other country, but there was the further advantage, that continuity of form and association were secured as nearly as was possible under existing conditions.

The unfortunate part of the matter is, that the change took place when art was at such a low ebb, and that very bad copies of debased buildings were made by untrained and incompetent men.

The evil effects of unfortunate conditions under which church architecture was introduced into these States, is not easily obliterated. The earlier generations of colonists grew up under the influence of the worst examples, and when general taste improved, they had not the advantage of those historic buildings in their midst, which spoke to the people of older lands, of an art which was better and more elevating than the associations of their every-day life.

I think I am correct in saying that religious buildings have exercised a greater influence in evolving, developing, and fixing the various styles of architecture than the far larger number of buildings devoted to secular use.

In former days, men lavished the best they had on the sanctuary in which they worshipped, as the temples of Egypt, Greece, and the Orient, the mosques of the Saracenic world, and the churches, cathedrals, and abbies of Christendom bear ample evidence.

In modern times—especially in the rural districts of new countries—the ancient order of things is reversed. Secular public buildings are often ornate; but only isolated instances occur of any attempt to erect a church which shall be in itself an act of worship, a shrine worthy of the object of our adoration.

I write this as an architect, and I ask the question, is it merely a passing phase, inseparably connected with the settlement of people in new lands—where we must temporarily bow to the inevitable, and have the necessary room now, trusting that the beautiful may replace it hereafter—or is it, that men are really not sincere in their professions; otherwise, how can the wealthy be content to live themselves in expensive and ornate dwellings, and then worship the Creator, whom they profess to esteem above all earthly things, in an unworthy building ?

If men mean anything when they express their gratitude to the Giver of all things for his bounty, their mode of thankfulness—so far as church buildings is concerned—has at all events the advantage of economy.

Apart from this aspect of the case let us glance at another, the educational and the Æsthetic.

Possibly religious buildings will never again be the sole instrument of evolving and fixing a national style of architecture. Still, I venture to think that they will continue to play an important part in influencing natural taste. Who can doubt, but that the three or four generations who have grown up in this State since its first settlement, and who have been in the habit of attending weekly since their earliest childhood some hideous erection in the rural-districts, have not had their appreciation of the artistic, and appropriate, thereby dwarfed. The eye requires education as well as the mind, and the mere fact of its being compelled to look on ugly and false things, renders it less capable of appreciating the refined and the true.

It is well that our important public buildings should be of high artistic merit; but they can only be in a few given centres, whereas every village throughout the land either has, or aspires to have its church.

If all these village churches could be made amenable to the true principles of science and art what an enormous effect they would have in moulding public taste; and what a difference they would make in the appearance of the landscape!

In England, there are now remaining about 9000 parish churches dating from the Middle Ages, which are spread throughout the length and breath of the land. Fergusson, in his "History," says:—"They are not so magnificent as "her cathedrals, nor so rich as her chapels; but for beauty "of detail and appropriateness of design, they are unsur-"passed by either, while on the Continent there is nothing "to compare with them."

It is true that all critics do not regard the English rural churches as being of such high architectural value; but when all allowance has been made for the prejudice of antagonistic schools of design, and for those buildings which fall below the average standard of excellence, it must be admitted that there is more than a germ of truth in Fergusson's lavish praise, when these buildings are considered solely from an architectural standpoint.

There can, however, be no doubt concerning the peculiar charm which they impart to the English landscape. The grey church spire, peacefully nestling among the brilliant green foliage, seems inseparably connected with all thoughts of rural England, and indelibly stamps on the scenery a tone of finished beauty which no other country possesses.

I regard the English parish church as one of the highest triumphs of architectural evolution, because it so eminently fulfils the reason of its being, and is so entirely suited to its surroundings.

But how—you may ask—does this bear on the question of Tasmanian rural churches, and how may we emulate the English example? I reply: By following the precedent set us, and endeavouring to bring our rural churches in these States into as thorough sympathy with the conditions existing here, as did the designers of the rural churches of the Mother-land.

The English type is our natural heritage; it is the best of its class which exists anywhere. What, therefore, is more appropriate than that we should build upon that stock, emphasising such variations as the altered conditions of society, time, material, and climate render advisable; adding thereto all improved methods of construction, hygiene, and experience; abondoning that which is effeté, unmeaning, and obsolete.

Thus shall we be guided by the truest principles of science and art, thus may we most readily bring our rural churches into sympathy with their environments, thus only can we hope to make them a living branch of architecture.

The present time is most opportune, for meeting this question in a serious manner, because there now exists a large and seemingly continuous demand for rural churches.

The older settled districts of this State were provided with church buildings in the early days of colonisation, but their design was usually of such a character as no well-wisher of art would desire to see perpetuated. Many of these erections have been removed within recent years, and more appropriate churches now stand in their place. In other instances, the original structure remains in all its pristine ugliness, but I have no hesitation in saying that considerable discontent is felt against these designs, and in many cases people are only waiting for a favourable opportunity to replace them with something more worthy.

In the newly-opened-out districts there is a most decided demand for church buildings; this demand is not likely to be satisfied immediately, for as soon as settlers feel that they have made some satisfactory progress in carving a home out of the forest, and are able to face the future with composure, one of their aspirations is to erect a church where they may renew those religious associations with which they were so familiar in childhood.

When architects are called upon to supply this demand, they usually find that the amount of money at their disposal is insufficient to pay for such a building as they would like to see erected, and they also discover, that frequently the class of materials, and available workmanship, are of such a type as to severely tax their patience, energy, and resourcefulness.

Yet I appeal to them to carry out the work for art's sake, and to give ungrudgingly of their time and ability in so good a cause.

More particularly do I appeal to those who have the ordering of such new buildings to seek the best possible advice; to place the work in the hands of skilful and competent men; and then to be guided, as far as practicable, by such counsel as they may receive.

My professional brothers will agree with me that these commissions are as a rule far from being profitable. The amount of money available is usually so small, that the time expended on the design is altogether out of proportion to the remuneration received. Yet I venture to think that most architects would rather do the work on even these conditions, than see their art still further debased by some soul-racking conceptions of an illiterate bush-carpenter.

By far the larger number of rural churches in Tasmania are erected with timber. This material is not used by preference, but simply through the force of circumstances, for as timber buildings can be erected in this State at a smaller outlay than any other class of structures, the choice frequently rests between wood or nothing.

In view of these circumstances, I propose to direct your attention to timber churches before considering those constructed with more expensive and less perishable materials.

In England, the erection of wooden churches has practically been abandoned for some centuries past, but during early Saxon times such erections were by no means uncommon. The age of wooden churches in England has practically passed away, and what is more, nearly all examples of that phase of architecture have likewise vanished.

One old Saxon wooden church—or rather the nave of such a building—still remains. It is situated at Greenstead, in Essex, and was built in the year 1013; and within those identical wooden walls, once rested the body of St. Edmund when on its way to Bury for final interment.

I have prepared a sketch of this church as it now stands; the chancel of later date and was erected in the 16th century. The tower, dormers, and porch are also additions. The original nave is constructed with upright posts, known in the building trade as "chestnut." This term, when applied to English building timbers, must not be understood to mean the chestnut of our gardens, *Castanea sativa.*

Builders indulge in much poetic nomenclature, but few of the fictitious terms employed in their vocabulary are more misleading than the application of the wood chestnut for that variety of oak known as *Quercus robur pubescens.* This timber is generally supposed to be inferior to *Quercus robur sessiliflora*, but it is said to be distasteful to spiders. The large roof of Westminster Hall, erected in the reign of William II., is carved out in this cobweb-proof timber.

Perhaps one of the most remarkable wooden churches in existence is that at Borgund, in Norway. The church was erected in the 12th century, and I have introduced a sketch of this interesting building because I thought its antiquity, picturesqueness, and decided national character would be sound evidence of the possibilities of timber design.

When I was in Norway, I was much interested in observing some of their methods of timber construction. Buildings are sometimes erected in much the same manner as our pioneer farmers construct their log fences. The timbers, however, being roughly squared, halved, and dovetailed at intersections, so that the superimposed log shall rest closely on its next lower neighbour. The core of the wall thus becomes one solid mass of pine, whilst the outside and inside linings are nailed vertically to this framework, or are fixed diagonally or horizontally to upright battens.

It will be thus seen that instead of the dead monotony of our horizontal weatherboarding, Norwegian architects enjoy a latitude and freedom which is most refreshing when compared with our strict and impartial uniformity.

In addition to the variety of choice concerning outside covering, the Norwegian methods of construction are favourable to the formation of projections, and the corbeling out of upper stories, and decisive architectural features, with an ease and propriety with which we are altogether unfamiliar. For instance, imagine a building—even only one story in height—built on a basement of logs showing the semi-rounded face to the outside, on the top of this the walls may be covered with upright boarding to a level even with the tops of projecting windows, whilst the superstructure may be corbelled out for a short distance, and then completed to the soffit with a covering of horizontal or diagonal boarding. Gables may again project, showing the constructive framework behind picturesque barges.

I do not urge that Norwegian methods of construction should be copied; their climate, conditions, and requirements are not the same as ours, and the timber which that country produces is not like that which grows in this State. I simply wish to emphasise the fact that one timber-producing country has achieved a certain amount of success in the construction of wooden buildings suited to their requirements and resources; and if this has been done elsewhere, there is no reason why the timber-producing countries of Australia should not hope for a like measure of success.

The class of church I have been most frequently called upon to design for the rural districts of Tasmania, is a building which will seat from 80 to 150 worshippers, and which will cost from £100 to £350.

Besides the body of the church which accommodates the congregation, I am frequently asked to provide a chancel, a porch, a vestry, and a belfry. With these accessories, it must be self-evident that even the amount of £350 is sufficiently low to tax the ingenuity of any architect who may desire to produce a creditable structure.

Because a building must be erected cheaply, it does not of necessity follow that it should be absolutely hideous, much less does it require that the construction should be at variance with the accepted laws of science.

There is a kind of parsimony which borders on the ridiculous. Beyond a certain limit, the cost of efficient construction cannot be reduced, and that spurious economy which would strain the bounds of possibilities, is, in effect, the most unmitigated extravagance. This kind of cheapness is not legitimate; it is incompatible with art, and therefore no honest architect could carry out a commission on these conditions.

Even where sound construction is required at the lowest possible cost, I urge architects—in the interests of art—to decide whether or not they can afford to give the time such a building requires, before they accept the responsibility of preparing designs. It is a well-known fact in actual practice, that the more economically a building has to be erected, the more labour, thought, and time must be expended on the scheme by the architect. It is often far easier to carry out a liberally appointed building where cost is not a very important object, than to design an economical structure where the architect is hampered at every turn through want of funds.

In the first instance, however, the architect gets adequate remuneration for his work, but in the second case he does not receive a fair monetary return for his labour. Whilst he is scheming and planning to save his clients money, he is also working hard to cut down his own commission.

I have pleasure in submitting to you a few designs for cheap wooden churches which I have from time to time carried out. I do not pretend that any of these structures are perfect; nobody, indeed, is more conscious of their shortcomings than the author. I know, however, that many of them are not exactly as they would have been had I been allowed to carry out my own dreams of structural beauty. The stern realities of actual practice are most potent in vapourising the ideal. Difficulties of site, difficulties of available meterials and workmanship, want of funds, the preconceived ideas and prejudices of employers, are all very real facts. Indeed, an architect scarcely ever has the chance of doing as he would—he must simply do the best he can under existing conditions; and this is what I have endeavoured to do.

I do not intend to dilate at length on the subject of the planning of small timber churches. The limits of variation are not large, yet it is surprising how many shades of difference are possible within circumscribed limits.

Generally speaking, the plans of a wooden church do not differ from the plans of a similar structure in brick or stone, except so far as may be necessitated by the altered character of the material employed. As churches, like all other buildings, are erected primarily from a utilitarian point of view, it should be the first care of architects to see that the ground plan is so arranged that all matters affecting the comfort and convenience of the congregation and clergy shall be perfect, and the suitability of the building for public worship shall leave nothing to be desired.

This I take it for granted must be accepted as an essential matter, but as the needs and possibilities of different districts differ so essentially, it is not possible to discuss their various requirements within the limits of a short paper like the one I am now reading.

There are, however, some points of general application, and I now propose to bring a few of them under your notice. To commence:—A true artist will always endeavour to so arrange his ground plan, that when the building is completed, its outline shall be appropriate, and pleasing to the eye.

Gothic architecture is essentially a monumental style, that is, its success depends largely on the symmetry and beauty of its outlines or sky-line, for its perfections—no amount of beautiful detail fully compensates for an ill-formed building.

It is also well to bear in mind that the more clearly and simply a finished building expresses the purposes for which it is used, in every feature, the more nearly it conforms to the highest ideals of constructive art.

Further, it is well to bear in mind, that a small country church should not attempt to look like a miniature cathedral. What appears appropriate and sublime on a large scale, becomes mean and ridiculous when reduced to the scale of a toy. Few things indeed more keenly offend my eye than those gabled excresences, about six feet square and serving as vestries, which one so often sees protruding from the sides of small country churches, which look as though they would like to be mistaken for majestic minster-transepts.

The scale of our ordinary wooden churches is not sufficiently extensive to admit of any unnecessary multiplication of architectural features, and I strongly recommend that accessory accommodation shall wherever practicable be so utilised as to increase and not diminish the scale of the structure.

This idea has induced me in some instances to place the vestry at the end of chancel behind the altar; and,in my judgment, a distinct gain has been thereby effected, not only in the outside and inside appearance of the building, but also in economy. I have employed this arrangement both in Anglican and Roman Catholic churches, and the only complaint I have received is that when members of the congregation use the vestry, as they are sometimes compelled to do, there is no means of getting from the church to the vestry without crossing the length of the chancel. This is considered to be undesirable.

When the vestry is placed in this position, the floor is fixed a few steps below the floor line of chancel. A low screen hides the occupants of vestry, but this screen is not sufficiently high to hide the east window. The vista down the building is thus lengthened, and, according to a well-know artistic truism, the picturesqueness of the interior is heightened by the partial obstruction which the screen offers.

I have also come to the conclusion that it is not advisable to make the roof of chancel lower than the line of main roof if the size of the building is small. This may be a matter of choice, and, of course, circumstances alter cases; but, generally speaking, I fancy the results are more satisfactory where the ridge-line is level, besides which the break of level means more expense, less space, and a more fussy outline.

The main point to bear in mind when designing a wooden church is to see that the ornament and construction used is absolutely suited to the material which is being employed. All imitation of purely stone construction should be rigidly shunned.

A pointed arch carried out in timber is a miserable sham. It does not make the design any truer to the historic style it parodies, but stamps the building as the work of an idealess copyist fit only to perpetuate that abominable debasement of honest construction known as "Carpenter's Gothic."

The deception deceives no one—it has not even the merit of being beautiful but even if it was, the wooden arch should be condemned, because such a construction is unscientific; and that which is illogical, and unsound in principle, can never be acceptable in art.

Timber lends itself more readily to picturesque and ornamental construction than does stone, but the character of embellishment required for one material is entirely unfitted for the other; yet, as most of the timber buildings of the Middle Ages have passed away, while the stone ones remain, it appeared to the modern copyist of mediæval work. that if he wished to reproduce Gothic buildings in wood, there was no alternative but to copy the stone churches which still exist.

It is true that all mediæval designers were not artists: still the architectural remains which have come down to the present day show that the greater number of them must have been men with intense artistic feeling, and certainly the standard of public taste was keener, and more exacting, than anything which now exists.

I do not say that mediæval designers never imitated stone construction—because the unbalanced mind has existed in all ages—but I do say that such imitation was not the rule, and where it did occur, the result was not such an outrageous offence against good taste as is an every-day occurrence with modern work. If mediæval architecture possesses one quality more than another, it is the feeling of truth, and the sense of propriety which pervades their designs.

This state of things was the result of a constant striving after architectural perfection. Mediæval architects had not the literary reserve we possess, they had not the same facilities for travel, and—in England at all events—they had few examples of historic buildings with which to compare their own designs; yet, during that period which we regard as the living era of Gothic art, we see a constant growth towards a higher type, and a higher ideal. Original errors and falsehoods are abandoned. Symmetry and proportion were improved, until at last their buildings seemed to testify in every detail that they were erected to suit only the special purpose for which they were used, and that they could not have been built so satisfactorily in any other material, at any other time, or in any other locality.

During Saxon times, many stone churches were built with rubble, faced at intervals with vertical stone quoins and pilasters—stone posts, in fact.

It is possible that these posts, which were generally only "shiners," may have been copies of Roman pilasters, yet it is far more probable that they were imitations of the wood construction prevalent at that time. Examples of this class of work still remain in the towers of Earl's Barton, Barton-upon-Humber, and Barnack, and are sometimes spoken of as "stone carpentry."

What convinced our forefathers of their constructive transgressions we cannot tell. Probably neither book learning, nor logical reasonings based on an analytical study of measured examples. Such helps we have, but we have not yet reached absolute perfection. Such helps they had not, yet they amended their ways.

Slowly, but surely, our forefathers advanced on the path of true progress, and only a few generations later, when the architectural development of the Middle Ages was at its best, it might with truth be said of its artists—that, when they worked with stone, they showed us the legitimate possibilities of that material as no age had ever done before; when they employed metal, they wrought us a dream of exquisite beauty, whose memory will not fade with the lapse of time; and when they used timber they produced a design of ornamental and constructional propriety which could not be executed in any other material without bordering on the grotesque.

If architecture could thus, during the Middle Ages, be developed on such strictly scientific lines, how is it that we, with our more perfect system of general education, fail to produce equal results?

Our race has not degenerated. No period of the world's history shows a better record of individual scientific and artistic capacity; and architecture—along with its sister arts—now produces true artists, but they appear as individuals, and their work does not seem to raise the whole tone of general buildings.

If we are thus compelled to lament that the general artistic tone of buildings falls short of a standard which might reasonably be expected in this enlightened age, we are forced to the conclusion that the fault lies not with architects, but with the building public, who will not take the trouble to see that their commissions are placed in the hands of capable men.

An inventor may perfect and simplify an hitherto clumsy appliance, and then place his results before an appreciative public; a manufacturer may produce a better finished and less costly article, and then push its sale in the open market; a painter, even, may place the results of his genius on canvas, and then offer the work for sale—but an architect must wait for a commission before his ideas can assume practical form; for architectural drawings are not the end in themselves, but only the means to an end.

THE TWENTIETH CENTURY HOUSE: A SUGGESTION TOWARDS THE SOLUTION OF THE SERVANT PROBLEM.

By John Sulman, F.R.I.B.A., Lecturer Sydney University.

The great and bitter cry of the distressed middle-class housekeeper of the present day in advanced countries like Australasia and the States, is the impossibility of obtaining capable servants, or indeed, in many cases, of obtaining any at all. And without servants the middle-class house, as we know it, is practically unworkable. All the signs of the times point, not to any alleviation, but rather to the accentuation of the difficulty, for as the status of the so-called "working classes" is improved, and wages increase, daughters will be less and less inclined to "go out to service," and if they wish to add to the family income, or provide pocket-money for themselves, will rather choose occupations with definite hours of labour which leave their evenings free, and do not cut them off from their own home and family life.

Many are the suggestions that have been made to meet the difficulty, but they are mostly of the palliative order. Says one, "Give the girls more liberty, let them out more frequently;" but to be valued the time must be in the evening, and the locality the city; and this is good neither for mistress nor maid, as some domestic work must be performed after the evening meal—we cannot all live in the city, and freedom for young girls at night without home restraint is not wholly desirable.

Another suggests a central bureau, from which servants may be sent out by contract to do specific work, in specific hours; but I have not heard of it being tried, though it will probably come. Many have attempted to solve the difficulty by employing girls of their own class, "lady helps," but the lack of physical strength and early training in household work, and the roughness of the work as at present conducted, renders this method only a partial success. There is in it, however, the germ of a possible solution; but if the demand became general the supply of workers would soon be exhausted.

Many have given up in despair the attempt to keep house at all, and have fled to hotels, flats, and boarding-houses as a refuge; but these are only the unmarried, or the married without children, and if the essentially British character of our population is maintained, this system is not likely to find general favour, even among the unencumbered, as the desire to possess a home of one's own, however small, is inherent in our race. For parents with young children, a house is absolutely essential if the well-being of the next generation is to be properly cared for. Of course, the wealthy will still be able to obtain domestic help as at present by paying highly for it, and possibly by employing relays when the hours of work are reduced, as they are certain to be; but this will still further accentuate the difficulty for those less well-off, and force on some other solution for the great mass of middle-class people of moderate means.

The foregoing considerations have long been patent, and it has occurred to me that the solution can be materially aided by the architectural profession, if public interest can be aroused and the intense conservatism of the average middle-class man, and especially woman, can be broken down. For the dwellings we now possess, even the most modern, are based on the root idea of two classes inhabiting the same domicile. This, of course, is a survival of the past, and commenced in the earliest ages, when slaves were plentiful. It was continued through the Middle Ages, when the household still included many retainers whose position was but little better than that of their predecessors. They were, however, apparently regarded as subordinate members of the family, and treated as such, so that their lot was not so hard as it would appear to us. The complete severance of interest between mistress and maid did not fully develop till the last century, and may be traced to many causes. Hence, the houses of the nineteenth century show a distinct separation of the two sets of inhabitants, and writers on house-planning do not fail to emphasise the fact. This separation is particularly noticeable in the kitchen department, the servants' sitting and sleeping quarters, and staircase thereto, and the provision of a passage (misnamed a hall) to give access to the front door without passing through any of the rooms.

In a house to be worked without resident servants of an inferior class, this separation is needless; and it goes without saying that the middle-class house of the future must be as compact and easily worked as it is possible to make it. It does not follow from this that the rooms need be any smaller than at present, as it is no economy of labour to be cramped, but it is essential that every unnecessary room, and especially every passage, shall be eliminated. Commencing at the entrance, an enclosed porch is evidently desirable to cut off draught from the apartments within, and to provide hanging space for hats, coats, &c. From this the hall may be entered—and by hall I mean, not the narrow draughty passage now known by that name, but the spacious apartment of our ancestors, which served as a general family gathering-place and living-room. From this the dining or eating room may be entered, and it need be no larger than would suffice for a sideboard, table, chairs, and sufficient passage-room around them. The not uncommon practice of making it a second sitting-room is insanitary, as, above all things, free ventilation between meals is essential to remove the odour of food, and it also tends to make the other sitting-room into a sort of show-place, used only on special occasions. In the house of the future there will be no room for anything so useless.

The most radical changes will have to be made in the kitchen department, which, as now planned, assumes one servant to cook and another to serve a meal in the dining-room. When the members of the family, or an assistant of equal status, have to do the cooking and serving, the present arrangements are impossible. I have seen it suggested that we shall have to go back to the roomy farm kitchen of olden days, and take our meals in the same apartment in which they are prepared; but I do not think this is necessary, and in a warm climate it would certainly be undesirable. But the kitchen must certainly be easily accessible from the dining-room, or where a servant is not available may open directly from it; and it might even be advisable that the opening should be wide, and closed with glazed doors, so that the stove may be in full view, while odour is kept out. The kitchen itself need not be large, as it will be no longer a sitting and dining room for the servants, and may combine in itself the functions of kitchen, scullery, storeroom, and pantry, for without a parlour-maid a separate store for china and glass is unnecessary. But it should be fitted in the most perfect manner possible to ensure cleanliness and expedite work.

First of all, the walls should be tiled throughout, the floor paved with marble, tiles, or some non-absorbent and impervious material, and the ceiling also rendered non-absorbent. The dirty coal fire cooking-range must give place to a clean and perfected gas-cooker or electrical appliances as soon as they are available. These should be placed at such a height that no stooping is required, set in a recess, and covered by a hood connected with a flue, so that the fumes of cooking would be removed as soon as generated. But here I must anticipate an objection that is sure to be raised, viz., the possibility of the supply of gas or electricity beyond the limits of towns. Well, in the country, the old order will have perforce to remain for a time; but as already the greater part of the population of civilised countries lives in urban districts, and the tendency is towards their increase, the objection is not so serious as may appear at first sight. And with the development of electric power, I quite anticipate the time when not only domestic work, but much of the farm labour of the country, will be carried on by this agent. But to return to the kitchen. The old-fashioned dresser will probably be superseded by ranges of cupboards, with glazed doors, in which all crockery, glass, plate, &c., will be kept in full view, but protected from dust. Cupboards for stores will also find a place on the walls; and there will be drawers for napery. The mistress will thus have everything to her hand, when wanted. A separate recess or closet, to be used as a larder, must, however, be provided; but this may be entered direct from the kitchen, or from a lobby adjoining, and need only be of moderate size; indeed, a space of 4 feet by 2 feet should be ample for a small middle-class household, as stores and food are now delivered daily in all urban districts. It should be divided by marble shelves into several separate stages for vegetables, milk and butter, pastry and bread, cooked and uncooked meats; and each stage should, of course, be separately ventilated.

One of the most difficult of domestic problems is that of "washing-up" after meals. It is unpleasant work, and takes a lot of time. Mr. H. G. Wells, in his interesting forecasts of the present century, in the *Fortnightly Review*, suggests soaking all the dirty articles in some chemical solution which will dissolve the grease, and then rinsing them in clean water. The idea seems feasible, and might be easily managed if a large and deep sink were provided which would resist the chemicals used, and also transmit heat easily. The crockery, &c., would be loosely packed in the sink, the cleansing solution run in and run off when it had served its purpose, the process repeated with clean rinsing water, and then by lighting gas heating jets underneath, the whole would be rapidly dried, and ready to put away for the next meal. The same method might also be applied to the cleansing of cooking utensils, and if made of aluminium, they would be light to handle, and easily kept clean outside, as well as in.

An ample and continuous supply of hot water is, in a modern house, an absolute necessity; and it will no doubt have been noted that the abolition of the coal fire range cuts off the hot water supply. It may be met by an American invention called the "Vulcan water-heater," which consists of a galvanised-iron water cylinder, and a small separate copper coil heated by gas, much the same in principle as the well-known bath-heaters. A thirty-gallon apparatus of this kind can be purchased in Sydney for nine pounds, and it is claimed that it will heat in three-quarters of an hour, and can be kept going for three halfpence per hour with gas at 4*s.* per thousand feet. For a small houshold this will no doubt suffice, but if a larger supply is needed I am inclined to think a vertical self-feeding boiler in a small cellar would be better, and certainly cheaper. With a good reservoir for coal, charging twice a day should suffice. Such a boiler would also afford a perfectly sanitary method of speedily getting rid of kitchen refuse, which if allowed to collect, even for 24 hours, in a hot climate is a source of danger to health.

In a servantless house every kind of work that can be deputed to outsiders will be, and therefore the washing of clothes and linen need not detain us—it must be done at a laundry; but a desirable reform is the provision of a proper receptacle for soiled linen which can be easily disinfected and cleansed. It should be kept outside, rather than inside the dwelling, say on a back verandah. For the drying of damp garments, or airing insufficiently dried linen, a drying chamber should be provided in connection with the hot water cylinder or boiler.

The sending out of linen to wash suggests the possibility of putting out the cooking as well; and one of the reforms of the near future in all populous centres is likely to be the establishment of co-operative kitchens, from which meals will be distributed to dwellings in the vicinity at probably little, if any, greater cost than those prepared at home. The economy in purchasing food wholesale, and in cooking in large quantities, is great, and would certainly pay for the cost of delivery. In fact, this method is already adopted in large institutions, such as hospitals, asylums, barracks, gaols, and other aggregations of humanity. The carts, trucks, or delivery vans are kept hot by tins of hot water. and in Sweden the system is actually in work for private dwellings, felt-lined boxes being used which conserve the heat of the food for a considerable length of time. With the supply of food might be combined the supply of crockery, or rather of light aluminium plates and dishes, &c.; thus solving both the cooking difficulty and the still greater one of washing-up. In that case, three-fourths of the domestic work of a house would be eliminated, and the kitchen might be reduced to the smallest dimensions, sufficient only for the preparation of a light or occasional meal, or special dishes that the co-operative kitchen would not ordinarily supply. The relief to the oppressed housekeeper would be so great that it really appears to me worth while to try the experiment in the neighbourhood of one of our larger cities. As a commercial speculation, I believe it would pay handsomely.

It will be noted that I have only referred to two rooms for family use, the hall, and the dining-room. In many cases, the master and the mistress will need a private room of their own: the man for reading, study, smoking, or converse with male friends; and the lady for special feminine visitors, for needlework, for retirement when tired, or for reading and writing, or study. In America, where the servant difficulty is still more acute than with us, a small room opening off the hall, called "The Den," is provided for the former, and a little boudoir for the lady. But the latter often prefers to use her bedroom, as it is larger and more airy, saves a separate room, and, as arranged in America, makes a good sitting-room.

This brings us to the sleeping quarters; and in warm climates, if these can be arranged on the ground-floor, much labour in running up and down stairs is saved. A bedroom in the States, is usually a fair-sized apartment, and except for the bed and dressing-table is quite unlike bedrooms in Australasia. The rest of the typical bedroom furniture is invisible, and a couch, easy-chairs, and a table or two complete the equipment, making it into a comfortable sitting-room. The washing apparatus invariably consists of a large fixed lavatory basin, with hot and cold water laid on, enclosed in a cupboard, so that all pipes may be left visible and accessible (they are of nickel-plated copper), and towels may be hung up to dry. Owing to the severe winter climate, these cupboards are always to the inside of the building to prevent the pipes from freezing, and hence they have no light or ventilation, except from the room itself. With us it would be better to place the lavatory cupboard next the outer wall, and put a window in it. I have noticed that fixed lavatories are being introduced into the newest houses in Hobart; but are placed in the bedrooms. This I consider a mistake, as however perfect a lavatory may be as a fitting, there is always a faint odour from it that is undesirable. It arises from the water in the trap, and from the overflow pipe, which cannot be kept perfectly clean. In a man's bedroom, a looking or shaving glass could be placed above the lavatory, and the dressing-table be dispensed with. A good, roomy hanging cupboard should be always provided, large enough to get right into, so that the upper part may be shelved for clothes, linen, &c., not in use; and on one side should be a chest of drawers, unless they are preferred in the room itself. The door of the cupboard should be fitted with a mirror in one large sheet to serve the same purpose as the usual wardrobe-door looking-glass.

All the bedrooms would be more or less alike, and, arranged in the manner I have described, would afford their occupants a private room of their own, when they needed quiet or retirement. Where there are young children, I would, however, suggest from practical experience, that the bedroom should not be used as a day-room, but the provision, instead, of a large room of the plainest character, almost or quite detached, and approached by a verandah. In it they could keep their toys, and shout or romp to their hearts' content; and if it could not be kept very clean, it would not affect the house itself. In the playroom of my own house, I have made many shutters, but few windows, and so can turn it into an open air playground.

If the house is two-storied, the position of the staircase is of some importance. It must be accessible from the hall, but should not, as in the States, ascend directly from it; for in that case the hall becomes draughty, and every sound from below penetrates to the upper rooms, and all service thereto must pass through the hall. A better position is between the hall, the dining-room, and the kitchen; and if the staircase has a separate external entrance, so much the better, as then every room in the house becomes accessible from outside without passing through another.

A common American custom is to connect the family rooms in general use by folding-doors. These have the advantage of making the most of a small house when friends are entertained, and are so far useful; but they have the disadvantage of allowing sound to penetrate very easily from one to the other when closed. A cellar or basement is also almost universal, and with a climate of extremes where much artificial heating, and the attendant piping, has to be provided for, is no doubt necessary. But with us a cellar for cool storage in summer, and for a hot water boiler, is all that is required; for sanitary reasons the ground-floor should, however, be raised quite three feet above the ground, and this height would be sufficient to give access to gas and water pipes, &c., for repair.

The heating of rooms in our climate is, I think, best carried out individually, rather than collectively, as in the States; and in the house of the future, where labour saving is of the first importance, the open wood or coal fire is out of place. It means carrying heavy fuel into the rooms, and the production and removal of dust. Gas fires, though not so cheerful, must be their substitute; and, of course, every fire must have its own flue.

The mention of dust suggests the point, that, after cooking, the heaviest household work is cleaning; but with the abolition of unnecessary rooms and passages, this in the modern house would be much reduced. It may be still further minimised by a better method of building, and especially of furnishing.

In the matter of building it is of the utmost importance, for sanitary reasons, that all inaccessible hollow spaces should be eliminated. The worst of these is that between the floor and ceiling, and hence a good solid floor is a desideratum. It may be made with concrete and steel joists, and on this the floor covering should be solidly laid. To my mind, there is nothing better than the hardwood parquetry almost universal on the Continent of Europe. It is ornamental, close-jointed, and wax-polished, so that washing is unnecessary, and a weekly rub over with a "frotteur" and a little turpentine and wax keeps it clean and sweet. Nailed-down carpets, especially of a fluffy nature, should be rigidly excluded, as they are a prolific source of dust, and a few loose rugs of close texture substituted. Skirtings should be solid, and preferably of a hard cement, with the angle between the walls and floor round as in hospital wards. The walls should be cemented and finished off with one of the finer plasters, as Keene's or Parian, instead of the wretchedly ineffective hair-mortar commonly used, and the ceilings should be finished with cement laid directly on the concrete. In a room thus constructed there would be no harbour for dust, and if the furniture be kept plain and simple, and the hangings few, and non-absorbent, the labour of cleansing would be reduced to a minimum. And here I must have a tilt at the ordinary drawing-room, which is crammed with knick-knacks, photograph-frames, loose cushions, drapery, and the odds and ends of all descriptions which the superior sex delights in surrounding itself with. It is inartistic, as the eye is absolutely confused and bewildered by the multiplicity of petty objects, so that anything of real value is probably unnoticeable; and it is, to my thinking, as wanting in taste as for a woman to wear all her jewellery at once. The Japanese, the most artistic race of the world, can in this matter, as in many others, teach us a lesson. Every home in the "Land of the Rising Sun," however humble, possesses a few works of art, which are kept carefully stored, and brought out one at a time for the pleasure of the inmates, and thus day by day come with the charm of freshness. We might do worse than follow their example. Such a course would render our rooms more sanitary, more easily cleaned, and far more comfortable—to the "mere male," at any rate; and when the present craze for a multiplicity of petty objects has had its day, our wives, sisters, cousins, and aunts, will find they can be just as happy as their grandmothers were, before the era of cheap frivolities overwhelmed us.

It may be objected that the house I have sketched though slightly smaller in size than those of the present, would be much more expensive to build. I quite admit it. But the saving in domestic labour would more than compensate. Let us a assume a family of six persons. In an ordinary middle-class house, they would probably keep two servants. The cost of each servant for board and wages would be at least £50 or £60 per annum. With a properly arranged dwelling, one could be dispensed with, and instead of the other let us assume a highly trained lady-help, or a capable educated servant, coming daily to do her work, and leaving when finished. They would and should receive higher wages than at present. but a saving of one person's food, and say half her wages, would be effected, equal to about £40 per annum. This at 5 per cent. represents a capital value of £800, which would be available for extra expenditure on the dwelling. A very good house for a family of six can be built for £1200, so that with £800 added, £2000 would be at command without incurring a greater total annual expenditure than at present. But so much would be quite unnecessary, as £300 extra, or a total of £1500, would amply suffice for all the improvements I have suggested, and thus a saving of £500 in capital could be effected.

One further point I would like to emphasise; and that is the absolutely necessity of a better and more practical system of education for the whole community. Firstly, for the workers who build the house—and I am sorry to say that in my opinion the skill of workmen is deteriorating, owing mainly to the craze for cheapness amongst employers, and also to the policy of the trades unions, whose sole aim seems to be higher wages, to attain which a restricted output, rather than enhanced skill, is fostered. Secondly, for house-users, a more practical training is absolutely essential, if the appliances I have suggested, and others that will rapidly follow, are to be a help instead of a hindrance. Every woman at the head of a household should know the why and the wherefore of all sanitary and mechanical appliances, how to use them, and keep them clean and in working order, and should be able on occasion to tighten up a nut, washer a tap, regulate a valve, drive a nail or a screw straight, or do at intervals the hundred and one little odd jobs that appliances of any kind entail; or otherwise, she will become, still more than at present, the prey of the predatory plumber, and the last state of that household would be worse than the first.

THE TRAINING OF MINING ENGINEERS.

By HENRY C. JENKINS, A.R.S.M., Assoc. M. Inst. C.E., Victoria.

THE training of mining engineers is so important a matter in the Australian Commonwealth—where mining is directly and indirectly one of the main industries, and in some parts the main industry; and where the problem as to how to make a legitimate profit for shareholders becomes daily a matter more and more one calling for scientific skill—that it hardly needs any apology for being brought before the notice of the Association.

It may, however, be asked, What is a mining engineer? And the term is certainly to-day both wide and vague—as wide and vague as the allied term "mining manager." Both of these terms are to some people synonymous as to persons who recognise the two classes, if indeed there be two classes, as persons whose business in life is to earn a profit for all concerned by actual mining operations, and who rather reserve the term "mining engineer" for those who by general training and wide practical experience have fitted themselves to be consulted with profit by clients, reserving, too, the term "mining manager" for those whose actual occupation at the moment is the direction of some definite undertaking. Such a manager may be, and should be, a man of high attainment in science, in practice, and in commercial skill, and one who would be in a lucrative consulting practice only that certain persons see it to their advantage to retain his full services for their own undertaking. The manager may, however, have an undertaking of moderate size, or else a small one; and in the latter case, the drudgery that must be done, and the pinch of poverty that small concerns often feel, tends far too much to make the average manager in some parts of Australia merely the superior workman—a man who energetically follows his own limited stock of knowledge, and "follows the pick-point." Not but that there should be the easiest possible road made for the intellectual industrious man to acquire the necessary engineering and other knowledge that would fit him to take part in management—the men who rise by merit get this knowledge somehow or other, even though they do not know it by its proper name. The unfortunate fact is, that there is still a large class of manager that we cannot discuss further except to say that it will be all the better for the country when the technical college makes the race extinct and people who are not managing mines, but who control them, learn that a manager has, or should have, far more intellectual and onerous duties than the directions of simple muscular effort. When it is recognised that a manager is the operating mining engineer, then there is some prospect of finding more mines laid out with well defined design; of finding more frequently proper and complete plans and records of all the workings, instead of an uncertain tradition only of the same; of finding proper means taken to secure ventilation; of economical means for handling the large amount of material that miners have to move daily, without everything being done, as is too often the case, by manual labour, often in the most awkward way; of finding the mine systematically worked, instead of each pocket being emptied as it is found—large dividends paid for six months, and then a long blank, whilst four or six men are painfully at work trying to find another patch, and as many more men, by no means fully employed, on the surface looking after them, and all the expenses of the staff, such as it may be, still going on; all the capital sunk in machinery, and the previous mine operations standing idle and costing money. As to the men who ought to be kept steady at work, they are looking for jobs elsewhere, and waiting for luck to turn. Such is the state, too often, of the mine "paying calls"—waiting for the work that the directorate and the management should have done in the days of prosperity, when it would not have cost a third as much to do. Fortunate is such a mine if sheer grit and luck finally pull it through, and it gets at full work again; too often it shuts down, some one buys the plant, its pumps are drawn, and what might have been a source of profit to the whole district and its shareholders is lost practically for all time to the State. It is in marked contrast to some instances of mining that can be seen in Australia. And why? Simply the want of mining engineers on its directorate or management. To take another case, not so bad. How many mine engines would not be at once condemned as positive encumbrances of the ground if a few indicator cards were taken; or, rather, what a busy time there would be on valves and details in the machine and fitting shops of the district if a few good mechancial engineers were really let loose in some of our settled mining districts. Whether the wood-carters or the coal merchants would be at first equally well pleased is quite another matter; but their energies would be soon absorbed in consequence, probably to supply the fuel for a greatly increased output.

Shareholders would see more dividends, and the workers more employment. The mine manager should not be indifferent to mechancial engineering.

It will be obvious, upon examination of the matter, that there should be a far wider opening for mining engineers than the really limited scope for consulting practice, with which it is often confounded; but until this is more generally recognised by those who direct mining enterprise, it is to be feared that the really good candidates for employment will be drained from the districts in which they are really wanted, and will find better treatment elsewhere, paid by outside capital.

Although no real distinction can be drawn between mining engineers or managers, nevertheless there be a broad line that can be drawn; but it is lower down the scale. The miner himself, for instance, is all the better for some instruction in addition to that involving his personal skill in using his tools, although this may itself be increased. The many foremen, as shift-bosses, need still more instruction; but the instruction remains of a limited kind. The moment, however, a man is put in charge of a plant, and has the responsibility of the direction of operations, it becomes necessary for him, unless the undertaking be a very feeble one indeed, to have an intelligent knowledge of a great many operations; he must be an engineer in the broader sense of the word before he can be successful. Just as the mechanical engineer has replaced the old millwright, so should the modern mine manager have room made for him—the leader of the operations should have a higher kind of knowledge to that possessed by his foremen in either case.

The proper kind of education for the operative, over and above the correct manipulation of his tools, will not be further discussed, as it is a subject all to itself, but one would urge that every facility that is possible should exist for those men whom nature has fitted to find their way to management, whether by evening study or actual scholarship. As the author had the honour to assist in recommendations upon this subject in Victoria quite recently, he will not now deal with this side of the matter, but deal at once with the case of the men who, from the outset, seek to prepare themselves for leadership.

The mining engineer has really an extremely complex set of conditions under which to work. He has, in the first place, often to make a profit for all concerned out of what may be at the start something of the nature of a geological puzzle. The puzzle is often easily read; at other times this is more obscure. But read it must be unless the mine is to be made a blind gamble; and he has to be himself sufficiently of a geologist to know when and how the services of the specialist are needed. He does not want anything at all of much that the specialist delights in; but he must know the broad facts of the science well, and be as good a petrologist and mineralogist as his other duties allow.

The deposit has subsequently to be worked, and the mineral won by the regular operations of the civil and mechanical engineer; limited, indeed, in treatment by the conditions of mine work, and often temporary in character, but the same in kind, subject to the same physical economic laws; and he must therefore, be instructed in the broad general principles of the engineer's art, with much special training in some branches. It is quite true that his work often must have less finish than a civil or mechanical engineer would tolerate—this is because it is temporary and must pay; but, against this want of finish, must be set such a task to only take one example, as the sinking of the main-shaft of a large deep mine in wet ground, a task that may tax all the energy and skill of the specialists in all the three branches of the profession; but which must be done with the mining man as the central figure. Nowadays, he must have more than a passing acquaintance with the specialist in electrical science, and, although he must, as in previous cases, sometimes hand over a problem to the specialist for its solution, yet his own knowledge must be sufficient to keep the unity of the plan of his own work, and it should also enable him to pick the best for his own purposes out of competing solutions. In putting in underground motors, for instance, he should know what is, and what is not, suitable when presented to him, and not condemn electrical transmission because his electrical engineer was not a miner, nor electrocute his men because he is blindly trying to follow where other engineers are leading.

The mining engineer, particularly when managing a property, often has to decide many purely metallurgical matters; indeed, it is very hard to say where the line can be drawn between mining and metallurgy, except, perhaps, in the extreme cases, such as those of the colliery engineer on the one side, and the mint refiner on the other; for, after all, the product of the commodity that commands the profit is not complete until the metal is extracted. Some branches of metallurgy, say—that of iron, for instance, need more pure and refined mechanical engineering than any branch of mining. As far as scholastic training is concerned, it must be urged that the men need the same thorough instruction in general science, much instruction together in the main branches of the art of engineering, and it is only toward the end of a long course of work that specialisation should begin.

It is generally conceded that the practical part of engineering, the power of producing skilled work, the practical bias of mind that measures all the contemplated operations as being limited by the necessity of making the best possible profit at the end can only be very imperfectly imparted, if it can be imparted at all, outside the actual field of commercial operations; it certainly cannot be imparted by those who have never been under its influence. At one time or another in his life, the engineer must learn many things for himself outside a college. He can start the acquisition of this very well before he receives the higher part of his training; indeed, there are many reasons why he should do so; but it has the drawback of tending to interrupt the mental training, unless a tax is placed upon the health of the student by compelling him to take a practical course in commercial operations just before his studies become exceedingly heavy in character.

Usually, it is more convenient to defer the serious part of the instruction in practical operations until after the course. This has one great disadvantage, as that the student tends to view the world, for a long while afterwards, from a more or less false standpoint, and to bring collegiate work into unmerited disrepute, forgetful that the very best courses of study by themselves, and without practice in a profession, may make a philosopher, but will not make an engineer. The growing practice of appointing men of practical and commercial skill as well as of high mental attainment, as teachers in many of the subjects, does help the student to take the correct bias of mind, but the latter, to be safe, must remember that his college training is but his preparation for a far more serious study that must go on for years before he can claim to know his profession. He is fortunate if, during this period he is profiting by the experience of those older than himself, whom he may be assisting.

A word now as to the scholastic course itself. This should be the same for those whose ambition is to manage a fair-sized mine, as for those who think that they see ahead the sweets of a consulting practice. It should include the most liberal education that can be given in the time at a student's disposal in mathematics, chemistry, descriptive geometry, mechanical drawing, geology, physics, the elements of civil and mechanical engineering, the practice of surveying, and of assaying. This purely preparatory work can be dealt with in about three years, but the courses, just as is now the case in so many technical colleges for other classes of engineers, should, if at all possible, be specially designed to fit in with the object in view, namely, to impart that systematic and useful kind of information that shall serve the mining engineer, as well as educate him in the more liberal sense. Thus, whilst much in the ordinary general science courses of universities would bear considerable strengthening, other parts could be taken in a much reduced form, and retained chiefly for the sake of educational sequence. It is purely a matter of time, and the amount that the student really needs to be taught in order to fit him for his final year's work and subsequent career. During a fourth year of study, he could then be given a severe course of professional study in mining and metallurgy, and he can then pass away from college to concern himself with practical operations. It is at this stage of the final year's work that he will profit by having taken care to acquaint himself with practical operations, even though it may have involved the loss of some holiday leisure.

Men trained in this way would be eligible for very many openings in the management of the better class of mine, always provided that they will pay the same serious attention to their practical study of the manual operations that they pay to their mathematics, chemistry, or cricket. There is no need to spend a great amount of time at these studies of manual operations, provided that the student means to learn all he can, for his object is not to be a skilled rapid workman, as to know the work of one, and the circumstances surrounding it, and if it be viewed as a recreation, there is no serious drawback to time being diverted from holidays to the purpose. It must be remembered, also, that more men are wanted, well-instructed in both the practice and theory of the mining profession than a number of "mining engineers," whose acquaintance with profit and loss is rather that of the city office than the mining-field. The need of men of high training in the practical field of Australian mining is still great, and it is to the training of these men that one must look for the advancement of legitimate mining.

SOME OF THE PHYSICAL PROPERTIES AND USES OF NICKEL STEEL.

By W. H. Warren, M. Inst. C.E., M. Am. Soc. C.E.,
Challis Professor of Engineering, University of Sydney.

History.

The first suggestion for the practical application of nickel as an alloy with iron is due to Farady. In 1820 and 1821 he and Stodart made a considerable number of iron and steel alloy experiments, consisting of Swedish horseshoe-nail iron melted with 1 per cent., 3 per cent., 5 per cent., 10 per cent., 20 per cent., and 50 per cent. nickel. The metals were found to combine well, the 3 per cent. alloy being specially malleable, and working satisfactorily under the hammer. Farady's valuable experiments do not seem to have led to any commercial application in England, although they opened the way to what has since been accomplished in this direction. In 1885 nickel steel and nickel iron were manufactured at Mr. Marbeau's works at Montalaire, France, under the supervision of Mr. Berthcault. Similar results were obtained at the Imphy Works in 1887. In 1889 Mr. James Riley published his valuable paper on "Alloys of Iron and Nickel," and in 1894 a length of shafting of nickel steel was constructed for the American liner *Paris*.

In June 1895 the Pennsylvania Steel Company made a heat of about four tons of open hearth nickel steel for the purpose of investigating its physical qualities when rolled into plates and bars. The results obtained in their experiments were lower than those from nickel steel produced in the ordinary way, in consequence of the small ingots obtained from the heat not allowing for a sufficient reduction in rolling.

In 1896 an investigation was made on the properties of nickel and iron alloys by Prof. M. Rudeloff, Assistant Director of the Royal Prussian Testing Department, the alloys being melted in small quantities. The results are interesting as showing the influence of varying proportions of nickel on the physical properties of the alloys, and are briefly summarized as follows:—

Expansion by Heat.—The coefficient of expansion by heat was found to decrease with the increase in the percentage of nickel, but was greater with the 98 per cent. nickel alloy than with pure iron, thus—

Pure iron...	1·000
Iron and 4 per cent. nickel	0·943
Iron and 16 per cent. nickel... ...	0·891
Iron and 98 per cent. nickel... ...	1·091

Tensile Strength.—The elastic limit, yield point, and ultimate breaking strength increase gradually by the addition of nickel up to 10 per cent., after which a gradual decrease takes place up to 30 per cent. With a further increase of nickel the elastic limit and yield point decrease still more, while the ultimate breaking load increases, being greater with 60 per cent. than with 30 per cent. of nickel. The elongation decreases as the percentage of nickel increases, till at 16 per cent. it is almost zero; afterwards it increases up to 60 per cent. nickel, and then again decreases. The elastic limit, yield point, and elongation of pure nickel are approximately 60 per cent. of those of pure iron, the breaking loads being about equal.

Compressive Strength.—The results obtained in compression are similar to those obtained in tension, but the resistance increases up to 16 per cent. nickel, and then decreases.

Drop Tests.—The results obtained in the drop test show an increase in strength up to with 16 per cent. nickel, and then a decrease until with 30 per cent. nickel it is the same as pure iron. Shearing tests gave similar results to those in tension.

The following table gives the results of mechanical tests made by Mr. Hadfield and Professor J. O. Arnold* on practically pure iron and nickel:—

Material.	Condition.	Unannealed. Elastic Limit.	Unannealed. Tensile strength.	Unannealed. Elongation measured on 2"	Unannealed. Reduction of area.	Annealed. Elastic Limit.	Annealed. Tensile strength.	Annealed. Elongation measured on 2"	Annealed. Reduction of area.
		Tons per sq. in.	Tons per sq. in.	Per cent.	Per cent.	Tons per sq. in.	Tons per sq. in.	Per cent.	Per cent.
Iron { C. 0·08 % / Fe. 99·80 ,, }	Cast...	14	20	16	34	not	o b	t a i	ned.
	Forg'd	14	22	47	76	9	18	52	76
Nickel. { C. 0·16 % / Ni 98·80 ,, }	Cast...	11	16¼	4½	9¾	not	o b	t a i	ned.
	Forg'd	14	32¼	45½	57	7	31¼	54	52½

* Proc. Inst. C.E., vol. cxxxviii., page 8.

The foregoing table also shows that the elastic limit and strength of pure iron is about the same in the cast and forged specimens, and that the ductility of the forged iron is greater. The effect of annealing pure iron appears to be a reduction of the elastic limit and strength, without affecting its ductility to a great extent.

The cast nickel was harder to file than the forged, although its tenacity is so much less. The forged nickel is much stronger and more ductile than the cast, which is only slightly affected by annealing; whereas the elastic limit is greater in the forged than in the cast nickel, but is reduced to one-half by annealing. The specific gravity of the cast nickel in these tests was 8·839, and of the forged nickel 8·826, which differ slightly from the values given by Moisson—8·3 for cast, and 8·8 for forged nickel.

Coefficient of Elasticity.—The coefficient or modulus of elasticity of alloys of cast nickel and iron having various percentages of nickel have been investigated by the German Commission, and reported on by Professor Rudeloff. The results, reduced to English units, are recorded in the following table:—

Percentage of Nickel.	Coefficient of Elasticity in tons per square inch.
0·05	13,880
0·91	13,240
2·05	13,680
3·01	13,720
3·98	12,780
4·92	12,660
7·84	12,280
15·60	10,280
29·78	7800
59·60	9200
93·52	11,200
98·56	10,720

A similar investigation has also been made by M. Ch.-Ed. Guillaume, but the experiments were made on bars supported at each end and loaded in the centre, whereas Prof. Rudeloff's results were obtained by subjecting the bars to a direct tensile stress. Guillaume's results are recorded in the following table:—

Percentage of Nickel.	Coefficient of Elasticity in tons per square inch.
5	13,720
15	12,120
19	11,260
24·1	12,280
24·1	11,040
26·2	11,740
27·9	11,500
30·4	10,180
31·4	9830
34·6	9780
35·2	9450
37·2	9260
39·4	9590
44·3	10,340
100	13,660

The following table gives the elastic limit, the load at fracture, and the elongations measured on lengths of 1 and 2 inches, and represents a summary of the results obtained by the German Commission:—

Percentage of Nickel.	Tons per sq. inch.			Elongation per cent. measured on.	
	Proportional limit of Elasticity.	Apparent limit of Elasticity.	Load at Fracture.	1 inch.	2 inches.
0·05	4·25	9·90	21·52	34·3	27·9
0·91	4·32	10·34	20·96	29·1	24·1
2·05	6·45	12·80	23·52	26·1	22·7
3·01	10·24	15.20	25·72	23·4	20·1
3·98	10·56	17·08	25·72	20·1	17·6
4·92	12·46	20·64	28·24	12·9	10·8
7·84	14·46	28·00	35·68	11·1	9·6
15·60	10·20	28·00	25·88	0·9	0·6
29·78	4·60	8·63	6·3	2·8	2·2
59·60	3·80	7·93	24·00	37·9	36·1
93·52	2·54	6·85	21·08	20·1	19·0
98·56	2·28	5·80	19·34	18·8	17·1

Tests of Nickel Steel manufactured in Great Britain.—A valuable paper was contributed by Mr. William Beardmore to the Institution of Naval Architects in April 1897, which deals with tests of nickel steel and its application in steel forgings, more especially in propeller shafts, railway cranks, axles, crank pins, tyres, &c., also in plates for shipbuilding. The following table gives the results of Mr. Beardmore's tension tests on carbon and nickel steel, showing the characteristic properties of the latter material relatively to carbon steel:—

Comparison of the Yield Point and Breaking Strain of Nickel and Carbon Steel.

Thickness in inches.	Carbon Steel.		Nickel Steel.	
	Ultimate strength, tons per square inch.	Yield point in tons per square inch.	Ultimate strength, tons per square inch.	Yield point in tons per square inch.
3/16	27·7	13·5	51·3	29·5
3/16	28·3	13·6	53·9	28·7
1/4	27·6	13·7	54·1	28·6
1/4	27·5	13·9	52·9	29·2
3/8	27·7	14·0	52·4	30·4
3/8	28·2	14·5	51·8	30·6
1/2	28·5	14·1	52·5	29·0
1/2	28·3	14·3	49·6	28·9
3/4	28·5	14·0	50·5	28·5
3/4	27·9	14·0	51·0	28·4
1	27·5	14·5	48·7	28·3

Here the yield point of nickel steel is equal to the ultimate strength of carbon steel.

Mr. Beardmore states that nickel steel can be bent, punched, drifted, and welded successfully; he also gives some experiments by Mr. Whyte of Leith Docks on the behaviour of nickel steel, mild carbon steel, and wrought iron when exposed to the corrosive action of sea-water for one year, in which the loss of weight was as follows:—

> Nickel steel 1·36 per cent.; carbon steel 1·72 per cent.; wrought iron 1·89 per cent.

A large number of tests of nickel steel are recorded in Mr. Hadfield's paper on "Alloys of Iron and Nickel" Proc. Inst. C.E., Vol. CXXXVIII.), which is well worthy of careful study.

Nickel Steel from the Bethlehem Iron Works.—In the Bethlehem Iron Works, U.S.A., nickel steel forgings are made from fluid compressed, acid open-hearth steel, and are carefully annealed after forging. To get the best results it is necessary to use an ingot twice the diameter of the finished forging to be made from it, in order that the proper amount of work shall enter into the metal during the time of its reduction in size under the press. The ingot also should have from 30 to 50 per cent. extra metal at the top which is cut off, as only the lower portion of the ingot is solid and suitable for forging purposes. Whenever the form and size of the forgings will allow of such treatment, they should be made hollow by boring, and they may also be oil tempered. Presses should always be used in preference to hammers, and should produce a pressure penetrating to the centre and causing a flow throughout the mass.

The steel used in the field magnet rings of the large Niagara electric generators was made at the Bethlehem works. Each ring was forged in one piece, without welding, from an ingot of nickel steel, 54 inches in diameter and 197 inches long. The ingot was cast solid and compressed by hydraulic pressure in the fluid state and during solidification. A hole was bored in the ingot, which was subsequently expanded on a mandrel under a 14,000-ton hydraulic forging press. The material was tested after forging to obtain the physical qualities desired, the results being as follow:—

Sample No.	Tensile Strength pounds per sq. in.	Elastic Limit, pounds per sq. in.	Elongation on two inches, per cent.
1	82,915	53,560	27·05
2	81,110	47,230	25·75
3	82,140	49,280	22·50
Average	82,055	50,023	25·10

Tests of Nickel Steel manufactured by the Firm of Fried. Krupp, of Essen, Germany.—The firm of Fried. Krupp, of Essen, manufacture substantially two kinds of nickel steel, differing as regards the quantity of nickel contained therein; that is to say, one has a comparatively small quantity of nickel amounting to from 3 to 8 per cent., according to requirements, and the other contains a large quantity of nickel amounting to 25 per cent. and more. The former is made of various degress of hardness, as ingot nickel iron, mild and medium-hard nickel steel. Nickel steel containing a high percentage of nickel is of special interest, on account of its ability to withstand rusting in a high degree. This material offers, indeed, great resistance to breaking strains, and possesses considerable elongation; but its elastic limit is much lower than in steel containing about 6 per cent. of nickel, and it is therefore less adapted for parts of machines subject to great strains. Its use was intended for fire-boxes in the construction of locomotives, and for similar purposes.

The tests recorded in Tables I. to X. and XII. to XIV. inclusive were made on three kinds of steel in the author's laboratory, and include tension, compression, shear, and torsion tests. They are denoted in the test sheets, as follows:—

F, mild; T, medium-hard; E, non-rusting.

The analyses of the three qualities was as follows:—

	Carbon.	Silicon.	Manganese.	Phosphorus.	Sulphur.	Copper.	Nickel, per cent.
F	0·10	0·012	0·33	0·008	0·034	0·056	6·01
T	0·34	0·224	0·24	0·013	0·010	0·064	6·10
E	0·566	0·338	0·49	0·016	0·019	0·064	25·74

Table XV. gives the results of corrosion tests.

Table XI. gives the results of testing specimens of steel manufactured by Messrs. Vickers, of Sheffield, in a similar manner to the specimens of nickel steel. These were cut out of an ordinary railway axle, and were tested for the sake of comparing carbon steel of high quality with nickel steel.

Tables XVI. to XVIII. give the results of testing nickel steel containing approximately 6 per cent. nickel, but of three degrees of hardness, which include tensile, alternating, bending, and impact tests.

Tensile Tests.—The tensile tests made in the author's laboratory consisted in the first place in the determination of the elastic limit and coefficient of elasticity, the extensions being measured by Marten's mirror extensometer.* The test pieces were afterwards divided between the refer-

*See Journ. Roy. Soc., Vol. XXXI., pp. 89-111.

ence points into spaces of one quarter of an inch, and connected to the autographic apparatus, and tested to destruction. The yield point recorded in the autographic diagram is consequently higher than would have been the case if the test piece had not been previously strained in obtaining the true elastic limit. The results of these tests are shown in Tables I. to V., and in the Summary Tables X. and XI.

Compression Tests.—These consisted of the determination of the elastic limit and coefficient of elasticity as in the tensile tests, the compressions being observed with the Marten's mirror extensometer. The length of the specimen was 10 inches, and the diameter 1 inch. One set of readings was taken on a specimen 2 inches long. The compression strength was determined by using cylinders 1 inch in diameter and 1 and 2 inches long respectively. The compression strength was taken as the yield point of the test piece. *See* Tables VI. to IX., and Summary of Results, Table XII.

Alternating Bending Tests.—These tests were made on turned specimens, reduced along the length over which the bending moment and fibre stress was constant, and having rounded shoulders. The machine was designed and made in the author's laboratory, and is fully described and illustrated in Mr. Madsen's paper, "Investigation of the Effect of Alternating or Universal Repetitive Stresses upon the Physical Properties of Materials." The extreme fibre stress produced in the specimens of nickel steel tested was 54,085 pounds per square inch, and the number of repetitions varied from 13,800 to 29,050. The bars were afterwards tested in tension in the usual way, and the elastic limit determined with Marten's mirror extensometer, as in other tests of the same material which had not been rotated. The results are recorded in Table XVI., which also shows the effects of raising the temperature of nickel steel on its elastic limit, strength, and ductility. The lowering of the elastic limit by repetition of stress is clearly marked in the mild variety of nickel steel; but in the two harder qualities the effect is less noticeable. Probably the form of the test piece is not the best for the purpose. Experiments on the effect of repeated stresses on nickel steel are still in progress.

Impact Tests.—These consisted of tension tests in which the load was suddenly applied, and in transverse tests on nickel specimens supported on bearings 6 inches apart. The impact machine used was similar to the one in the Royal Testing Laboratory, Berlin, for testing specimens. The weight of the hammer used was 122·5 lbs. for tension tests, and 121·3 lbs. for transverse tests. These tests are only preliminary, and are still in progress, but Tables XVII. and XVIII. give some of the results obtained.

Torsion Tests.—These consisted of the determination of the value of f in the equation—

$$f = \frac{T}{0{\cdot}196\, d^3}$$

and the measurement of the total angle of twist in degrees. *See* Table XIII.

Shearing Tests.—These consisted of the determination of th load necessary to shear the specimen on two planes, *i.e.*, in double shear; the results are summarized in Table XIV.

Corrosion Tests.—To obtain an indication of the relative values of the nickel steels as regards their resistance to corrosion, specimen discs of various irons and steels were prepared, as shown in the accompanying table. These were first weighed and placed in a large beaker containing about a gallon of a weak* solution of sulphuric acid, which was maintained at a temperature of from 170°--180° F. for twenty-four hours. The discs were then removed, thoroughly cleaned, and re-weighed.

It is necessary to draw attention to the elastic limits obtained both in tension and compression, as the results may appear low when compared with similar results obtained from autographic apparatus. The large multiplication obtained by the Marten's mirror apparatus shows a deviation from the straight line much earlier than could be seen in any autographic diagram. Careful tests of Vicker's axle-steel made with Kennedy's extensometer gave an elastic limit of 16 tons per square inch, whereas the Marten's apparatus gave 14·5 tons per square inch. Until a standard method for determining this point is agreed upon, it will always be difficult to compare the results obtained by experimenters using different extensometers.

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* One part by weight of strong sulphuric acid to one hundred parts of water.

Table I.

Determination of the elastic limit and coefficient of elasticity in tension of nickel steel "F" (mild).

Length upon which elongations were measured = 150mm (6 in.)

Diameter = 0·6085″ Area = 0·2908 square inches.

Load in 1000 lbs.	Readings in $\frac{1}{5000}$mm.		Mean Extension[1] in $\frac{1}{10000}$mm.	Differences per 1000 lbs.	
	Top.	Bottom.			
0	3·12	2·19	5·31	1·56	
2·5	4·70	4·50	9·20	1·70	
3	5·10	4 95	10·05	1·86	
4	6 00	5·91	11·91	1·81	
5	6·90	6·82	13·72	1·89	
6	7·82	7·79	15·61	1·82	
7	8·75	8·70	17·43	1·87	
8	9·66	9·64	19·30	1·85	
9	10·58	10·57	21·15	1·87	
10	11·51	11·51	23·02	1·83	
11	12·44	12·41	24·85	1·93	
12	13·41	13·37	26·78	2·04	† Limit of Elasticity
13	14·43	14·39	28·82	2·60	
14	15·70	15·78	31·42		

† Limit of Elasticity = 12,500 lbs. or $\frac{12,500}{0\cdot2908}$ = 43,000 lbs. per sq. in. (19·2 tons)

Coefficient of Elasticity = 27,730,000 lbs. per sq. in.
= 12,375 tons per sq. in.

[1] Obtained by adding the figures in the preceding two columns.

Table II.

Determination of the elastic limit and coefficient of elasticity in tension of nickel steel "T" (medium).

Length upon which the elongations were measured = 150mm. (6in.)

Diameter = 0·609″ Area = 0·2911 square inches.

Load in 1000 lbs.	Readings in $\frac{1}{5000}$mm.		Mean Extension in $\frac{1}{10000}$mm.	Differences per 1000 lbs.
	Top.	Bottom.		
0	0·00	7·00	7·00	
				1·13
1	0·48	7·65	8·13	
				1·87
2	1·30	8·70	10·00	
				1·91
3	2·18	9·73	11·91	
				1·90
4	3·10	10·70	13·81	
				1·92
5	4·03	11·70	15·73	
				1·74
6	4·85	12·62	17·47	
				1·87
7	5·78	13·56	19·34	
				1·88
8	6·80	14·42	21·22	
				1·87
9	7·79	15·30	23·09	
				1·89
10	8·78	16·20	24·98	
				1·64
11	9·62	17·00	26·62	
				1·88
12	10·60	17·90	28·50	
				1·80
13	11·52	18·78	30·30	
				1·90
14	12·50	19·27	32·20	
				1·90
15	13·48	20·62	34·10	† Limit of Elasticity
				2·16
16	14·48	21·78	36·26	
				2·11
17	15·62	22·75	38·37	
				2·19
18	16·66	23·90	40·56	
				2·46
19	18·00	25·20	43·02	
				4·23
20	20·00	27·25	47·25	

† Limit of Elasticity = 15,500 lbs. or $\frac{15,500}{0·2911}$ = 53,200 lbs. per sq. in. (23·75 tons)

Coefficient of Elasticity = 27,120,000 lbs. per sq. in.
= 12,110 tons per sq. in.

Table III.

Determination of the elastic limit and coefficient of elasticity in tension of nickel steel "E" (non-rusting).

Length upon which the elongations were measured = 150 mm. (6 in.)

Diameter = 0·6075″ Area = 0·2899 square inches.

Load in 1000 lbs.	Readings in $\frac{1}{5000}$ mm.		Mean Extension in $\frac{1}{10000}$ mm.	Differences per 1000 lbs.	
	Top.	Bottom.			
0	0·00	5·00	5·00		
				0·08	
1	−0·02	5·10	5·08		
				2·02	
2	+0·72	6·38	7·10		
				2·16	
3	1·76	7·50	9·26		
				2·04	
4	2·82	8·48	11·30		
				2·08	
5	3·92	9·46	13·38		
				2·13	
6	5·08	10·43	15·51		
				2·11	
7	6·22	11·40	17·62		
				2·11	
8	7·34	11·39	19·73		
				2·26	† Limit of Elasticity
9	8·52	13·47	21·99		
				2·78	
10	9·89	14·88	24·77		
				4·03	
11	11·85	16·95	28·80		

† Limit of Elasticity = 8,500 lbs. or $\frac{8500}{\cdot 2899}$ = 29,350 lbs. per sq. in. (13·1 tons)

Coefficient of Elasticity = 26,340,000 lbs. per sq. in.
= 11,760 tons per sq. in.

Table IV.

Determination of elastic limit and coefficient of elasticity of Vicker's axle-steel No. "5" in tension.

Length upon which extensions were measured = 150 mm. (6 in.)

Diameter = 0·610″ Area 0·2922 square inches.

Load in 1000 lbs.	Readings in $\frac{1}{5000}$ mm. Top.	Readings in $\frac{1}{5000}$ mm. Bottom.	Mean Extension in $\frac{1}{10000}$ mm.	Differences per 1000 lbs.
1	1·39	7·52	8·91	
				1·75
2	2·15	8·51	10·66	
				1·83
3	2·99	9·50	12·49	
				1·81
4	3·89	10·41	14·30	
				1·78
5	4·77	11·31	16·08	
				1·82
6	5·66	12·24	17·90	
				1·73
7	6·51	13·12	19·63	
				1·78
8	7·39	14·03	21·42	
				1·84
9	8·29	14·97	23·26	
				1·87 † Limit of Elasticity
10	9·20	15·93	25·13	
				1·86
11	10·09	16·90	26·99	
				2·74
11·5	10·78	17·58	28·36	

† Limit of Elasticity = 9500 lbs. or $\frac{9500}{0{\cdot}2922}$ = 32,500 lbs. per sq. in. (14·5 tons)

Coefficient of Elasticity = 28,680,000 lbs. per sq. in.
= 12·805 tons per sq. in.

Table V.

Determination of the elastic limit and coefficient of elasticity in tension of Vicker's axle-steel No. "6."

Length upon which elongations were measured = 150 mm. (6 in.)

Diameter = 0·610″ Area = 0·2922 square inches.

Load in 1000 lbs.	Readings in $\frac{1}{5000}$ mm.		Mean Extension[1] in $\frac{1}{10000}$ mm.	Differences per 1000 lbs.
	Top.	Bottom.		
2·5	2·41	7·69	10·10	
				1·66
3	2·79	8·14	0·93	
				1·78
4	3·60	9·11	12·71	
				1·68
5	4·40	9·99	14·39	
				1·75
6	5·25	10·89	16·14	
				1·74
7	6·10	11·78	17·88	
				1·75
8	6·97	12·66	19·63	
				1·84
9	7·87	13·60	21·47	
				1·92 † Limit of Elasticity
10	8·82	14·57	23·39	
				2·61
11	10·10	15·90	26·00	

† Limit of Elasticity = 9500 lbs. or $\frac{9500}{0·2922}$ = 32,500 lbs. per sq. in. (14·5 tons)

Coefficient of Elasticity = 29,000,000 lbs. per square inch
= 12,950 tons per square inch.

Table VI.

Determination of elastic limit and coefficient of elasticity in compression of nickel steel "F" (mild).

Length upon which contractions were measured = 10″

Diameter = 1″ Area = 0·7854 square inches.

Load in 1000 lbs.	Readings in $\frac{1}{5000}$mm.		Mean Compression in $\frac{1}{10000}$mm.	Differences per 1000 lbs.
	Top.	Bottom.		
1	0·00	4·00	4·00	
				1·01
2·5	1·20	4·32	5·52	
				0·46
3	1·27	4·48	5·75	
				0·85
4	1·81	4·79	6·60	
				0·86
5	2·35	5·11	7·46	
				0·93
6	2·90	5·49	8·39	
				0·85
7	3·39	5·85	9·24	
				0·86
8	3·85	6·25	10·10	
				0·89
9	4·30	6·69	10·99	
				0·91
10	4·79	7·11	11·90	
				0·89
11	5·29	7·54	12·79	
				0·91
12	5·69	8·01	13·70	
				0·86
13	6·11	8·45	14·56	
				0·87
14	6·55	8·89	15·43	
				0·90
15	6·98	9·35	16·33	
				0·87
16	7·40	9·80	17·20	
				0·90
17	7·80	10·30	18·10	
				0·86
18	8·18	10·78	18·96	
				0·92
19	8·60	11·28	19·88	
				0·86
20	8·98	11·76	20·74	
				0·88

Table VI.—*continued.*

Load in 1000 lbs.	Readings in $\frac{1}{5000}$ mm.		Mean Compression in $\frac{1}{10000}$ mm.	Differences per 1000 lbs.	
	Top.	Bottom.			
21	9·37	12·25	21·62		
				0·90	
22	9·75	12·77	22·52		
				0·91	
23	10·13	13·29	23·43		
				0·88	
24	10·51	13·80	24·31		
				0·89	
25	10·88	14·25	25·20		
				0·80	
26	11·30	14·70	26·00		
				0·87	
27	11·67	15·20	26·87		† Limit of Elasticity
				0·99	
28	12·08	15·78	27·86		
				0·94	
29	12·40	16·40	28·80		
				0·92	
30	12·70	16·98	29·72		
				1·00	
31	13·15	17·57	30·72		
				1·05	
32	13·55	18·22	31·77		
				1·07	
33	14·02	18·92	32·94		
				1·30	
34	14·60	19·64	34·24		

† Limit of Elasticity $= 27{,}000$ lbs. or $\frac{27{,}000}{0{\cdot}7854} = 34{,}400$ lbs. per sq. in. (15·35 tons).

Coefficient of Elasticity $= 28{,}770{,}000$ lbs. per square inch
$= 12{,}850$ tons per square inch.

Table VII.

Determination of elastic limit and coefficient of elasticity in compression of nickel steel " F."

Length upon which contractions were measured $= 2''$

Diameter $= 1''$ Area $= 0{\cdot}7854$ square inches.

Load in 1000 lbs.	Readings in $\frac{1}{5000}$ mm.		Mean Compression in $\frac{1}{10000}$ mm.	Differences per 2000 lbs.
	Top.	Bottom.		
5	0·40	4·39	4·79	
				0·34
6	0·55	4·41	4·96	
				0·32
8	0·69	4·59	5·28	
				0·26
10	0·85	4·69	5·54	
				0·29
12	1·02	4·81	5·83	
				0·33
14	1·19	4·97	6·16	
				0·30
16	1·34	5·12	6·46	
				0·35
18	1·50	5·31	6·81	
				0·36
20	1·67	5·50	7·17	
				0·35
22	1·82	5·70	7·52	
				0·39 † Limit of Elasticity
24	2·01	5·90	7·91	
				0·46
26	2·12	6·15	8·37	
				0 53
28	2·48	6·42	8·90	
				0·67
30	2·85	6·72	9·57	
				0·44
32	3·02	6·99	10·01	
				0·79
34	3·40	7·40	10·80	

† Limit of Elasticity $= 23{,}000$ lbs. or $\frac{23{,}000}{0{\cdot}7854} = 30{,}580$ lbs. per sq.in. (13·1 tons)

Coefficient of Elasticity $= 28{,}140{,}000$ lbs. per square inch.
$= 12{,}560$ tons per square inch.

Table VIII.

Determination of the elastic limit and coefficient of elasticity in compression of nickel steel "T."

Length upon which contractions were measured = 10″
Diameter = 1″ Area = 0·7854.

Load in 1000 lbs.	Readings in $\frac{1}{5000}$mm.		Mean Compression in $\frac{1}{10000}$mm.	Differences per 2000 lbs.	
	Top.	Bottom.			
5	2·10	5·74	7·84		
				1 77	
7	3·10	6·51	9·61		
				1·69	
9	4·01	7·29	11·30		
				1·75	
11	4·96	8·09	13·05		
				1·74	
13	5·89	8·90	14·79		
				1·76	
15	6·83	9·72	16·55		
				1·79	
17	7·76	10·58	18·34		
				1·72	
19	8·61	11·45	20·06		
				1·78	
21	9 52	12·32	21·84		
				1·76	
23	10·41	13·19	23·60		† Limit of Elasticity
				1·80	
25	11·31	14·09	25·40		
				1·78	
27	12·18	15 00	27·18		
				1·80	
29	13·08	15·90	28·98		
				1·82	
31	14·00	16·80	30·80		
				1·83	
33	14·91	17·72	32·63		
				1·92	
35	15·88	18·67	34·55		
				1·86	
37	16·81	19·60	36·41		
				1·93	
39	17·79	20·55	38·34		
				2·02	
41	18·76	21·60	40·36		
				2·18	
43	19·85	22·69	42·54		
				2·18	
45	20·96	23·76	44·72		

† Limit of Elasticity = 23,000 lbs. or $\frac{23,000}{0·7854}$ = 29,300 lbs. per sq. in. (13·1 tons)

Coefficient of Elasticity = 28,170,000 lbs. per square inch
= 12,570 tons per square inch.

Table IX.

Determination of elastic limit and coefficient of elasticity **in** compression of nickel steel " E."

Length upon which contractions were measured = 10″

Diameter = 1″ Area = 0·7854 square inches,

Load in 1000 lbs.	Readings in $\frac{1}{5000}$mm.		Mean Compression in $\frac{1}{10000}$mm.	Differences per 1000 lbs.
	Top.	Bottom.		
1	0·00	0·00	0·00	
				1·00
2	0·50	0·50	1·00	
				0·98
3	0·98	1·00	1·98	
				1·02
4	1·50	1·50	3·00	
				1·00
5	2·00	2·00	4·00	
				1·00
6	2·50	2·50	5·00	
				1·00
7	3·00	3·00	6·00	
				1·00
8	3·50	3·50	7·00	
				1·00
9	3·98	4·02	8·00	
				0·92
10	4·40	4·52	8·92	
				0·94
11	4·86	5·00	9·86	
				1·01
12	5·35	5·52	10·87	
				1·02
13	5·85	6·04	11·89	
				0·95
14	6·32	6·52	12·84	
				0·98
15	6·80	7·02	13·82	
				0·99
16	7·30	7·51	14·81	
				1·00
17	7·80	8·01	15·81	
				0·98
18	8·29	8·50	16·79	
				1·01
19	8·80	9·00	17·80	
				1·00

Table IX.—*continued.*

Load in 1000 lbs.	Readings in $\frac{1}{5000}$mm.		Mean Compression in $\frac{1}{10000}$mm.	Differences per 1000 lbs.
	Top.	Bottom.		
20	9·27	9·53	18·80	
				0·96
21	9·73	10·03	19·76	† Limit of Elasticity
				1·06
22	10·26	10·56	20·82	
				1·04
23	10·78	11·08	21·86	
				1·08
24	11·30	11·64	22·94	
				1·03 Specimen was permanently bent.
25	11·81	12·16	23·97	

† Limit of Elasticity = 21,000 lbs. or $\frac{21,000}{0·7854}$ = 26,750 lbs. per sq. in. (11·99 tons)

Coefficient of Elasticity = 25,460,000 lbs. per sq. in.
= 11, 360

Table X.—Summary of Results obtained in Tensile Tests of Nickel Steel.

Test No.	Description.	Original Dimensions.		Stress in Pounds.		Stress in tons per sq. in.	Limit of Elasticity in tons per sq. in.	Yield Point in tons per sq. in.	Ratio of Limit to Break per centum	Contracted Dimensions.		Contraction of Area, per cent.	Elongations measured after fracture.		Local Elongations, in.	General Elongation, per cent.	Co-efficient of Quality.	Co-efficient of Elasticity in tons per sq. in.
		Diameter in inches.	Area in sq. ins.	Total.	Per sq. in.					Diameter in inches.	Area in sq. in.		On 6 ins.	On 3 ins.				
F	Mild	0·608	0 2908	73600	21400	32·88	19·2	23·05	58	0·319	0·0806	72·3	1·75	1·08	0·41	22·3	7·3	12375
T	Medium......	0·609	0 2911	114250	33250	51·40	23·75	36 00	46	0·460	0·1662	43·0	1·30	0·80	0·30	16·6	8·5	12110
E	Non-rusting.	0·607	0·2705	106100	28700	47·88	13·10	23·75	27	0·321	0·0811	70·0	2·35	1 35	0·35	33·3	15·7	11760

NOTE.—The yield points were raised in consequence of the elastic limit having been first determined by Marten's mirror apparatus.

Table XI.—Summary of Results obtained in Tensile Tests of Vicker's Steel.

Test No.	Description.	Diameter in inches.	Area in sq. ins.	Total.	Per sq. in.	Stress in tons per sq. in.	Limit of Elasticity in tons per sq. in.	Yield Point in tons per sq. in.	Ratio of Limit to Break per centum	Diameter in inches.	Area in sq. in.	Contraction of Area, per cent.	On 6 ins.	On 3 ins.	Local Elongations, in.	General Elongation, per cent.	Co-efficient of Quality.	Co-efficient of Elasticity in tons per sq. in.
5	Vicker's axle steel, test pieces cut from the same axle.	0·610	0·2922	76200	22250	34·15	14·5	25·22	42	0·408	0·1261	56·5	1·30	0·85	0·40	15·0	5·1	12805
6		0·610	0·2922	77000	22500	34·40	14·5	22·48	45	0·406	0·1260	56·6	1·23	0·80	0·37	14·0	4·8	12950
2a		1·125	0·9941	77153	76700	34 40	14·5	20·85	45	0·770	0·4656	53·16	on 10 in. 2·10	on 5 in. 1·46	0·82	12·8	4·4	
1a		1·125	0·9941	75940	75500	33·94	14·5	20·70	42	0·760	0·4458	55·16	2 53	1·59	0·65	18·8	6·3	
1b		0·840	0·5541	76240	42250	34·03	14·5	...	42	0·565	0·2507	54·75	2·30	1·41	0·56	17·8	6·0	
2b		0·840	0·5541	76240	42250	34·03	14·5	...	42	0·567	0·2525	54·44	1·72	1·13	0·46	11·8	4·0	

NOTE.—The yield points in table were raised in consequence of the elastic limit having been first determined by means of Marten's extensometer. In Nos. 5 and 6 the true yield point, from extensometer readings, was 18·4 tons per square inch.

Table XII.

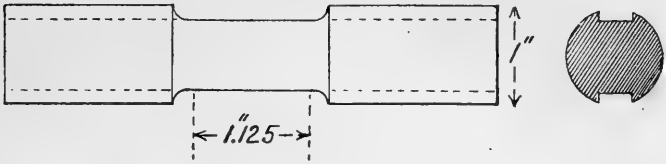
Summary of Results obtained in Compressive Tests of Nickel Steel.

Diameter of test piece 1 inch, area 0·7854.

Reference Letter.	Description.	Length of test piece in inches.	Elastic limit in tons per square inch.	Coefficient of elasticity in tons per square inch.	Compressive strength in tons per square inch.	Maximum load applied in tons per square inch.	Plastic compression with maximum load per lin. in.
		10·00	14·50	12705			
F	Mild ...	2·00	...	...	24·2	44·5	0·11
		1·52	...	...	...	63·6	0·26
		10·00	13·10	12570			
T	Medium ...	2·00	...	...	42·0	69	0·137
		1·48	...	...	...	73	0·172
		10·00	11·99	11360			
E	Non-rusting	2·00	...	...	25·3	55·5	0·115
		1·49	...	...	25·3	70·0	0·175

Table XIII.

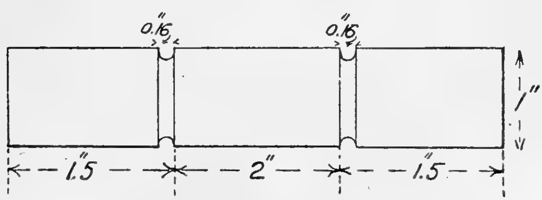
Torsional Tests of Nickel Steel.



Reference Letter.	Diameter of test piece in inches.	Length of test piece in inches.	Total twisting moment in inch pounds.	Value of f in equation $f = \frac{T}{0{\cdot}196d^3}$ in pounds per sq. in.	Total angle of twist in degrees.	Length of test piece after fracture in inches.	Percentage of elongation or shortening.
E	0·715	1·125	10931·3	152578	900	1·140	+1·3
	0·714	1·125	6809·6	95448	405	1·120	—0·44
T	0·714	1·125	8960·0	125591	180	1·125	0

Table XIV.

Shearing Tests.



Reference Letter.	Diameter in inches.	Area in square ins.	Total load in double shear in pounds.	Double shear per square in. in pounds.	Single shear per square inch.
E	0·780	0·4778	99456	208096	104048
F	0·783	0·4815	71568	148624	74312
T	0·783	0·4815	95200	197568	98784

Table XV.

Description of Specimen.	Original Weight, grains.	Final Weight, grains.	Loss in Weight.	Loss in Weight per cent.
Nickel Steel, E (non-rusting)	No loss	could be	detected.	
„ „ F (mild) ...	743·0	731·8	11·2	1·51
Krupp, Essen, K	755·1	736·4	18·7	2·48
„ $\frac{HE}{K}$ (special ingot iron)	747·5	726·8	20·7	2·77
Dalziell's Steel	738·5	715·9	22·6	3·06
Patent Shaft and Axle Co. ...	738·3	705·3	33·0	4·47
Lowmoor Boiler Plate ...	731·0	694·0	37·0	5·06
Monkbridge Boiler Plate ...	733·2	690·2	43·0	5·86
Nickel Steel T (medium) ...	754·5	705·0	49·5	6·56

TABLE XVI.

Description.	Original Dimensions.		Stress in Pounds.		Stress in Tons, Per square Inch.	Limit of Elasticity, tons per sq. inch.	Ratio of Limit to Break.	Contracted Dimensions.		Contraction of Area, per cent.	Elongations, measured after fracture		Local Elongations	General Elongation, per cent.	Coefficient of Quality	Revolutions before testing.
	Dia. inches.	Area. sq. ins.	Total.	Per sq. inch.				Dia. inches	Area. sq. ins.		On 6″	On 3″				
Nickel Steel containing approximately 6 per cent. of Nickel, Mild	·625	·3068	22,800	74,320	33·18	23·4	71·9	·334	·0876	71·1	15·6	10·5	·54	17·0	5·6	...
	”	”	22,900	74,640	33·32	22·5	67·7	·340	·09079	70·4	16·75	10·8	·485	19·9	6·7	...
	”	”	22,750	74,150	33·10	22·5	68·1	·337	·08919	70·9	15·0	10·2	·54	16·0	5·3	...
	”	”	22,820	74,370	33·20	22·9	69·2	·337	·08919	70·8	15·48	10·5	·52	17·6	5·9	...
	”	”	22,550	73,500	32·81	20·3	62·1	·345	·09482	69·1	15·8	10·0	·42	19·3	6·3	20,200
	”	”	22,500	73,340	32·74	20·3	62·1	·345	·09412	69 1	16·0	8·4	·08	25 3	8·3	14,350
	”	”	This specimen broke in the Alternating Machine.							...	...	...	...	...	...	27,650
Ditto, Medium	·625	·3068	31,250	101,860	45·47	30·6	67·2	·427	·1432	53·3	11·6	8·0	·44	12·0	5·5	...
	”	”	31,000	101,050	45·11	30·6	67·8	·400	·1257	59·0	12·6	8·4	·42	14·0	6·3	...
	”	”	30,750	100,240	44·75	30·6	68·6	·385	.1164	62·0	13·0	8·7	·44	14·3	6·3	..
	”	”	31,000	101,050	45·11	30·6	67·8	·404	·1280	58·1	12·4	8·4	·43	13·4	6·0	...
	”	”	31,250	101,860	45·47	32·0	70·4	·396	·1232	60·0	13·6	8·8	·40	16·0	7·3	20,800
	”	”	31,250	101,860	45·47	31·7	69·9	·407	·1301	57·6	12·0	8·2	·44	12·6	5·7	13,800
	”	”	31,250	101,860	45·47	28·1	61·7	·393	·1213	60·4	12·7	8·6	·45	13·6	6·2	29,050
Ditto, Hard	·625	·3068	37,400	121,900	54·42	38·6	70·9	·480	·18095	41·0	9·6	6·6	·36	10·0	5·4	...
	·624	·30582	36,750	120,170	53·64	38·6	72·4	·480	·18095	40·8	9·3	6·4	·35	9·6	5·1	...
	·625	·3068	37,580	122,500	54·68	39·2	74·5	·479	·18019	41·2	9·4	6·4	·34	10·0	5·5	...
	”	”	37,243	121,520	54·25	38·7	72·6	·480	·18070	41·0	9·4	6·5	·35	9·9	5·3	...
	”	”	37,750	123,050	54·93	38·7	70·4	·471	·17417	43·2	9·2	6·1	·30	10·3	5·7	15,050
	”	”	36,275	118,240	52·78	37·8	71·6	·433	·14705	52·[illegible]	9·1	6·7	·43	8·0	4·2	28,450
	”	”	36,275	118,240	52·78	37·0	70·3	·472	·17490	42·9	9·0	6·2	·34	9·6	5·1	15,500
											On 5″	On 2½″				
Ditto	0·745	·4359	56,200	129,000	57·6	40·9	71·0	·620	·3019	30·7	0·80	0·44	0·08	14·4	8·2	*
	0·745	·4359	54,200	124,500	65·6	44·2	79·0	·570	2551	41·4	0·85	0·57	0·29	11·2	6·2	†

* Tested in an oil bath at a temperature of 505 p r cent. F. † Tested in the ordinary way.

Note.—The extreme fibre stress in all the rotating tests was 54,085 lbs. per square inch. Bending Moment = M, f = intensity of fibre stress, r = radius of specimen = ·3125″. $f = \frac{My}{I} = \frac{M}{\cdot 775403} = 54{,}085$.

Table XVII.

Drop Tests.—Tension.

Weight of Hammer 122·5 lbs.

No.	Description of Specimen.	Length	Diam.	Area.	No. of drops.	Height of drop in feet.	Extension in inches. on 3″	Extension in inches. on 6″	Work done per drop, ft. lbs.	Total work in breaking Specimen ft. lbs.	Remarks
		inches.									
1	Mild Steel, 6·1 per cent. Nickel.	6	·625	·306796	1	6·56	0·22		803·6	6830·6	Broke on 6th drop.
					2	9·84	0·45		1205·4		
					3	9·84	0·69		1205·4		
					4	9·84	0·97		1205·4		
					5	9·84	1·31		1205·4		
					6	9·84	1·53	2·1	1205·4		
2	Hard Steel, 6·1 per cent. Nickel.	6	·625	·306796	1	9·84	0·14	1·10	1205·4	7232·4	Broke on 6th drop.
					2	9·84	0·26		1205·4		
					3	9·84	0·40		1205·4		
					4	9·84	0·60		1205·4		
					5	9·84	0·81		1205·4		
					6	9·84	0·83		1205·4		
3	Mild Steel, 6·1 per cent. Nickel.	6	·400	·125664	1	6·56	·32	1·5	803·6	2009·0	Broke on 2nd drop.
					2	9·84			1205·4		
4	Mild Steel, 6·1 per cent. Nickel.	6	·400	·125664	1	9·84	·50	1·5	1205·4	2410·8	Broke on 2nd drop.
					2	9·84			1205·4		

5	Mild Steel, 6·1 per cent. Nickel.	6	·400	125664	1	10·18		1·2	1247·05		Not broken.
6	Mild Steel, 6·1 per cent, Nickel.	6	·400	·125664	1	10·118		0·82	1239·7		Not broken.
7	Mild Steel, 6·1 per cent. Nickel.	6	3 inches.	·070686	1	8·20				1004·5	Broke 1st. blow.
8	Medium hard Steel, 6·1 per cent. Nickel.	6	3	·070686	1	7·54	·58			923·6	Broke 1st blow.
9	Medium hard Steel, 6·1 per cent. Nickel.	6	3	·070686	1	6·56	·66			803·6	Broke 1st biow.
10	Medium hard Steel, 6·1 per cent. Nickel.	6	3	·070686	1	4·92	·60			602·7	Broke 1st blow.
11	Medium hard Steel, 6·1 per cent. Nickel.	6	3	·070686	1 2	3·28 3·28	— ·64		401·8 401·8	803·6	Broke 2nd blow.
12	Medium hard Steel.	6	3	·070686	1	4·10	·55			502·25	Broke 1st blow.
13	Hard Steel, 6·1 per cent. Nickel.	6	3	·070686	1	3·608	·45		441·9		First blow produced necking, not broken through.

Table XVIII.

Drop Tests—Transverse

Weight of Hammer 121·3 lbs.

No.	Description.	Breadth inches.	Thickness. inches.	Area. sq. inches.	No. of drops.	Height of drop in feet.	Work done per drop. ft. lbs.	Total work.	Remarks.
1	Mild Steel, 6·1 per cent. Nickel	1·02	1·02	1·0404	1 2 3	3·28 4·92 6·56	397·8 596·7 795·6	1790·1	1. Considerably bent 2. Began to open at nick 3. Bent at right angles and broke across
2	Mild Steel, 6·1 per cent. Nickel	1·01	1·01		1 2	6·56 6·56	795·6 795·6	1591·2	1. Bent and slight tear at bottom of nick 2. Torn
3	Mild Steel, 6·1 per cent. Nickel	1·01	1·01		1 2	6·56 6·56	795·6 795·6	1591·2	1. Slight opening at bottom of nick 2. Torn
4	Mild Steel, 6·1 per cent. Nickel	1·05	1·10	1·105	1 2	6·56 6·56	795·6 795·6	1591·2	1. Slight tear 2. Torn
5	Medium hard, 6·1 per cent. Nickel	1·15	1·05	1·2075	1 2	6·56 6·88	795·6 799·6	1595·2	1. Tear at nick greater than with No. 1 2. Broke through

6	Medium hard, 6·1 per cent. Nickel	1·1	1·07	1·177	1	4·92	596·7		1. Tore at nick
7	Medium hard, 6·1 per cent. Nickel	1·05	1·01	1·0605	1 2	3·28 3·28	397·8 397·8	795·6	1. Very slightly opened 2 Considerable tear
8	Medium hard, 6·1 per cent. Nickel	1·15	1·1	1·265	1 2	2·62 2·62	318·24 318·24	636·48	1. Very slightly opened 2. Considerable tear
9	Hard Steel, 6·1 per cent. Nickel	1·0	1·0	1·0	1	4·92	596·7	596·7	1. Broke through
10	Hard Steel, 6·1 per cent. Nickel	1·0	1·0	1·0	1 2	1·64 1·64	198·9 198·9	397·8	1. Slight tear 2. Considerable tear
11	Hard Steel, 6·1 per cent. Nickel	1·07	1·1	1·177	1 2	0·984 1·312 1·312	119·34 159·12 159·12	437·58	1. No tear 2. Very slight tear 3. Increasing tear
12	Hard Steel, 6·1 per cent. Nickel	1·0	1·0	1·0	1 2 3	1·312 1·312 1·312	159·12 159·12 159·12	477·36	1. Tear just visible 2. Tear increasing 3. Tear increasing

Conclusions on the Results of Testing Nickel Steel.

Elasticity, Strength, and Ductility.—It will be seen by referring to Tables X., XI., and XVI. that the elastic limit, tensile strength, also the ratio of the elastic limit to the tensile strength, and the ductility are much greater in nickel steel than in ordinary carbon steel. This is shown in the results recorded in the paper for all nickel steel. Comparing the results of testing Vicker's axle-steel, which is well-known for its excellent qualities, with Krupp's nickel steel, it is clear that the latter is much superior to the former. The results of the impact tests recorded in Tables XVII. and XVIII., although not as complete as the other tests made by the author, show that nickel steel possesses an enormous resistance to shocks and suddenly-applied loads.

The experiment in the oil bath at 505° F. proves that there is no practical diminution in the essential qualities of the material due to this temperature.

Again the experiments on repeated stresses alternating between tension and an equal compression clearly demonstrate the enormous endurance of nickel steel, even with a fibre stress of 54,085 lbs. per square inch, which was considerably above the elastic limit of the material in the mild quality, and about equal to it in the medium quality. The effect of repeated stresses in the rotating machine was clearly shown in the mild variety, but is very slight in the harder variety of nickel steel.

The results of testing Krupp railway axles by a Commission of Engineers in Germany show the superiority of nickel over the best crucible carbon steel. The axles were first cut in the middle by means of a sharp turning-tool to a certain depth, thus artificially damaging them, and then subjected to the drop test. The crucible steel axle was fractured with the first blow of approximately 1 ton falling 3·3 feet; the fracture being dense, finely granulated, and serrated. The nickel steel axle required thirteen blows from heights varying from 3·3 to 21·3 feet to produce fracture, the axle deflecting 7·3 inches, and gradually tearing away on the underside of the nick. A hollow nickel steel axle damaged and tested in a similar manner sustained fifty-four blows, of which thirty took place from a height of 36 feet (that is, with a momentum drop of 80,000 foot-pounds).

Uses of Nickel Steel.

Armour Plates.—It appears that the first application of nickel steel for armour plates is due to Messrs. Schneider and Company, Le Creusot, France. The effect of the nickel, which is added in the proportion of from 2·5 to 3·5 per cent., is to produce toughness and prevent cracking. The best armour plates to-day are produced by different alloy combinations, such as nickel-chromium steel. Again, the best process for face-hardening plates is that due to Fried. Krupp, of Essen, which is a great improvement on the Harvey process.

Gun Steel.—The firm of Fried. Krupp employ nickel steel, containing approximately 6 per cent. nickel, in the manufacture of guns. The American Government has also recently built 8-inch breach-loading guns containing 3 per cent. nickel.

Boiler Plate Steel.—It is claimed that Messrs. Carnegie, of Pittsburg, U.S. America, was the first to produce nickel steel boiler-plates. Messrs. Fried. Krupp have rolled nickel steel plates containing various proportions of nickel, but they find that alloys containing less than 25 per cent. cannot be rolled with a faultless surface; the ordinary 3 and 6 per cent. nickel steel plates have rough surfaces. The 25 per cent. nickel steel was intended for locomotive fire-boxes, as its resistance to corrosion is considerable, but so far as the author is aware, no locomotive engineer has designed a suitable fire-box for this material. The writer saw a nickel steel fire-box at Krupp's works at Essen which had been made for the Hanover railways, but the spacing of the stays and thickness of the plates were about the same as in an ordinary American steel fire-box. No modification in the design was attempted in order to take advantage of the special physical qualities of the material, consequently the extra stiffness of the plates rendered them much more difficult to work than ordinary steel plates, and the results were not very satisfactory. The author considers that a fire-box of 25 per cent. nickel steel could be designed and built which would be much more satisfactory than an ordinary steel or copper box; but the stays should be more widely spaced, and the thickness of the plates made $\frac{5}{16}$ or $\frac{3}{8}$ of an inch. Fire-box stays have been used experimentally in America made of steel containing 3·7 per cent of nickel, which have shown considerable endurance in rotative tests—much in excess of ordinary carbon steel.

Railway Axles, Propeller Shafts, Crank Shafts, Piston Rods, Connecting and Coupling Rods, and Forgings for Engines, Hydraulic Cylinders, &c.—Nickel steel has been largely used by Messrs. Fried. Krupp in the manufacture of large forgings, crank shafts, propeller shafts, crank and cross-head pins, railway axles, large piston rods for engines and steam hammers, and hydraulic press cylinders. For such purposes nickel steel is much superior to carbon steel, and the good results obtained more than compensate for the increased price of the material. Straight and crank axles of nickel steel have been used to a considerable extent on the railways in Europe with most satisfactory results, which might reasonably have been anticipated from the results of the physical tests, viz., high elastic limit, resistance to repeated stresses in the alternating bending tests, ductility, and strength. It is generally considered that all large forgings should be forged with the hydraulic press in preference to the steam hammer, and whenever practicable a hole should be bored through the axis of the shaft to remove any possible defects and give lightness. The removal of material along the axis is also desirable, since its position in regard to the radius of gyration renders it least effective. Again, it is an advantage to compress the ingot while it is in a fluid state, after the method introduced by Sir J. Whitworth. To obtain the best possible results, forgings should be tempered in oil in preference to annealing them.

Annealing and Treatment during Heating and Forging; Welding.—The effect of annealing is to slightly reduce the tensile strength and tenacity in nickel steel containing from from 3 to 6 per cent. of nickel, and to increase slightly the ductility.

Nickel steel containing a high percentage of nickel does not harden, but the 3 to 6 per cent. alloys are capable of having a high degree of hardness imparted to them. Owing to this fact and other special properties of nickel steel, it is necessary to carefully treat it during during the heating and forging, as unsuitable treatment may destroy its good qualities. Nickel steel cannot be welded in a satisfactory manner, and test bars always break at the weld.

Corrosion.—In regard to resistance to corrosion, nickel steel containing from 3 to 6 per cent. nickel does not possess any marked superiority over ordinary carbon steel; but the 25 per cent. alloy shows considerable resistance to corrosion. In the author's experiments repeated boiling in a 1 per cent. solution of sulphuric acid extending over four days, the steel surface was as brightly polished as when first immersed; it is, however, considered by Hatfield and others that all nickel steels yield to the corrosive mixture ultimately, when the experiments are extended over a sufficient time.

ESTIMATING THE AMOUNT OF RAINFALL AVAILABLE FOR STORAGE PURPOSES FROM RAIN-GAUGE DATA.

By C. B. Target.

THE GREAT WESTERN RAILWAY ROUTE.

By F. Grove.

MODERN REQUIREMENTS IN NEW BUILDING ACTS.

By J. S. Ellis.

INVESTIGATION ON THE EFFECT OF ALTERNATING OR UNIVERSAL REPETITIVE STRESSES UPON THE PHYSICAL PROPERTIES OF MATERIALS.

By I. E. V. Madsen.

SECTION I.

SANITARY SCIENCE AND HYGIENE.

PRESIDENTIAL ADDRESS.

By SIR T. N. FITZGERALD, C.B., F.R.C.S.I.

THE NATURE OF DISEASE.

WHEN, some months ago, I received an invitation from the Secretary to take the chair at the Section of Hygiene and Sanitary Science of this Association, I at first felt dubious about accepting it. It seemed to me, on the face of it, rather incongruous that one whose whole life has been almost exclusively devoted to the practice of an art little concerned with the dissemination of sanitary knowledge should fill the office of Chairman at your meetings; indeed, I was disposed to decline your courteous proposal. However, on reflection, my impulse changed, especially when I called to mind how essentially of late years the observance of the strictest hygienic rules had become necessary to the highest developments of surgery. I remembered, too, with the keen enjoyment a soldier feels in relating the tales of his various encounters, the contests we had had with the lay authorities who control our institutions, about the expense and inconvenience of introducing antiseptics; what struggles we engaged in with those who at the time met our efforts with the terms "fads" and "nonsense." Would they not now blush could they be reminded of their former obstinacy, and the contempt they expressed when we endeavoured to impress upon them the imperativeness of isolation in offensive and infective cases, and the benefit of a sweeter atmosphere for the others? Many of our former opponents are, alas! dead, but still a few remain who, in other matters—medical and elective—are as irreconcilable and as opposed to change as ever. These and other memories returning, I decided to accept your offer.

Then came another difficulty—the choice of a subject. For the address which inaugurated the office would have to be on a matter more or less connected with the purport of this Section, and, outside my profession, I could by no means consider myself a professed hygienist. However, after some deliberation, I decided in addressing you on "The Nature of Disease."

Sanitary Science is almost exclusively interested in the cause and prevention of disease, but to limit my remarks to the latter alone would have compelled me to adopt the tone of an expert in sanitation, which I have already told you I am *not*. Hygiene belongs equally to the man in the street and to the full-fledged medical expert and the scientist. In fact, it is to the former that all interested in this branch of knowledge have to make their final appeal. We may deliberate and discuss, draw up proposals and suggest alterations; but to the Legislative Chamber we must finally come. There sit our masters, and they must be instructed ere they can be expected to pass the laws the skilled scientist suggests. As a matter of fact, in social science we stand on a different level from the one we occupy in relation to the public in the medical world. In the latter, the physician is authoritative. He can give his orders in military fashion; he has not to explain or to instruct. It matters little to him whether the patient understands the nature of his affection or the design of the treatment. But the public must be taught before they can act and give effect to the hygienist's views. Therefore, in this Section, we speak to the general ear. We must elicit their appreciation; our terms must be those in vogue, and our language as non-professional as possible.

In selecting the title—"The Nature of Disease"—I remembered the advice of an old and valued friend, who, when once placed in the same position as I stand in, namely, that of speaking to an audience on a semi-professional subject, advised that the text should be as comprehensive and indeterminate as possible, connected—but only loosely—with the subject under review. In treating of the nature of disease, I can sail my barque in many waters. Its vagueness is attractive; it permits me to traverse many subjects over which from time to time I have had much cause to ponder, especially when I recall to mind the many changes that have taken place in one lifetime, in the thoughts of those who direct the current and varying shades of medical opinion.

Preventive medicine relates almost wholly to the causes of illness, and concerns the connection of man with his neighbour, not only in health, but in those aberrations from it which we call disease. These causes were, and are, in a manner, now considered under the headings of "extrinsic" and "intrinsic." But although this classification still suffices, a different importance is now attached to the parts that certain causes play in the foundation and spread of maladies. Of the extrinsic causes, heredity stood foremost, occupying a far more important position in the opinion of experts, at that time, as a cause of disease, than it holds to-day. We recognise most thoroughly that nervous affections of all kinds, from insanity to a simple migraine, are transmissible, and what is more, neuroses are capable of being, as it were, cultivated, intensified or decreased, according as the parents are stable or otherwise in their nervous dispositions. We admit, too, that deformities and disfigurements, due to defective development, are passed down, though very uncertainly. In the transmission of nervous disorders, there is in a measure, a reliableness which is not found in handing down congenital defects. For instance, in the alcoholic, if the children are begotten whilst the parents have given way to inebriate habits, the offspring are nearly always in some manner unsound in their mental organisation.

Deformities, on the other hand, are rather what a horse breeder calls "failure, or the result of a nick." Two perfectly healthy people, free from malformation of any description, marry, and their entire family may display evidences of imperfect development, such as auricular appendages, cleft palate, multiple fingers and toes, and so forth, from the eldest to the youngest child. Their offspring in turn may, and generally do, beget perfectly healthy children; but if the first-born is deformed, there is a strong probability that any others who may come into the world may be similarly affected. Deaf-mute may unite to deaf-mute, and their children be perfectly healthy. Now, it is not the same in mental diseases. Nervous instability can be calculated almost with certainty as to its transmissibleness. Formally, it used to be considered that the inter-marriage of relatives had much to do with the appearance of such irregularities as cleft palate, but this is considered to be very doubtful, and the evidence in its favour is far from strong. Hugg, a great authority on the subject, denies it altogether, and points in evidence to the intense relationship that must have existed in the earliest and pre-historic stages of man's being. Certainly, in all wild species, developmental aberrations are extremely rare, and, though teratological, are fairly common; the reverse being the case in man. As I have said, for my part, I doubt if intermarriage is as detrimental as it is generally considered to be, though it is a question of some importance, as much happiness may be pent up in its answer. In a measure, it is a natural thing that cousins should marry, considering the proximity with which their relatives are often brought up. Their probable similarity of tastes, and the adjustment of property, render such marriages often not undesirable where there is no nervous fault to stand in the way. I know that a strong prejudice still exists against such unions; but I am certain that harm seldom results, and that deformities are just as rare amongst them as they are in distant marriages.

Syphilis is undoubtedly hereditary. This is as clear a point as any in Pathology. It can even descend to the third generation; but I fancy as a transmissible poison in this respect it stands alone. This is very remarkable. It is said that leprosy also descends from parent to child. In the first place we know very little about this disease itself, and almost nothing about its transmissibleness. This is just one of those loose statements which we so frequently encounter in medicine. A Brown-Sequard or a Brodie speaks, or in the course of some lecture makes, an ill-digested statement, and at once it is regarded as an indisputable truth. Take, for instance, the former's remarks on organic fluids, and the latter's allusions to perchloride of mercury and sarsaparilla. A suggestion from men like these often becomes a dogma, and so with leprosy. I believe it is very doubtful, as far as is known, whether this disease is at all hereditary, and so with gout. If there was one thing, some thirty years ago, of which we were perfectly certain, it was the hereditariness of this disease. Our own views in this respect have certainly very much changed, and so have the manners and habits of that circle of society which used to be so affected with gout. In these days we meet with the disease principally in its latent forms, as underlying some other affections, such as urethritis, articular disturbances, and irritations of the mucous membrane. Those frank explosions which used to be so frequent among the leisured classes, and for which all sorts of quack remedies were sold, are much less often met with nowadays. We do not therefore infer that the disease is in any way extinct; but it certainly is not the scourge it used to be amongst the wealthy.

Rheumatism is another complaint which bore the same evil character. Now, I question if anybody assigns to it a parental origin. We are rather inclined to think it an accidental and microbic affection, and we have learnt this as much from its association with chorea as from the revelations of the microscope. So with phthisis or tuberculous disease. Formerly, if anyone had doubted its transmissibleness, or what is not quite the same thing, the disposition to it, one would have been thought unscientifically sceptical, and yet to-day it is held that heredity forms a very small, if any, factor in its causation of the malady. And this really I consider a most important point. Assurance Companies load lives on this account in a most reckless and senseless manner; but whether a disposition can be derived from the parents is more than doubtful. It is certain that the bacillus is very rarely transmitted as the noxious agent is in syphilis. Opinion is tending in the direction of considering phthisis as being always an induced, and therefore a preventable, disease, eminently infectious, and, consequently, very little connected as to causation with family proclivities. Now, if such is the case, and inquiries are daily strengthening this opinion, what a singularly false position we have been occupying until recently. I notice, at the Tuberculosis Congress, Koch expressed himself strongly in favour of the non-hereditariness of, or to a disposition to, tuberculosis. That singular and indefinable weakness of constitution which was supposed to incline to tuberculosis, and which physicians have of late years been in the habit of treating with cod-liver oil, fats, and such like, is probably a myth, as most of these dogmas are. Phthisis and its dissemination depend on environment, and the reason why certain families suffer so heavily, and others in their neighbourhood entirely escape, is exclusively on account of their surroundings. In other words, the sufferers contract the disease from one another, in the same way as other parasitic diseases are spread, and why here and there a member is saved is due to some local cause, such as a well-ventilated bedroom, or to the effect of some superior sanitary condition. I confess I am strongly in favour of this view. How often do we see tuberculous surgical disorders, such as spinal disease, hip and other joint affections, confined to one house, or the sedentary one of the family suffering, and yet the neighbourhood, apparently, perfectly healthy.

We come now to Cancer, which was so long considered eminently hereditary. Surgeons seem to be always looking for some parental cause to account for disease. Well, now, the tendency of thought, and especially since Sir James Paget wrote on the subject, seems to be wholly in the other direction, assigning its apparent hereditariness to coincidence or infection. Coincidence is the bane of scientific investigations and statistical conclusions. Out of the long list of diseases that the preceding generations of physicians, for want, perhaps, of some more definite cause, was always considered to be part and parcel of the individual, and derived from his parents.

The neurotic then remain, in my opinion, the only disorders, excepting syphilis, that are not accidental or acquired. That this represents a great revolution in thought it not to be gainsaid, when we consider how seldom children in facial likeness, form, height, or character resemble their parents, and how, in animals, the most careful selection in breeding and mating so rarely produces similarity. So many other causes come into play in the determination of the individual, of which soil is not the least, and in the production of disease, ventilation, and food play so great a part that we can understand why disorders are not so frequently transmitted as our fathers thought.

Age, sex, and temperament are other intrinsic factors which have their bearing in this connection. These were well-known to our predecessors, but what they were totally unacquainted with is the powerful influence of the secretions of, until recently, apparently unimportant glands. Who, a few years ago, would ever have thought that life could not exist without the coloid product of the thyroid? The same with the supra-renal capsules, and it would seem that hypertrophy of the pineal is accompanied, like the others, with its own peculiar malady. Depend upon it, there is a great future in the elaboration of the uses of these various secretions, of which bile is one. This fluid, at once an excretion and a secretion, must play a great part in the welfare of the economy; and what its function is as regards the latter has, as you are aware, never been determined.

Let us pass now to the intrinsic causes of disease. Here, I naturally desire to emphasise the part the bacillus plays. When I was a student, the germ had no place in the investigation of etiology. Parkes, the most distinguished Professor of Hygiene that the last century produced, in 1866, in his address to the probationers at the Military School of Medicine, laughed at the idea of the microbic nature of the exanthemata. He said—"Microscopic power has been so extended that the hand can now be magnified to the size of Mont Blanc, and nothing has been revealed which could for a moment lead one to suppose that germs had any relation to the cause of disease." He considered that labour in this direction was energy thrown away, and advised his hearers to discard such new-fangled theories as nonsense. This, of course, was previous to the days of staining. "Fungi," says Dr. Beale, who, I am very glad to say, is still living, "can no more be regarded as a cause of disease than vultures which consume the carcase of the dead man, the cause of his death." (Beale, "Disease Germs," p. 79.) "No connection has been shown to exist between contagious disorders and any kind of fungus" (*Idem*, p. 82). Scarlet fever, and the like, were then attributed to telluric or atmospheric influences, to the malevolence of damp soil, and the banefulness of re-breathed air, laden with organic, but not living, particles. Still, the ground at this time was partly prepared for the reception of the new theory, namely, the dissemination of contagious disorders by living microbic influences; and, when Koch's work on the infective maladies appeared, his doctrines were received with a readiness that I do not think has ever been equalled in the annals of medicine. It seemed to account for so much which had been such an enigma to us. As you are aware, any new suggestion takes a long time to obtain even respect from the general body of the profession, and is usually most strongly condemned by those who have had the least opportunity of inquiring into the subject. Still, clinically, there were at times several indications which led grave men to strongly suspect that infectious and contagious diseases were in some way connected with a germ growth. Microbes lying dormant in some unsuitable breeding-ground were, by accidental cultivation, and transportation to more favourable sites, enabled to fructify, and, by their proliferation, exercise an enormous influence in the propagation of disease. The march of cholera was an instance.

Starting from a low lying jungle in Bengal, where it had long been known and designated as the "white diarrhœa," it suddenly changed its endemic and comparatively harmless characteristics into the epidemic and malignant disease which spread so much over India and Europe about the third decade of last century. Its progress, in spite of winds and meteorological obstructions always in the path of traffic and trade communications, ever down stream, and never up, pointed to some living molecule as the cause of the epidemic. At this time, military authorities and hygienic experts were strongly opposed to the germ theory. The Germans favoured it much. Still, I remember that, long before the isolation of a cholera bacillus, many of us suspected the existence of some such thing, and acted accordingly. Consequently, when the discovery was announced, and it was clearly shown that these contagious febrile diseases were entirely due to the multiplication of vegetable germs, the information was received with wonderfully little cavil or dispute. Of course, there are some who even now talk of the non-contagiousness of phthisis, and sneer at the imputed wickedness of the typhoid germ; but these are entirely outside the Schools, and their opinions are based on insufficiently-weighed and misread evidence. The germ theory and the specific nature of these microscopical organisms is the discovery, not of last century alone, but of all time, and has so revolutionised the medicine of to-day as almost to stultify the knowledge of the past as to the nature of infective diseases.

Magnificent has been the advance along this line. With the study of the morphology and natural history of germs, the successful application in the matter of treatment has not, perhaps, kept the same pace. Something has been effected; there may be a great deal in tetanus and diphtheria; and good results seem to have accrued from serum injection in typhoid fever. Yet, it cannot be exactly said that these diseases have been mastered. They have been, to a certain extent, rendered amenable to control by poisoning their bacilli with their own excreta.

Triumphs have been achieved, too, in dealing with hydrophobia by attenuating the virus, and there seems to be some evidence that occasionally septicæmia is influenced in the same way as antitoxin acts in diphtheria; but I doubt if much more has been accomplished. Typhoid fever is nearly as resistant to treatment as ever; its mortality is as high, and its records are as deplorable, as they were before bacteriology was heard of. If any improvement has taken place, it is very slight, and it may be considered to have been accomplished rather by hygienic arrangements than by the intervention of the physician. I doubt if we shall ever do much in the direct treatment of fevers, and our hopes lie rather in prevention than in the likelihood of ever being able to meet infective and contagious disorders with medicinal remedies. Typhoid, and its kindred diseases, have their purpose, like everything else. Fevers may seem a curse when their inroads come home to us, and leave the hearth desolate; but where would our drains be without, and what an immeasurable distance would then separate the rich from the poor.

Sanitation has probably done more to link classes together than even improved education has been able to accomplish. Imperfect hygienic surroundings mean sickness and poverty, the two great factors in the causation of crime. When I hear a complaint of the costliness of such-and-such a drainage scheme, I often say to myself, "Well, it will be cheaper than feeding the inmates of the gaols!" Open places and parks keep children clean, and off the streets, and the education of the industrial school aspirant commences in the latter. Fevers, or, rather, the dread of them, are great levellers, and force all to acknowledge a community of interest that otherwise would, and, in fact, did, until recently, receive but scant recognition.

So far, infectiveness, as it promotes cleanliness, has its uses. Transgression in defective drainage, dirty habits, rotten and unventilated buildings, implies departures from health which will not confine themselves to the districts in which they start. The sanitation of the slum thus becomes the health of the boulevard, and the care of the one is necessary to the happiness of the other. No beautiful suburban mansion or walled-in garden will keep out fever, if the drains of the office that the merchant inhabits are unventilated, and the caretaker's family is sickening with malignant exanthemata. So, out of our very selfishness, we recognise the value of sanitary science. To-day, every city, worthy of being distinguished as such, removes its slop-waters and excreta in some hygienic manner, instead of burying it in a hole right in the midst of us, as was the practice only a few years ago.

Up to this point, the public are educated, and, thanks to the general press, they are commencing to entertain the idea that consumption is an eminently infectious disease. But this is nearly the limit to which their knowledge in sanitation extends, and it is only to-day that this much has been acquired. We have still to teach them more. For instance, they should learn that our Asylums, Incurable Hospitals, and Benevolent Infirmaries are charged with the consequence of syphilis, that still stalks rampant in the land; that if this disease was controlled, and not dealt with as something from which the public should shrink, tabes and general paralysis—two diseases worse than death itself; yes, worse than cancer and articular rheumatism—might be almost wholly wiped out from amongst us, and be heard of only "as a tale that is told." Late investigations have shown that these palsies are entirely preventable, if their cause is removed, by the regulation of that class by which the disease is spread.

No doubt, except with a strictly professional audience, this is an extremely difficult subject to deal with, but it is no less important, and I do hope that some member of this Section will be courageous enough to bring forward a paper on this matter; for, though the disease, in a measure, is diminishing in virulence in its first and second stages, yet its manifestations in its tertiary forms are, as they become better recognised, admitted to exist in situations and in types never until recently suspected. I feel certain that something must be done, and that shortly, to grapple with the dissemination of this disease. I do not wish to say more on the subject, because it can best be discussed in connection with a special contribution; but I must assert that. to my mind, it is just as necessary that this evil should be well ventilated as any other hygienic infringement that can be mentioned.

Another scourge to Society is Alcoholism. Now, how can this disease—for disease it is—be encountered? By further enactments against the sale of intoxicants; by more parental legislation; or by endeavouring to alter the perceptions and habits of the people? Well, in my opinion, we have had enough of law in this respect. Those who want drink will have it, in spite of all the prohibitions that can be devised. If we cannot keep tobacco out of our gaols, I do not see how we can restrain a free people from alcohol; and it is, moreover, scarcely fair that all should be deprived for the sake of a few. Is it well, too, to further interfere with what is so glibly styled "the liberty of the subject"?

On this ground, then, I hold that the teetotaller stands in a firm and rational position. If, by further enactments, society could be benefited at the expense of the individual, Assemblies have a perfect right, and, in fact, should, pass such laws as will protect the community against the excesses of some of its members, even if it involved a loss of personal freedom; and habitual drunkards should be regarded as a pest, liable to be removed and confined for a time in the same manner as a typhoid fever patient would be, if he were sickening in a public place. Consequently, for those who possess pecuniary means, I would advocate the establishment of inebriate institutions, and the legal retention of the drunkard until such time as expert medical advice considered his mental organisation restored. I often think that, by timely restraint, many valuable lives might be saved to the State; for the inebriate, except for this defect, is often a very valuable member of the body politic. Strong drinkers are frequently strong thinkers. I am sure we lose much by the wanton way in which we allow these men to destroy themselves.

However, asylums of this kind are only suited, for obvious reasons, to those who have means. With the general body, such restraint has nothing to do. Among the labouring classes, the potations of the drunkard are limited, and, when his money has gone, he has to go to work again. He injures himself for a time, and renders himself and his family poor; and, so far, is a nuisance. Now, most of these men acquire the habit from a desire to relieve the monotony of existence. They eat, drink, labour, and sleep; and, from this routine, day after day, week after week, there is only the relief that Sunday affords. What could be more miserable to a man of more than average intelligence than occupying a three or four-roomed cottage in a thickly-populated suburb? Men, gregarious in their habits, repair to the public-house for company's sake, when the daily paper is read. There is nothing more to do but smoke and go to bed. The only change these men can find is in such diversions as the religious conventicle affords. The majority drink, or, at all events, commence to drink, simply for want of congenial company, and because our system of occupying separate tenements precludes that social intercourse which is so beneficial to mankind.

This is the principal cause of alcoholic intemperance amongst what we would call "the working people." Of course, some are alcoholic from defective will-power, which generally commences from the habit, in colonial parlance, of "shouting" or "treating," and the custom, once acquired, becomes very difficult to overcome. With these topers the case is hopeless. They have lost all respect for themselves, and, unless some powerful influences intervene, which occurs as much accidentally as any other way, such as religious conversion, or a marriage, with its responsibilities, their future is lost. They sink lower and lower, until they meet their end in some public institution. To my mind, it is not by Act of Parliament, and further harassing the vendors of alcoholic liquors, that any improvement in the drinking habits of the people can be expected. I do not wish to imply that the traffic should be unrestricted—that would be illogical—but I do urge that amendment is much more likely to take place in affording the working classes better resources in the way of evening amusement.

Living in single houses, clustered round their factories or places of occupation, no doubt, has its advantages, and, in many cases, may be absolutely necessary; where it could be done, however, I would certainly suggest a more common life—a system of living in flats, for instance—instead of spreading out, as is the custom with us, seven or eight miles from relatives or friends. Such dispersion renders public converse impossible. Other means might be devised. Theatrical entertainments, musical performances, free exhibitions, and such like. All these things are much more likely to relieve the monotony of life. and diminish our drinking habits, than piling restraint upon restraint, as many well-wishers of their kind desire, until absolute prohibition is ultimately reached.

The bicycle, I venture to say, has done more to elevate the people in the matter of temperance than a week of lectures have been able to effect. It is in this direction, then, in my opinion, that philanthropists should work. I have lived too long not to recognise the dulness of the "lives of the masses," and how productive of evil this lack of variety must be. "Too many holidays," said a friend of mine to me once. "Not at all, but too little to do on these occasions." No doubt at these times you are better off for amusements than we, in a big city like Melbourne, with your beautiful river and the sea at your door; but, with us, to the labouring classes, these breaks must be dreamy days, and drinking is too frequently the outcome of this weariness, and the would-be social reformer had better not forget it.

We come now to Cancer. I referred to it in alluding to heredity, as an intrinsic cause of disease. Let me tell you, at the outset, save that its microscopic characteristics have of late been much elaborated. little more is known of this disease than we were acquainted with in my student days. Clinically, its variations still puzzle us; at one time marching with feverish rapidity, and at another time remaining almost torpid for years. As you know, opinions are divided as to its nature, whether it is due to the invasion of a parasite, or to some other cause. To my mind, the evidence in favour of the former is extremely weak, and only the results obtained by Professor Coley with his fluid lend probability to the theory. There is no doubt, if his accounts are correct, sarcoma, or that form of cancer which is characterised by undue multiplication of the embryonic cell, is, in some way or other, connected with germ invasion. The Professor's antidote, if I may call it so, is, as you are probably aware, an anti-toxin provided by a streptococcus and the bacillus prodigiosus, and, being such, its curative action must solely depend on its germicidal properties.

Now, there is one thing about this fluid I cannot understand, and that is why no other surgeon or physician, in using it, meets with anything like the success that its originator attributes to it. I do not for one moment doubt the correctness of Dr. Coley's reports, but I have never heard that anyone else who has tried it has, as yet, succeeded in effecting a cure in sarcoma. At all events, though this remedy has been before the profession for the last three or four years, it has never received, and it certainly has not now the support of the profession, which a treatment, if successful, almost always secures. This one thing we know about carcinoma—that it is not contagious, and only infective in the already cancerous. All means have been tried to convey this disease to animals, and probably the attempt to do so to man has also been made, although, from the nature of the circumstances, these instances have never been published. This looks very unlike the disease being of parasitical origin.

Quite recently, a medical man in Melbourne has endeavoured to show that cancer is due to defective glandular secretion. The theory is not exactly a new one—Is there anything new under the sun?—but it has been more pointedly put than has hitherto been done. He says the bile secretion contains a soap which acts as a solvent on cholesterine, and that it is the crystallisation of this substance out of the living cell that constitutes cancer. His arguments are too long for this paper, but the point that I wish to bring under your notice is his suggestion, that the absence of salt, as an article of diet, may have much to do with the cause of this disease, and that its increase may be attributed to the much larger consumption of sugar, displacing salt. He also surmises that drinking rain-water, or, as he terms it, "demineralised water," may have much to do with malignancy. I cannot give an opinion on these points, but, as cancer is such a fearful disease, I think that anything and everything bearing on its cause or cure should be brought forward.

We come now to Tuberculosis, which causes more misery and poverty than all other diseases put together. Tubercle, with the various maladies its invasion occasions, has been very much to the front of late, through the meeting of the British Congress on the subject, and the prominent place this interesting topic has taken in the general press at Home, at one time, almost to the exclusion of everything else except the Boer war. The subject is just one that the public can understand when placed before them in a popular manner. I never remember anything to have engrossed the general mind so much as this has done. Those who read, professionally or otherwise, Professor Koch's address, must have enjoyed an interesting discourse. Some of the remarks were certainly most astonishing. For instance, those on the descent of tubercle. They were most upsetting; so opposed to all preconceived opinions. Medicine at times is most bewildering. We frequently, after careful consideration, come to a certain conclusion, which, for a time, is universally accepted, then someone provides us with the results of other experiments, and all the ideas we thought to have been definitely settled are blown into thin air, and we forthwith adopt a totally different view. I have no doubt that, if a canvass had been made, every nine out of ten men would have declared that if one thing was certain in Medicine, it was the existence of a predisposition to phthisis, and opinions to the contrary would have been laughed out of Court.

I must say that the question of the transmission of tubercle, or even an inclination to the malady, whenever I have given a thought to the subject, has seemed to me rather doubtful; but now we have the assertion of Dr. Koch, and no one can speak with the like authority, that hereditary tuberculosis, though not absolutely non-existent, is, nevertheless, excessively rare. But to this I have made allusion before, and only mention it now to emphasise that we are at liberty, in considering practical measures, to leave this form of origination entirely out of account.

Well, now, where are our actuaries and those who for so many years have been employing their time in constructing tables and drawing up statistics for Life Assurance Companies? It is a question of the utmost importance, for if the Professor is right, the elimination of tubercle becomes merely a question of sanitation. A few strong municipal restrictions, and this disease may almost disappear from our midst, to break in again on our reverting to unwholesome habits. But, if it can be transmitted, or even if a disposition can be handed down from parent to offspring, the picture becomes sad, and the outlook is not nearly so hopeful. If such should be the case, though few seem to incline towards Dr. Koch, it must be a very subtle peculiarity, and so imponderable an influence as to be quite beyond our grasp.

Let us turn to the side of the eminent doctor. How often do we see the thinnest, poorest-looking children grow up to be fine strong men, and that without having had any special care bestowed on them. These, after the age of puberty, frequently seem never to contract any malady, and pass their lives with scarcely a sickness. So often is this the case that I would discard the term "delicate" altogether, in the sense in which it is generally used. Applying it only to those who suffer from some neurosis, such as epilepsy, prematurely-born infants are "pukey" for a time, and are generally more or less so for the first three or four years of their lives, but if brought up amongst healthy surroundings they are no more disposed to tuberculosis affections than those who from the first tear at the nipple with lusty ferocity.

No, inheritance won't do. Tubercle means insanitary dwellings, crowded, unventilated bedrooms, and want of sunlight. Melancholic convalescents from fever and those debilitated from wounds and extreme hardships, all things considered, are not more inclined to tubercular phthisis than any other people; but those who work in close atmospheres, who sleep in badly-aired chambers, and are herded together in limited spaces, certainly are eminently so. Every medical military officer knows this, or Parkes' "Manual of Hygiene" was written for nothing. The depressing poison which devitalises the system, and allows it to become a breeding-ground for tubercle, is re-breathed air. Lock three people in a cell with but scant communication with the outside, and let them inhale, night after night, each other's breaths, and, as sure as they're there, one will shortly go under with the dreaded bacillus. This is the predisposition. A peculiar want of vital resistance, induced by inhalation of organic particles, really causes the susceptibility of which we read so much.

Let it be known, then; declare it from the house-tops, for it concerns all, that tuberuclosis is an infectious disease, in its way almost as communicable as an exanthema, or fungus disease of the skin. The sooner this is recognised the better; for then can be begun more preventable measures, which it is for you to suggest, for you to educate the public into grasping, and for them to insist on their representative bodies passing, in the shape of such enactments as will make sanitation something real and beneficial.

What these suggestions are, let me endeavour to briefly outline, as they will be enumerated from time to time by bodies similar to yours in Europe and the States of America:—

(1.) The isolation and notification of phthisis. If it is possible to effectually carry out any of the schemes hitherto devised, then, to be of use, a certain completeness is necessary. One could not report the wife of a labouring man and omit the inhabitant of a fashionable suburb. An in-interference with the latter would have to be very carefully performed, and would require more than the average *savoir faire* to avoid friction. Still, some proposal, happy in its incidence, might come from you, and I would suggest that the opportunity should be seized, and the subject fully discussed.

(2.) Another proposal that could be made is, that the Central Board of Health in each of these States should have working under them, and constantly visiting all districts, certain sanitary instructors, whose object should be, by house to house visitation, to point out to the proprietors and inhabitants the defects in their dwellings. In the late plague scare in Melbourne, this scheme was actually carried out, with, I am prepared to say, great success; but, as soon as the fright was over, these officers were dismissed, and we—that is to say, the people of Melbourne—have returned to our former haphazard methods. Phthisis is a disease of the poor, and, as some authors put it, "increases in an inverse ratio to the rates." I am sure an immense amount of the disease could be prevented by improving the dwellings of the working classes, and that the regulations with respect to the erection of their tenements should be more stringently enforced, and placed in more resolute hands than those in which they are now. Sleeping rooms are often built without even a fireplace or any opening communicating with the outside air, and it is a rare thing to see any attempt at ventilating the floors. I could spend all this evening detailing to you the faultiness in workmen's dwellings, and it is just these little seemingly unimportant matters which allow the propagation and dissemination of tubercle.

(3.) Another subject which is very much to the fore in Europe and America, is the establishment of Sanatoria. In my early days, we were taught that such institutions were most undesirable, as by concentrating consumptives in a few wards, they tended to spread the disease. This view seems to have changed, and the agreement of opinion seems to be that much good can now be effected by affording an asylum to the phthisical in the earliest manifestations of the disorder.

I cannot say I have had much experience in this direction. However, I have been informed that the establishments at Echuca and Mount Macedon have been the means of saving many lives. I should fancy it would have been better to have gathered these people together, like the Israelites of old, under separate tents, instead of in a brick or wooden building; for the phthisical bear cold very well, contrary to the general idea, and these temporary canvas constructions can be destroyed or exposed to the light in a manner impossible with more permanently built shelters.

There is only one other matter that I wish to allude to, and that is Dr. Koch's remarks on the relation of bovine to human tubercle. It would seem that the two are not identical, much to the surprise of everyone like myself, who obtains his microscopical knowledge second-hand. The great pathologist, Virchow, whose name amongst us is one to conjure with, seems to be of the same opinion. If so, it is very curious, and we have been going to such trouble in Pasteaurising milk and condemning tuberculous carcases for nothing. As regards the latter, some alteration in the law is most certainly required. In an address delivered in another place, I called attention to this injustice, and I wish to emphasise it again. It seems that when a beast is condemned as unfit for food, having been bought at auction in the usual manner, the cost falls on the butcher instead of the grazier, which is striking at the top of the tree, instead of at the root. If we wish our herds to be clean and healthy, the pastoralist should recognise that he would have to bear the expense of any loss, and that it would pay him better to have his cattle clean and regularly inoculated, than to send them to market unfit for consumption.

Gentlemen, I am afraid I have been discursive, but as I said, the nature of the subject has prevented me from concentrating my hygienic knowledge. As I said before, these are but a few ideas that have struck me as I considered what I should write. I look upon this Section as certainly the most useful in social science. These meetings have effected an enormous amount of good in Great Britain. Who can forget the fœtid cesspit, and the typhoid and diphtheria of former times. Sitting here, we smile at such things now, and yet, with a few exceptions, you may visit any farm-yard in the country districts and you will find all these foci just as prominent, just as common, as they were in the great cities twenty years ago. Hence, the benefit that arises from these meetings. It is not so much that we learn, but that the general public are informed, and yet in teaching, we also learn according to the proverb—*qui docet discet.*

LIGHT, THE ORIGIN OF HEALTH.

By Harry Benjafield, M.B., Hobart, Tasmania.

Light, as sunlight, is now acknowledged to be the greatest force in the Universe, and it is not complimentary to our great nineteenth century idea to recognise the fact that 10,000 years ago, or probably longer, our early ancestors recognised this fact more fully than we do now. Primæval man crept out of his primitive abodes, where he had huddled in fear through the darkness of the night, to watch the dawn spread over the heavens and, as he did so, he sang—

> "Shine for us with your best rays, thou bright Dawn,
> Thou who lengthenest our life; thou the love of all,
> Who givest us food; who givest us health,
> Thou daughter of the sky, thou high-born Dawn
> Give us riches high and wide, protect us always with your blessing."

And, as he sang, the great fiery orb of day arose, and he fell on his face and worshipped it. As he began to build houses to live in, he must needs build temples and dedicate them to his God, the Sun. The great temple in Heliopolis dedicated to Ba, with its obelisk representing the Sun, is one of these. In this temple, the prayer of the sick man went up to the Sun, as God of the temple, as follows:—"Let me not enter into the house of clay; have mercy, almighty, have mercy. If I go along trembling like a cloud driven by the wind, have mercy, almighty, have mercy." And if we turn to our Bibles, with minds divested of all old theological crusts, we shall be astonished to learn from it that they who wrote it certainly placed light next to God, if they did not look upon it sometimes as God.

"And God said let there be light—This was the true light which lighteth every man coming into the world. He was in the world, and the world was made by him."

Catching the spirit of this, painters, from those who decorated the Catacombs downwards, have pictured the Deity as embodied light, with a halo of light-rays all around him, emanating from His person. By the way, it is very significant that our word "Deity" means Sun-god. The old Aryan word to shine was "dyu," from which he called his God the Sun dyaus, which in Latin became "Deus," and in English "Deity." Then, when he began to look upon the Sun as a Father; he called it "Dyaus-pitar or Heaven Father, which in English became "Our Father which art in heaven."

In Genesis we learn that the earth was "waste and void" until light broke through the darkness. Geology agrees with Genesis that until light came there was no life. How life originated is not known, but, when light fell on the earth, its crust or surface soon became a living mass; and all this living mass, from the Saprophytic bacteria which exist in untold millions, to the huge forest trees, are all built up and vivified by the sun, and if the sun ceased to shine upon the earth it would quickly again become waste and void like the moon.

Sunlight, or light coming direct from the sun, is a compound wave-motion, which, acting on the eye, produces a sensation of light, acting on the body produces the sensation of heat, acting on, say, water, it lifts it up to form clouds; thus it produces energy, and this energy is indirectly convertible into electricity.

If the motion comes in fairly long waves we feel heat, if shorter waves we see light, and if shorter still, energy is produced. Thus it comes about that when apparently dead matter is put in the sun's rays it becomes warm, and in a short time begins to move, and we say that it is alive.

The tiny microbes which dart about in a drop of water, are simply a gelatinous atom without organs; still they are endowed with the same living principle as dwells in us; in short, the sun has warmed and put energy into this tiny atom, and it lives. Put more of these microbes together, and we get a larger animal—multiply cells of a similar character to a sufficient size, and we get man.

The tiny black seed appears to be quite dead, but put it in the earth, where the sun's heat and light can reach it, and its cells will begin to multiply until a tiny shoot appears above the ground—and now, as heat and light and energy get to work within, its cells multiply, water is attracted, matter is built up, until by-and-by we find our tiny gum-seed has grown into a huge tree, which contains say a hundred tons of matter built up in its structure, all put together by the sun's rays, and every day requiring more energy to carry on its wonderful internal works than could be produced by ten men working upon it. Every day some 2000 gallons of water have to be lifted to the top, say 300 feet high. Solid matter for adding to its structure has daily to be carried up. Thus light, Nature's great master-builder supplies the energy for all Creation; and, undisturbed, Nature arranges that these things which are made up by light should remain in the light, and if they are removed from the light they pine away and die, whilst the more light they get the faster they grow. In a very similar way, our bodies are built up by sun—influence, and our energy, comes from the sun; our bodily heat also comes from the sun; and even the energy which at this minute is producing ideas in my brain-cells came from the same source.

As all the work of our gum-tree is thus carried on by light, it follows that every expedient will be adopted to catch and store as much light as possible; and this is done by green particles—called chlorophyll—which circulate in the blood of the plant just as red cells or corpuscles do similar work in our bodies. When you see a plant a deep-green colour you know it is healthy and strong; and when you see your child with rosy cheeks and ruby lips, you call it ruddy health. Light has produced these effects in both cases. And in both organisms all the work of each body is carried on by this blood. The blood of the plant gathers lime and carbon and nitrogen and a host of other things from the earth, and, after sundry mixings and dilutings, the compound is exposed to the light, and these green particles use the light to mould them into the most beautiful forms. But a few months ago these beautiful flowers and luscious fruits were contained in a heap of particularly offensive manure. Now we see some of the sun's exquisite handiwork in manufacturing, from such material, things which not only charm our eyes, but others which delight our palates, whilst they give health to our bodies. But this is what I want to enforce. This result has only been obtained by constant exposure to an abundance of light. The same materials placed even in your living or bedrooms would have produced very different results.

A young English student came to Tasmania two years ago with pale cheeks, diseased body, miserable digestion, bad appetite, and practically no strength. On my suggestion, he took light work on a farm, but work which demanded that he should be in the open sunlight from sunrise to sunset. After being there six months, he called to see me, and, really, I scarcely knew him. The pale cheeks had become a ruddy brown, and the hands and arms, which had been exposed to the sun constantly, were even browner than the cheeks, and big enough to floor a bullock. Disease was disappearing from the body; the digestion was equal to damper and bacon; whilst the appetite was a match for any bushman's—which is saying a lot. That all this meant additional strength goes without the saying.

Now, after two years of this life, he is a perfect young Hercules—grubbing and felling trees, digging, ploughing, and equal to all kinds of work.

The same sunlight which transformed such poor material into these fruits and flowers first put colour into this man's blood, then he could digest his food, he wanted larger and yet larger quantities of food, which well digested and assimilated, gave strength, and threw off disease. Before coming here, he had swallowed buckets full of iron, and other tonics; operations by noted London Surgeons, had utterly failed to cure his disease, whilst his poor digestion had been coaxed by delicacies, and forced by bitters, until the stomach rebelled against everything. But the sun just laughed at the lot, and sunlight speedily took the place of iron, operations, and bitters. Thus, this beautiful piece of mechanism called man was brought into existence by energy derived from the sun, this mechanism was thrown out of gear and nearly wrecked by being deprived of the sunlight, and was again restored by the sun, when it was given a chance to do so. The disease from which he suffered was scrofula, and scrofula, like consumption, is produced by microbes, and these microbes, or, bacilli, die when brought into plenty of sunlight. If you put say a pair of wet boots into a dark cupboard, they will, in a few days, get covered with mould, which will eat into the leather and destroy them. Now boots, or leather. is animal matter, and mould is a microbe, which feeds upon, and destroys it, as long as the boots are in the dark. But bring them out into our bright sunshine, and see how quickly the mould will die down and disappear. In this case a few spores of the mould plant, which thrives in dark, damp places, fixed on to the boots, and rapidly multiplied. soil and situation being favourable. Microbes which attack and destroy our bodies are subject to similar law. They, too, thrive and multiply in dark places, and especially delight in dark, damp rooms, but hate sunshine, because it is their great enemy. We very rarely, or never, see scrofula or consumption in people who live out in our sunshine. The microbe which produces consumption is now as well understood as the mould-plant which grows on our boots. It, too, thrives in dark, damp rooms, and multiplies enormously when it enters the human body, if that body is in a condition favourable for its growth; but if it enters a healthy body, out in the bright sunshine, it just dies, and is thrown out. The modern treatment for curing consumption, when the lungs and body are infested with myriads of these germs, is just the exposure of them to direct sunshine and fresh air; and I am perfectly convinced that in this treatment the direct sunshine has not yet been used enough. When we send Röntgen rays through the body. it illuminates the whole interior, like a flood of light in a dark room. But these rays are only one form of light; and there can be no question but many of the chemical and invisible rays in direct sunlight go right through our bodies, like these rays; and in going through they kill the bacilli in the lungs.

I would keep consumptives in the sun, with their chests bare, until the skin became the colour of a bushman's arms. And with our 2200 hours of sunshine a year we can do this without any trouble. The bacilli which produce plague, typhoid, cholera, and indeed, the whole family of them, are just denizens of darkness, and they die when exposed to the sunshine. In this, the first year of her reign, Queen Alexandra is instituting a treatment in the London hospitals, by light, of a severe skin-disease called "lupus," which is produced in unhealthy subjects by one of these bacilli.

The day will yet come when the consumptive bacillus will not be allowed to murder 60,000 victims a year in England alone (and probably a million a year in the various countries of Europe and America) whilst sunshine, the great remedy, dances around us in such profusion. In the treatment of typhoid fever, a hospital matron recently gave me a wonderful instance of how the sun will assist to cure. In Western Australia, she had charge of some hundreds of patients, and of those treated in tents which allowed the light to come through freely. she never lost one, whilst many died among the patients in hospital.

Sunshine, when passed through a prism, breaks up into a number of different coloured rays, such as are seen in the rainbow, and these rays have wonderfully different effects on living organisms. The first colour is red, second orange, third yellow, fourth green, fifth blue, six indigo, seventh violet. Plants kept constantly under the red rays are stimulated by them, and grow much faster than in whole sunlight, whilst similar plants placed in blue rays at the other end of the spectrum, do not grow at all—indeed, ultimately die out—although the temperature and moisture are kept up equal to those in the red rays. In Nature, when the sun is exerting all its powers to ripen the pips in the apple, it paints the outside red. Again, nearly all our berries turn a bright red as the sun is ripening the seeds within them.

These indications show that the colour used most by sunlight to promote growth and health is red. The most important indication of all is the colour of our blood. That its red colour has some profound significance there is no doubt.

There is a disease called "leucocythemia," in which a large quantity of the red corpuscles become white, and the blood gets visibly paler and paler as the disease progresses; and, as the blood grows paler, every organ in the body begins to suffer, until the patient ultimately dies. In another disease, called "pernicious anæmia," the red corpuscles disappear slowly; and, as they diminish in number, the patient's strength grows less, until he dies. Everybody knows that sturdy health is denoted by red cheeks and ruddy lips, whilst declining health generally pales the countenance. Cancer, consumption, and other wasting diseases have this effect upon the blood. As we know that sunlight can colour fruits, &c., so we know that it has the power to produce colour in the blood; and it is most important to find out how we can get the best results from sunlight for keeping the body healthy, and to cure diseases when they exist.

Dwellings.—In the case of women and children, a great part of their time is spent in the house; therefore, to the seeker after health, the position and design of the house are of the utmost consequence. The position should be where the greatest possible amount of sun can be obtained, and the windows should be built so as to admit it. And just here, I would point out to fond mothers the absurdity of many women, who get a house well situated, with large windows, and then spend any amount of money in blinds and shutters of various sorts, to keep out the light, because it takes the colour out of their carpets and furniture. Well, it is simply a choice to be made, whether you will have fine furniture and pale unhealthy children, or whether you will prefer children to carpets; and it has struck me as very significant that the colours which are worst for health are the very colours which fade most rapidly. Red and allied colours, which favour the sun's red and heat rays, are the very colours which are considered "fast," whilst blue and violet seem to be swept away by the sun's rays, as a nuisance to be obliterated. In furnishing for health, various shades of red and white are the colours to be selected. Blinds in living-rooms should be limited to white lace curtains, and bedrooms, especially for children and invalids, would be best with these, and perhaps a red blind to draw down when absolutely necessary.

Clothing.—When we fully recognise the value of light as a health-giver, we shall pay much more attention than we do now to the colour and texture of our clothing. Nature clothes the most delicate of animals in wool; and Nature is wiser than we are. The same amount of cotton as the sheep has wool, would certainly not save its life in a cold, wet, wintry night as its fleece does; and as a clothing for us there is no comparison between the value of wool and any arrangement of cotton. But the colour of the clothing is what interests us just now, especially as it affects the transmission of light to our bodies. The delicate sheep, clothed in its fleece of wool, will be all night beneath the snow and be all right in the morning. Again, we have often seen it exposed all day to our bright sunshine at a temperature of 150°, and yet it seems to be none the worse for the heat; indeed, it seems to flourish most in hot weather. The colour of its clothing is white, or a yellowish white, which allows all the rays of light to readily pass through, and at the same time prevents heat escaping too readily from the body. Science and Nature thus teach us that our bodies will get the greatest benefit from the sun if clothed in white.

The next best colour is undoubtedly red, which allows the healthy red rays to pass through readily; or perhaps a combination of red and white would be best. And these colours I would especially advise for children and invalids. The worst colours for health are the various shades of blue and violet.

How can we induce people to come out into this beautiful health-giving light? This is the most serious question of all. We get 2200 hours of sunshine in a year, and hundreds—yes, thousands—of our women and children are not out in it 200 hours in the whole year. Mothers of families tell me that they cannot get out; their servants tell me the same tale. Workmen in factories and hotels talk of long hours and no sunshine, and poor little white children are met with who are not let out into the sunshine because of their complexions, or perhaps from fear of sunstroke; and then society sits up through a great part of the night, and lies in bed while the beautiful sun is shining. This is all wrong, and very much of the suffering now endured would be prevented if everybody took a few hours sunshine every day; and if we could educate our women to see how necessary it is I am sure it could be done, and more work gone through than is now done by the same hands, because a brighter intellect and stronger body would be behind the hands. The noble bands of women who are now doing such excellent work in nursing the sick are a development of modern times; and could we not have a "Sunshine League," who, by preventing sickness, would do even better work. I can see room for such a league to work everywhere; where the nursing sisters now save one life, our Sunshine League could save ten. Such a league would enrol scientists amongst their number to give more attention to the effects of light on health than has ever yet been given, and advise accordingly; it would carry such knowledge into the homes of the people, and get at least some efforts to profit by it. Then a branch here, living in our grand sunshine, might correspond with a branch in England, and, when invalids came from there, might meet them and help them to get back their health. If our Queen does not consider it *infra dig.* to cure a few cases of lupus with light, what would she not be prepared to do if we could show her that the 200,000 English consumptives would live, if brought into our sunshine, or the 150,000 cases of chronic bronchitis. And yet I am perfectly sure that a great part of the 60,000 consumptives who die annually in England could be saved, and nearly all the bronchitis could be cured, by our sunshine. But a Sunshine League could find plenty of work here, as many people live in dens which their owners should be ashamed of; others who live in decent houses never let the sun into them. Then there are workshops a disgrace to the employers; and waitresses and servants whose hours of employment should be shortened. Bedrooms, in which we spend one-third of our lives, and where more consumption and such like diseases are caught than in all other places, are placed in outlandish, dark parts of the house, and children especially are put to sleep in abominable attics and out-of-the-way places.

Fond mothers who keep their best rooms for drawing-rooms, and spare rooms for visitors, and put their children in these dark holes, make a most grievous mistake, and do their children a great injustice. Rooms where children are kept should have large windows, always uncovered when the sun, or even daylight, can be obtained. And invalids of all kinds should be kept in the sun and light as much as they can possibly stand. Arloing has proved that sunlight kills disease bacilli in proportion to its strength.

Geisler found that the blue and violet rays destroyed the typhoid bacilli, consequently typhoid patients should be in strong light, which has passed through blue or violet-coloured glass. And they would tolerate that much better than sunglight. Koch states "that the tubercle bacilli is killed by the action of direct sunlight, in a time varying from a few minutes to several hours, depending upon the thickness of the layer exposed. Diffused light has the same effect, although a considerably longer time of exposure is required." Sternberg writes—"We may conclude, with Duclaux, that sunlight is one of the most potent and one of the cheapest agents for the destruction of disease-producing bacteria; and that its use for this purpose is to be remembered in making practical hygienic recommendations. The popular idea that the expósure of infected articles of clothing and bedding in the sun is a useful sanitary precaution is fully sustained by scientific experiments."

All this, and much more I could quote, go to show that light gives health in many ways—that it gives health by strengthening and building up the body, that it preserves that health by killing disease-germs outside the body, and that it will penetrate the body and kill them there if sufficient opportunity is given. When my paper on "Sunny Tasmania for English Invalids," was read in London, Sir W. Broadbent spoke of it as "a dream." But there is nothing of the dream about it. If these statements are facts, they will apply to countries as well as individuals; and the more sunshine a country gets, the more healthy will it be.

England gets about 1100 hours of sunlight in a year. Tasmania gets about 2200, or double the English amount. If it is true that sunshine gives health, we must see it in our statistics. When I lived in England, the healthiest country district I could find was in Wiltshire, where the mortality was 15 per 1000. The statistics of all Tasmania show last year 11 per 1000, but this includes Hobart and Launceston, two seaport towns. Exclusive of these towns, there are 117,000 people living in the country and in the five mining towns scattered through the country. The total mortality in these was 9 per 1000. But of this number about one-third died of old age, and, as many accidents occur on the mines, 1 per 1000 died of violence. If we deduct these two causes, which no climatic conditions could avert, we get a mortality of 5 per 1000. Of these, again, about one-third are deaths under one year old, and mostly premature and neglected children. If these are deducted, we have a mortality of ·2 per 1000. That is to say, that during the year 1900, of the 117,000 people living in the country districts of Tasmania, only 2·75 per 1000 died between the ages of 1 and 65, and, excluding accidents, &c., only ·2 per 1000 between these ages. Again, if we take consumptive diseases as a test of the health of a country, we get something like the following:—In England, last year, something like 2 per 1000 died of phthisis or consumption, and many more from obscure consumptive diseases of a tubercular origin. In these country districts of Tasmania, from every form of tuberculosis, there were registered 58 deaths, or 1 in 2000, which is one-quarter the English death-rate from tubercular diseases. But many cases of consumption come here from other countries, which will account for some of the above deaths. Then the five mining towns are of recent growth, and their sanitary surroundings are by no means what they should be. When one looks at the little dark huts in which a great number of our settlers live, it is extraordinary that the death-rate amongst them is so wonderfully low, and amply proves my contention that sunny skies give long lives, as most of these settlers only stay in their houses a few hours out of the 24, most of their time being spent in the sun and fresh air. My first scene in the opening of this lecture was primæval man, bowing down to the sun in worship, and praying it to give him health. In voicing the trend of modern science, I, too, as a sanitarian, would call upon you to accept the sun as the great health-giver of today. God, our Heavenly Father, demands our profoundest spirit-worship; but when He filled the world with light, and sent the sunshine in such rich abundance, and placed light in such a prominent position in the Bible, He intended us to recognise it as His great gift to the world; and, if we do not so accept it, and so use it, we have no right to complain of His treatment when we, or our children, grow sick and die—which we assuredly shall do if we break Nature's laws.

PLAGUE ADMINISTRATION (MILITARY) ON THE CAPE PENINSULA.

By W. Ramsay Smith, M.B., C.M., B.Sc. (Edin.), Chairman of the Central Board of Health for South Australia.

[*Abstract.*]

It is doubtful if any city was ever in such peculiar circumstances as Cape Town found itself in at this time. Fresh drafts of troops from England and the Colonies were arriving daily; and the old drafts, time-expired men and invalids, were being shipped home. Boer prisoners were also being deported from the camps to various parts of the world. Plague had appeared in the city and had laid hold of all classes of a mixed population to an extent that there was no means of accurately gauging. Corpses were being found in the streets, and the authorities were unable to trace the houses from which they had been ejected. The religious beliefs and peculiar susceptibilities of sections of the coloured population had to be allowed for in all civic action.

Plague had also broken out in various quarters of the Peninsula, including the military camps, and it seemed impossible to trace its origin or the paths of its propagation.

After serious consideration of the subject with the principal medical officer, Surgeon-General McNamara, of whose liberal and comprehensive views and accurate foresight regarding administration I cannot speak too highly, I was requested by him to embody my views and experiences of the subject in a Memorandum, which I did, under the following heads:—

1. Mode of Propagation of Disease.
2. Infectiveness.
3. Diagnosis.
4. Suspicious Cases.
5. Contacts.
6. Preventive inoculation.
7. Curative Treatment by Serum.
8. Medical Inspection at Embarking.
9. Danger to Healthy Troops Landing at the Cape.

This Memorandum formed the basis of all action and instructions, both on the Cape Peninsula and on transports conveying troops, invalids, or prisoners. Into details I do not enter. In addition to the military inspections, the

local authority carried out a systematic inspection of all troops and others after embarking at Cape Town. For this, Dr. Thomas, who had had a great deal of experience of plague in Bombay, was responsible; and I can testify from repeated and extensive personal observation to the thoroughness and efficacy of the inspection.

All invalid-ships, and troopships with returning drafts, besides being inspected in the ordinary manner by the Embarking Medical Officer, were specially inspected, and had instructions given by the Surgeon-General personally regarding all possible contingencies relative to the appearance of plague or other such disease during the voyage; and there is no doubt that the confidence begotten by this in the responsible medical officers of the ship was a very strong element in the total results.

If results count for anything as a guarantee of the efficacy of a method, then the plague administration by the military authorities at Cape Town should have much to commend it. Nine months have passed since the time of which I write, and although many thousand troops, invalids, and others have left Cape Town during that time, I do not find that any case of plague has been exported by any troopship or invalid-ship from Cape Town, or that any suspicious case has occurred on board any ship after leaving that port.

SANITATION AT CAPE TOWN.

By H. C. Kingsmill, M.A.

[*Abstract.*]

Cape Town occupies a plain about a mile in width between the bay and Table Mountain. This plain stretches round the bay in the form of a horse-shoe, several miles in length. The original water-supply was taken from the little River Riebeck, and this stream is still used by the native women for the clothes of the community, and receives the drainage of a continuous chain of suburbs extending from Cape Town to Wynberg, which have uncontrolled access to it without any system of sewerage. The water is now, consequently, totally unfit for human consumption. The present water-supply is of good quality, derived from the higher levels of the mountain, and giving pressure enough to be utilised for electric lighting. The average daily consumption of water is about 30 gallons a head, or 2,000,000 gallons a day. The collecting area is limited, and the rainfall upon it varies from 46 to 62 inches a year, with an annual evaporation at the Molteno reservoir of 61 inches. The total expenditure on waterworks is £234,000 for the last ten years. In Cape Town the Municipality have laid down sewerage works at a total cost of £270,000 during the same period. There are still 550 houses in Cape Town undrained—exclusive of the suburbs above-mentioned; and £3500 a year is spent on the carting away of night-soil.

There are incomplete works at Port Elizabeth for sewering the town, but they have been discontinued on account of insufficient water-supply.

In Durban there are waterworks furnishing over 44 gallons of water a head for domestic use; and about half the houses are drained in connection with the public sewers.

At Johannesberg the water-supply is very inadequate, so no attempt can be made to sewer the town. Part of the houses are furnished with closets with movable pails, and an introduction has been made of the Liernur pneumatic system. It is described as very successful, not only in Johannesberg, but also at Madras, Amsterdam, Leyden, and Trouville; and a description is given of the working of the system.

SOME EXPERIENCES OF QUARANTINE.

By C. F. Ponder, M.B., C.M., Edin

[*Abstract.*]

If quarantine could be enforced in an absolute way, it might secure a community from the invasion of certain dreaded diseases. But in practice it is found to be impossible to enforce a complete quarantine. Examples of this were given from the writer's experience, showing how failure came in owing to the presence of unguarded loopholes by which the disease might leak past.

Quarantine to be effective must be complete: practically we must isolate ourselves from the rest of the world—passengers, vessels, goods, even letters requiring to be disinfected before admittance. To do this thoroughly, is impossible, because the appliances and trained officials are not available—the expense so enormous as to be prohibitive—and even when not successful, the germs of disease in some mysterious way are found to leak past, an epidemic of smallpox threatens. The only preventative known for this disease is vaccination and revaccination. The value of vaccination is illustrated by the case of Germany. There vaccination is compulsory before the end of the second year of life, and revaccination during the school age. The result is that Germany is free from epidemic of smallpox—the few cases that occur being almost entirely on the frontiers of badly vaccinated countries. The town death-rate from smallpox in 1899 in England was 42-fold, in Austria was 67-fold, in Belguim was 174-fold, and in France was 231-fold, that of German towns.

The value of revaccination is illustrated by the 1901 epidemic of smallpox in Glasgow. Here within a few weeks nearly half a million persons were revaccinated—and not one of these took smallpox.

Old objections to vaccination have ceased to have force. Now only calf-lymph is used—so risk of infection from unhealthy children is avoided. Operation of vaccination is practically painless, and, with the rarest exceptions, successful. A protected community is preferable to quarantine.

AN ACCOUNT OF THE WORK OF THE BRITISH CONGRESS ON TUBERCULOSIS.

By Miss C. L. Montefiore.

Section J.

MENTAL SCIENCE AND EDUCATION.

PRESIDENTIAL ADDRESS.

By Professor Arnold Wall, M.A.,

POETRY AS A FACTOR IN EDUCATION.

The subject of my present paper is one of such wide importance and interest, and seems to me to bear so deeply and strongly and in so many different directions upon the springs of character and conduct, that my chief difficulty in treating it is to compress what I must say upon the subject into the limits allotted me. I have thought it best, therefore, to narrow the field somewhat by dealing with a concrete case first. I do not think that in doing this I shall lose anything by taking the case of a man of such exceptional experience in the matter of education as John Stuart Mill. His is, it is true, an extreme case; but I think that the study of it will tend to throw my subject into very strong relief, and thus to make its treatment easier for myself and my hearers.

Mill tells us in his Autobiography that he became a prey, at the age of twenty, to a strange mental disease, a hideous apathetic melancholy, which he can only describe in the words of Coleridge:—

> "A grief without a pang, void, dark, and drear;
> A drowsy, stifled, unimpassioned grief,
> Which finds no natural outlet or relief
> In word or sigh or tear."

He describes how a small ray of light broke in upon his gloom from reading a passage in Marmontel's Memoirs, and how this brought him some relief. It hardly concerns us to inquire what this passage was; it is sufficient to say that it moved him to tears. Nor do I intend to dwell upon the first of the two lessons which Mill tells us he learned from this terrible experience of his youth; it is sufficient to observe that Mill now found himself to be the victim of a very extraordinary system of education which had been imposed upon him by his father—an education wholly intellectual and non-emotional, and one tending to develop in an abnormal degree the power and the habit of analysis.

What concerns us here is Mill's Second Lesson, and here I must allow him to speak for himself:—

"The other important change which my opinions at this time underwent was that I, for the first time, gave its proper place among the prime necessities of human well-being, to the internal culture of the individual. I ceased to attach almost exclusive importance to the ordering of outward circumstances, and the training of the human being for speculation and action. I had now learned by experience that the passive susceptibilities needed to be cultivated as well as the active capacities, and required to be nourished and enriched as well as guided." He goes on to say that he "never turned recreant to intellectual culture," but he realised that the power and practice of analysis, though an essential condition of improvement, had consequences which required to be corrected by joining other kinds of cultivation with it. "The cultivation of the feelings," he says, "became one of the cardinal points of my ethical and philosophical creed." Very significant for us is the sentence which follows:—"I now began to find meaning in the things which I had read and heard about *the importance of poetry and art as instruments of human culture.*"

When Mill had thus been painfully convinced of the necessity of the culture of the feelings, he turned to music and poetry. His experience in music is interesting and amusing, and is often quoted, but does not concern us here. The first permanent relief he obtained, he tells us, from reading Wordsworth. He had tried Byron at the worst period of his depression, and got no good from him, "but the reverse." Wordsworth exactly suited his condition. This poet had himself passed through a very similar crisis, as recorded in the "Ode on Intimations of Immortality in Early Childhood," and also Wordsworth addressed himself to what had always been one of the strongest of Mill's pleasurable susceptibilities—"the love of rural objects and natural scenery." But this was not the chief benefit which Mill derived from him. "What made Wordsworth's poems a medicine for my state of mind, was that they expressed not mere outward beauty, but states of feeling and of thought coloured by feeling under the excitement of beauty. They seemed to be the very culture of the feelings which I was in quest of. In them I seemed to draw from a source of inward joy, of sympathetic and imaginative pleasure, which could be shared in by all human beings . . . . From them I seemed to learn what would be the perennial sources of happiness when all the greater evils of life shall have been removed; and I felt myself at once better and happier as I came under their influence . . . . The result was that I gradually but completely emerged from my habitual depression, and was never again subject to it."

The case which I have here sketched in Mill's words should have many lessons for us. Allowing for the peculiar constitution of the subject's fine mind, and for the abnormal conditions of that mind at the moment when Wordsworth first touched it, we may at least draw one general conclusion, namely: *That if education be directed too exclusively towards the cultivation of the intellectual faculties of the mind, so that the emotional faculties are neglected, very disastrous results may follow*; and I would add: The finer the mind, and the more delicate its susceptibilities, the greater is the danger of ruin to the growing soul. Leaving aside all the other lessons which may be drawn from Mill's case (even for the present the interesting question of Wordsworth's wonderful "healing power" and its sources), I have here a firm basis for some remarks on poetry as an instrument for the cultivation of the emotional side of human nature; and, I may say, I think that in an age when so-called "scientific" culture is showing such a strong tendency to oust the "humaner" system of education. too much stress can hardly be laid upon this view of my subject. Poetry, I would say, is soul-food; of mind-food I suppose we shall always have enough and to spare. Intellectual repletion is synonymous with soul-starvation; and I think I have now said enough to indicate a rock ahead.

I must now clear my way a little by describing briefly what I refer to as education in this paper. I have thought that two kinds of education may be pretty clearly distinguished—the haphazard and the systematic; and again two kinds—education for character and education for intellect. (Education for a special purpose—technical or professional education—I must omit altogether to consider.) I think, too, that my double classification may turn out to be really one. By the haphazard kind of education I mean (using an extreme term to characterise it) that kind of education which has been in vogue in England, with some not very radical changes and natural growths, from the sixteenth century to the present day, or, rather, yesterday. It is that inconsistent, apparently ill-organised, mainly "classical" education, which, combined with the wonderful social machinery of the English public schools and universities, has made the British nation what it is. By the systematic kind of education I mean that well-balanced, well-thought-out, well-carried-out system of training the young which is now being aimed at by all civilised nations, with, I think I may say, the United States of America at their head. The system is, so far as I know, not perfectly organised as yet anywhere. Its field is of course rather the primary and secondary schools, in England and her dependencies and colonies, than the great old-established public schools, grammar schools, and universities. There, war is being carried on briskly between the votaries of the old and the new kinds of education. At its best, the new system aims at good citizenship as its ideal result.

I think I am right in supposing that the old haphazard method of education aimed, in a vague, ill-defined and instinctive way perhaps, at the development of character, and in education in this sense I of course include the whole of that "social machinery," as I called it, of the English public school and university, which, I venture to think, has been the most potent factor in moulding the character of the upper and middle-class Englishman of the past. Whereas the more modern system has for its object rather the cultivation of intellect, the production of efficient, dutiful, and law-abiding citizenship, and the advancement of the physical and mental well-being of the State. There can, of course, be no question (leaving aside social influences) whether the first or second of these systems is ideally the better. The old method has, from a logical standpoint, hardly a merit; the new has all the merits and excellences possible. Yet the old method seems to have made England great, and the new has certainly introduced and developed to a most pernicious degree the present system (*must* I say inevitable or irreplaceable system?) of examinations.

Let me now show what seems to me to be the bearing of my subject upon the conflict which I conceive to be now impending or actually waging between the two methods of education which I have endeavoured to sketch, premising that I have been obliged for the sake of clearness in argument to represent them as perhaps more clearly distinct and more vitally in opposition to one another than they really are.

I think we shall find that the old system, from the point of view of poetry in education, is open to very severe criticism, and that the new system, from the same point of view, is threatened by a great danger. I cannot think that poetry, English poetry that is, had its fair share of attention, or anything like it, in the old English system of education. The plea for the study of English literature in the universities put forward by John Eachard in 1668 went unregarded, though winged with the feather of a very pretty wit, till the present day, when the heavier attack of Mr. Churton Collins has at last made a gap in the enemy's ranks. We cannot acquit the educators of English youth in the past of wholesale neglect of the masterpieces of English literature. By haphazard, indeed, and in a random scrambling way, I believe most Englishmen of brains and culture did gain some knowledge of at least our greater lights, of Shakespeare certainly, of Milton probably, and of a few of the really great, but that is the most we can say. I hold no brief for the old system from the point of view of poetry in education, and cannot here enter into the vexed question of the benefits arising or likely to arise from the study of Greek and Latin poetry by English schoolboys and youths.

In dealing with the modern style, I must return to the case of Mill and my main conclusion from it. I cannot but think that the tendency now-a-days is to make our educative system too exclusively rational and intellectual, to appeal to the reasoning faculties rather than to the gentler and more spiritual emotions. (The appeal to some of the lower emotions, the combative especially, is no doubt quite strong enough.) I must venture to say that I think Mill's disease is by no means unknown in the present generation, but that it exists in a very much milder form—milder by reason of the less terrible result upon the less susceptible and delicate organism. I must not pause to describe what would seem to me to be the present-day forms and symptoms of emotional starvation in the young, nor would I be understood to speak of the disease as present and rampant, but rather as incipient and menacing. I would say that there seems to be a danger, if things continue to develop as they do at present, that our youth may cultivate the mnemonic and mechanically rational powers at the expense of the feelings, and that very serious injury to character may be the result.

Coming to the more practical side of the question, as I hope to do by degrees, I must now describe how the term "poetry" is to be understood in this paper. If I thought it necessary to choose a definition of poetry for my purpose I should choose either that of Wordsworth: "Poetry is the spontaneous overflow of powerful feelings" or the more mystical one of Coleridge: "Poetry is the blossom and the fragrance of all human knowledge, thoughts, passions, emotions, language." Poetry, according to Wordsworth, being the outcome of strong feeling, must also stir feeling in the reader; it must stir or soothe; it must influence the feelings. This will fit in admirably with Mill's Lesson. Without classifying or defining poetry any further for the present, I would say then that all true poetry must make an appeal to the feelings, must stir or soothe. It would be superfluous for me to emphasise the fact that the higher feelings are meant; some of the finest art work of English poets must be a sealed book to youth because they appeal to the lower rather than to the higher feelings. I must consider as subsidiary and beside my subject all the incidental teaching which poetry may supply. I shall not dwell upon the fact that history may be studied in Shakespeare, ancient cosmology in "Paradise Lost," Middle English phonology and grammar in Chaucer, and a fine old rugged foreign tongue in Beowulf. Poetry has already suffered much by performing the office of a whetstone. The outcry against the modern "annotated editions" of our classics is already so loud that I need not pause here to add my complaint to its volume. I am dealing here only with the influences of poetry itself unannotated yet understood, upon the mind and heart of youth. And I think I may take it as a good general rule that all poetry which does not stir the higher feelings may be neglected so far as the best and most essential kind of training of youth is concerned.

Taking this as a general rule I may now proceed to examine the various kinds of poetry which are open to the teacher to choose from. I must premise that I am now to speak of poetry for boys and girls. The University "man" must of course fend for himself, and all classes of poetry are, or should be, open to him.

To begin with the oldest kinds—the genuine epic, the epic of Homer, is most admirably suited for the education of youth. Kinglake's eloquent testimony to the effect of its magic upon his childish mind would be enough to prove this. But the reflected or "deliberate" epic, "Paradise Lost," for example, is by no means so suitable. I believe most young people of both sexes learn to dislike Milton violently from being obliged to read "Paradise Lost" at school. No author so lends himself to the arts of the annotator and the prospective examinee. I must confess that I should like to see "Paradise Lost" banished from the schools (if it be not so already), and I do not think that Milton's fame would suffer by its banishment. Other epics we have none. Homer may be read in Pope's Translation: youth is not likely to be very critical about diction, and it was in this form that the "Iliad" touched Kinglake. Chapman's Translation of the "Iliad" is by no means suited for youth. But his "Odyssey" I know to be very pleasing to the palate of the young.

I think, on the whole, that the influence of the genuine epic, with its appeal to the healthy and natural story-loving instinct of youth, and its imaginative presentment of the primitive and basic virtues, is entirely for the good; and in the absence of any great accessible English epic for the purpose, I should personally like to see a fairly complete series of translations from the pure and noble classics of the Icelandic prose saga-literature read in place of it in our schools. I can conceive of no more bracing, stirring and tonic course of study than this.

The educative function of the epic may to some extent be performed by a selection from Scott's admirable balladesque narrative poems; some of the stirring war-poetry of Dobell, Tennyson, and Campbell, Aytoun's "Lays of the Scottish Cavaliers," Henley's "Lyra Heroica"; some very carefully selected pieces of Mr. Kipling; and by such modern work as that of Mr. Newbolt. These, however, I can only regard as very second-rate substitutes for the true epic.

Of lyric poetry I need say little, not because there is little to say, but because it is so very obvious that this is the class of poetry which is from every point of view the best for the purpose I have in view. Besides, have not Messrs. Palgrave (in the "Golden Treasury") and Henley (in the "Lyra Heroica") and a host of others, made this clear by their admirable selections and collections from the vast body of our English lyrical poetry? In lyric poetry everything that is best in English literature is included, with the exception of the work of the great dramatic schools.

Here, however, I must utter again a note of warning. There is an immense mass of lyrical poetry in English, produced mainly from the days of Surrey and Wyatt, early in the 16th century, to the end of the 17th century, which is entirely amorous and complimentary in its tone. It is most frequently fanciful and "metaphysical," also frequently coarse and gross; this body of verse contains much of the very best of English lyric poetry; yet I think that it is, on the whole, unsuited to youth. There are hundreds of these exquisite songs which are in their very "dialect of thought," if I may so express myself, incomprehensible to youth, and, if understood, not beneficial. I refer to such gems as "Drink to me only with thine eyes," Lilly's "Cupid and Campaspe," Waller's verses "On a Girdle," and many of

Shakespeare's sonnets, which are included in the "Golden Treasury." I cannot see that any good purpose is fulfilled by the study of this class of poetry by the young. If we educated with the idea of making poets, and courtly ones, the case would be different.

There is another matter connected with lyric poetry about which I feel strongly and must speak briefly. There are many beautiful lyric poems whose meaning is so abstruse, obscure, or attenuated, that it is not comprehensible by the young, except perhaps by great effort. I refer to such poems as Wordsworth's great ode "On Imitations," &c., Blake's "Whether on Ida's shady brow" and "The Tiger," Vaughan's "Happy those early days," parts of Tennyson's "In Memoriam," and many of the songs of Wordsworth, Keats, and Shelley. I believe that poems of this kind, though not fully understood, have, or may have, great influence upon the minds of the young. If learned by heart, they remain a perpetual possession, lying far back in the mind, subtly and unconsciously touching and directing the springs of feeling and thought. They act like fine melody, which carries no distinct formal idea to the mind, yet touches, stirs, and elevates. It is in poems of this kind that the most delicate, most stately, and beautiful rhythms of our tongue are attained, and such rhythms are a possession and a treasure apart from the meaning they convey. I do not believe that any boy or girl could recite, mentally or aloud, Wordsworth's "Ode" or Blake's "Whether on Ida's shady brow" without being spiritually the better for it. Of this I am very deeply convinced, and I am sure that it is in this class, and by this indefinable touching of the imagination and the soul, that poetry has its best, deepest, and most lasting influence upon the minds of the young of both sexes. It is here and in this way, I think, that true poetry enriches life.

I shall presently have occasion to speak of the danger of compelling children to read or learn poetry, and it is especially with reference to this class that I would emphasise the warning. I think this is too delicate and subtle an influence to be directed, as it were, by steam pressure upon the child-mind. I would remind you of Lamb's comment on one of Wordsworth's poems: "The instructions conveyed in it are too direct, they don't slide into the mind of the reader *while he is imagining no such matter.*"

Of dramatic poetry I must also speak more briefly than I should like to do. The great bulk of the Elizabethan school, of which English literature is so justly proud, must, by the very nature of its subject, its almost exclusive treatment of vile and loathesome features and tendencies in human nature, its revelling in bloodshed, crime, lust, and graveyard horrors, be barred to our youth. Shakespeare already has his place; I think he is overtaught and over-annotated, but must let that pass for the present. I would only remark that the greatest of Shakespeare's plays, especially Othello, Lear, and Hamlet, are very questionable food for youth. Dealing as they do with mature passions of a very violent nature in violent disturbance, and touching upon the deepest and most obdurate secrets of our nature, they are hardly calculated, I think, from any point of view to influence the young healthily and naturally. But the value of the historical plays, and especially of the humorous characters presented in them, cannot be overrated. I feel, though I should find it hard perhaps to explain or justify the feeling, that an intimate literary acquaintance with a character like Falstaff, as with Mrs. Gamp, or Captain Costigan, or Mr. Jorrocks, is an excellent preparative for entry into the world of real men and women. And I should say that the peopling of the mind of the young with such personages is among the best results attainable from the study of the historical dramas of Shakespeare. I need not dwell upon the educational advantages to be gained, from a different point of view, by the reading of Marlowe's "Edward II.," of Browning's "Strafford," of Tennyson's "Harold" and "Becket," and of Taylor's "Philip van Arteveldt," because the case is obvious, and I have preferred to dwell rather upon the deeper and more essentially character-forming influences of poetry upon the mind. I need hardly apologise for introducing this remark on Falstaff and similar creations on the ground that he is a prose creation. I must of course speak of dramatic poetry as a class or not at all.

Spenser must be considered apart. The influence of his great allegory upon the minds of youth is proverbially great, and I can only say that it must be good. But I doubt whether all, or even the majority of the young of our generation, feel his charm. And I would say that if the charm be not felt, it is unjust both to the poet and to the pupil to make the reading of the "Faery Queen" compulsory. I am, I confess, not able to estimate at all accurately the degree of interest taken in this poem by boys and girls, and must express myself very diffidently about it.

Our religious verse, especially of the Carolean period, is so rich, melodious, and profound that I think it should have a very large share of attention in any curriculum of poetry for the young. The best work of Vaughan, Herrick, Milton, Donne, and their contemporaries, cannot be too highly praised, and its effect upon the minds and characters of English youth should be very great. I should not hesitate to recommend the learning by heart of a large number of pieces of this school and period by way of both æsthetic and moral training. Their influence makes for purity and gentleness in life, and what could be a better aim?

I have now dealt with all those kinds of poetry which I believe to be most essential and valuable in the training of youth. I must also say something of those kinds which should, I think, be either excluded altogether or given a very subsidiary place. The ballad I have not spoken of separately, as it may be considered a special (and a very excellent) kind of lyric poetry; and what I have said of lyric in general will apply also to our ballad literature—to the great unnamed authors represented in Percy, to Coleridge, Wordsworth, Tennyson, and Browning as ballad-writers. The following kinds of poetry or verse I should mention as being more or less unsuitable for reading in schools:—(1) Satire, which is at its best in English a growth of exotic character, based upon classical models which are hardly admirable in any sense. The satirical work of Nash, Oldham, Defoe, Dryden, Marvell, Pope, Churchill, and Dr. Johnson, as well as of the more genuinely English Skelton and Butler, may, I think, be neglected in schools. I do not think that boys and girls need be encouraged to admire the arts of giving pain and making personal enemies ridiculous. (2) Pastoral poetry, with some exceptions, like "Lycidas." Beautiful as the work of our best pastoralists is—the work of Drayton, Wither, and Browne, for example—it is of exotic inspiration and essentially false in its prettiness and its optimistic presentment of toy-shop humanity. If we want the real poetry of sheep and of shepherd, of stream and rock, and wood and mountain, we can find it in Wordsworth, in Matthew Arnold, and many other poets of our own time. (3) Rhetorical poetry. Poetry which is essentially rhetorical and declamatory, whose diction is glittering and tawdry, should, I think, be barred altogether or relegated to the elocution department. Collins' Ode on the Passions, *e.g.*, is admirably suited for the training of Wopsles. Mrs. Meynell, I think, recently pointed out that Gray's "Elegy" was unsuitable for reading by the young. Her statement aroused much comment, as the "Elegy" has been for so long the prime favourite among English poems for the schools. I must say that on the grounds I have just mentioned, I think Mrs.

Meynell was right; and I would exclude from a curriculum of poetry for the young all poems which resemble the "Elegy" in its pretentiously rhetorical, yet commonplace, philosophy. (4) *Didactic* poetry of all kinds, even the descriptive. The didactic work of Thomson, Dyer, Cowper and their school should, I think, be barred, in spite of much elegance and beauty in isolated passages. The chief drawback to even the best work of the descriptive and didactic poets of the Eighteenth Century is, I think, the fact that they are not poetry according to Wordsworth's definition of Mill's requirements. They are not the overflow of spontaneous or of powerful feeling. They have no spontaneity and no power. They can do no harm, but we need not fall back upon them as though our literature had nothing more vital and dynamic to offer us. (5) Humorous poetry. I must naturally refrain from saying much of this class, as its influence at its best is very different from that which I have made the subject of this paper. I should, of course, not deny that the influence, or rather the temporary effect, of such excellent work as that of Barham and Hood is for good; and very sorry I should be to think that these authors will not be read and laughed over by young people for many generations to come.

Having now endeavoured to show, in outline merely, what kinds of poetry the teacher has ready to his hand as educational instruments, I proceed to develop more fully what I have already incidentally touched upon—the influence of poetry upon character. I may say that the influence of the best poetry upon the mind and the character is, in general, to purify, to stimulate, to brace, and to harmonise. The best poetry, especially of the lyric and religious lyric classes, purifies by raising the tone of the mind above earth, and directing the spiritual energies into their proper channel. I would not be understood to recommend or uphold the study of deeply mystical or Platonic poetry by the young. I think that nothing more profound than "In Memoriam" need be read by young pupils, and that only in the higher grades. Such work as Shelley's "Prometheus Unbound," the bulk of Browning's productions, and the "metaphysical" poetry of Donne would be altogether unfitting for our purpose. The authors whose influence makes for gentleness and purity of life are rather those I have spoken of under the head of religious poetry—Herrick, Vaughan, Crashaw, Milton, and Herbert; and among more modern writers: Tennyson, Arnold (in isolated pieces only), and Wordsworth. This purifying and raising the tone of the mind is one of those functions which can only be adequately and fitly performed by poetry, and I can have no hesitation in saying that the poets who are likely to do this best are those genuinely English, manly and gentle writers, Wordsworth and Tennyson. Wordsworth can, of course, only be read in selections; but the whole of Tennyson's work is most excellently calculated to influence the minds of youth in the best possible directions.

Poetry also stimulates. It is part of its function, as I have said above, to stir the feelings. It may stimulate to thought and to action. The heroic virtues, physical and spiritual, are best learned in poetry. All those activities, and that thorough control of them, which we call "manliness" are here to be learned. I would instance "The Idylls of the King" as poetry which should make for true manliness. I must not over-rate the importance of patriotic and bellicose verse as mental tonic. I would not say that poetry is likely to be a more efficient instrument than prose in this instance. Indeed I fear there is some danger of our going too far in this direction. Just as I think that most of Browning's work is too subtly and abstrusely philosophical to be studied with full advantage by the young; so I would utter a note of warning against a part, at least, of the vigorous "patriotic" doggerel of Mr. Kipling, and still more strongly against most of the verse which has been written under his influence. Mr. Kipling's "Imperial" poetry has of course great excellence, as had that of Tennyson before him; but admirable as its influence may be upon the minds of youth, and especially from the political point of view, upon Colonial youth, it falls outside the sphere with which I am endeavouring to deal in this paper.

When I say that poetry's function is to harmonise I use an expression which needs some explanation, as it hardly says what I mean, yet is the only term I can find to my hand. I mean that in a sense the best poetry has the tendency to make all people consciously or unconsciously philosophers. It makes men wise. It tends to produce and foster that true wisdom which was noted by Tennyson's nearest friends as eminently characteristic of him. It is that wisdom which results from a due appreciation of the value of things in relation to one another and in relation to life. It is that wisdom which is a kind of harmony in the mind, which is interfused throughout the mental structure, which acts subtly, profoundly, and as it were by a divine instinct. Part of Mill's Second Lesson was this: "The maintenance of a due balance among the faculties now seemed to me of primary importance." It is this balance of the faculties, and this only, that can produce true wisdom in minds not otherwise capable of the highest flights. I believe that this harmonising and tuning of the mind can only be produced by the study of the best poetry (I would perhaps except the prose of Carlyle, of Ruskin, and of Sir Thomas Browne), and it seems to me that it is here in this way so hard to define and so hard to understand that poetry produces its best, highest, and most permanent effect upon character. I am well aware that mental balance, mental harmony, and wisdom are fruits of mature growth, and are not to be expected in the young; but it would be superfluous and impertinent for me to insist upon the fact that it is during the plastic period of youth, and during that period only, that the instrument can be prepared and the field tilled for the future harvest. Tennyson has given beautiful expression to the thought I have here endeavoured to describe, in his little lyric called "The Spiteful Letter," in some other brief lyrics of the same period, and at full length in that very subtle and profound lyric, number 114 of "In Memoriam." This harmony of the mind is also characteristic of Wordsworth, especially in his 1797 to 1807 period, and I would instance especially the rather puzzling lyrics "I heard a thousand blended notes" and "Up, up my Friend, and quit your books," the most beautiful and profound stanza of which, by the way, Mr. John Morley has pronounced to be "a half-playful sally."

I feel deeply that I have not been able to do justice to this part of my subject. I hope, however, to have shown, at any rate, what my own conviction is in the matter of the influence of poetry upon character. I must leave much unsaid, and leave the subject at the risk of repeating myself *ad nauseam*, with the remark that the highest function of poetry is to attune the mind to wisdom, and that the wisest of our poets, and the best to study if wisdom be desired, are the two great laureates of the nineteenth century.

I must now come to the practical and much-vexed question of the manner in which poetry should be studied by the young. I hope to have shewn that it is eminently desirable that poetry should form an important part of the ordinary educational pabulum of the growing mind, nay, that it would be dangerous to omit it. This has of course long been recognised, and a certain amount of poetry is always read in one way or another in schools. The question is: "How should poetry be treated in the schools if we desire that it should produce its fullest effect upon the minds of our pupils?" I cannot hope to answer this question fully. I shall presently put before you a tentative or provisional "curriculum in English poetry for the young," based upon the considerations which I have discussed in the earlier part of my paper, and I hope that this will go some way towards answering it. In the meantime I must add a few words upon the manner in which I think this mental food should be administered.

In the first place, I am deeply convinced that in this department, at least, there must be no driving, no compulsion. The fact that compulsion is, in fact, commonly resorted to in this matter, is partly due, no doubt, to the uninviting and even repulsive nature of the poetic fare which is too often put before the young. I believe that the youthful mind will gain little or nothing from the enforced study of poetry, before which it instinctively recoils. I am thinking of "Paradise Lost," and I am not quite sure about Gray's "Elegy." I think that all poetry which is not "simple, sensuous, passionate," to use Milton's own phrase, is likely to be uninteresting and unattractive to the young. When I hear a person say of a poet, "We read him at school," I understand him to mean "and therefore I have not read him since."

This is sad, but I am afraid that in the majority of cases it is true. And I do not think that this state of things is due only to the unattractive nature of the poetry usually read in the schools; it cannot be so. It is due also in part to the manner in which really attractive poetry is made repulsive and a bugbear to the learner. I must enquire briefly how this is done, for of the fact that it is done I can have no doubt.

There are, I think, three reasons why most people do not look back with pleasure upon the poetic part of their school curriculum. The first is the compulsion I have already alluded to, due to the unattractive nature of the material to be studied. The second is over-teaching and over-annotation of texts, the too common practice of making the poem a peg upon which to hang historical, philological, and metrical disquisitions. The third, and the most potent of all, is the examination system. With the first of these causes I have already dealt. I propose now to say a few words of the second and the third.

With regard to over-teaching and over-annotation of texts, I can hardly speak strongly enough. It has been my lot to review a very large number of school editions, "edited and annotated for schools," of the great English classics, principally, of course, of Shakespeare. There are some brilliant exceptions; but, in general, I may say that I can conceive no more efficient method of diverting the attention of the learner from what is essential to what is extraneous and incidental in works of literary art, than that supplied by the ordinary "annotated edition." The notes are not only superfluous and irrelevant—(I have seen, for instance, a "note" on one of Macaulay's Essays explaining gravely that "Bob" is short for "Robert"; and another on a passage in which the mole happened to be referred to, consisting of a long account of the appearance and habits of the animal, lifted bodily from a dictionary of natural history)—they are not only very frequently compiled by incompetent persons and done in a hurry (this kind of work not being highly paid)—but such passages as do really need a word of explanation or comment are too often explained and commented upon at such length, with such solemnity and parade of authorities, such copious reference to folios, and quartos, and Hanmer, and Steevens, and Malone, that no pupil can really be blamed for thinking that after all the notes are the chief thing, and that the examiner will certainly ask questions based upon them and not upon the text. It is by no means uncommon for students in higher classes than those I am referring to, to go up for examination in a given text without having read the text itself, but full charged with the thunder of the notes. To be honest with you, I will confess that I have done it myself, when pressed for time, with success, which is a poor compliment to my examiners. I made a practice, as a reviewer of school editions, of comparing the bulk of the text and of the notes in all cases, and I frequently found cases where the notes outbulked the text by twice or three times its volume, the notes, be it observed, being printed modestly in smaller types. These facts speak for themselves. I can hardly trust myself to speak of the results which I believe to follow, almost inevitably, the study of our great classics in this manner. Nobody will, of course, deny that in the case of Sixteenth and Seventeenth Century authors some explanatory and glossarial assistance is necessary for the comprehension of the text. What we must demand is that this assistance be reduced to a minimum, that the attention of the reader be not drawn off incessantly to irrelevant and subsidiary matters, however interesting these may intrinsically be; and that as far as possible in the schools explanations should proceed from the teacher rather than from the text-book. I need hardly add that a wise and competent teacher knows how to cause his pupils to explain difficulties for themselves, and obtrudes himself as little as possible upon the attention of his class.

I believe that this evil, which I consider a great and crying one, may be remedied by the adoption for study in schools of the least annotated, and least "edited" texts; and, in the case of modern authors, I am strongly of opinion that unannotated texts are by far the best. A series of English classics on the model of the late Prof. Henry Morley's well-known little National Library Series, cheap, well-produced, and unannotated, is, I think, the *editio desiderata* for use in schools. I must not leave this subject without adding that there seems already to be a fairly strong reaction setting in against over-annotation and its allied evils, and that in the case of Shakespeare, at least, there are now editions (notably that edited by Prof. Herford for Messrs. Macmillan) which leave little or nothing to be desired in the way of dispedagogisation.

I come now to the third cardinal fault in the teaching of poetry in schools, and what I have to say on this head applies also, to some extent, to the study of the English classics at the universities, old and new. It is only with reluctance that I can admit that the examination system is really necessary in any department, but I must allow that in most subjects it is an unavoidable evil. I do not propose to enter at length here upon the question whether literature can be taught, or whether examinations in literature can be so conducted as to obviate the danger of cramming. The subject has attracted much attention in England of recent years, and has been the *casus belli* in several controversies. Some prominent English literary journals, notably the *Saturday Review*, have taken up a very decidedly hostile attitude to the examination system, as tending to encourage cramming and the development to perfection of the crammer's art. This seems to me very encouraging. With examinations and their effects in general I cannot here deal however, but must enter a most vigorous protest against our English classics being made the subjects of examinations in our schools. I would say, if examinations are really a necessity in schools, for the purpose of testing the relative capacity, industry, and progress of the pupils, let the English classics form an unrecognised, unofficial department of the school curriculum. I do not believe it is possible for any child or youth to enjoy or appreciate thoroughly any poem in which he is about to be, or has been, examined in the ordinary school way. I need not dilate here upon the evil effects of reading with a view to examination. It will be sufficient to say that the mind of the reader is directed solely, or almost so, to the detection of possible "points" and "likely" passages for examiners; and that the chief quality fostered and encouraged by this kind of reading is a kind of sharpness which may be called "examinee's cunning," and is only accentuated, aggravated, and acidulated by the emulative instinct which must always accompany the expectation of a list of marks or "examination result." I should weary you if I should endeavour to describe fully what I believe to be the effect of this kind of reading with a view to a competitive test. I will say briefly that it is benumbing to all the higher faculties, that it encourages feelings and instincts which need no encouragement, and that it would be quite impossible for any pupil to gain, from the reading of English poetry, under this system, any of the great advantages which I have spoken of as likely to result from the study of it when fitly and decently encouraged.

I suggest, therefore, that the reading of English poetry by schoolboys and girls should be interfered with as little as possible by teachers, and that no examination of any kind should be held in this subject. I think that some way might be devised by which the reading of certain books might be encouraged without the possibility of reward or punishment in case of industry or neglect. Many and many an English schoolmaster has made his pupils genuine lovers of English literature, and of English poetry especially, by simply reading to them, out of school hours, the right books in the right way; or by merely lending his books judiciously. It is in some such unofficial way as this that I should like this all-important kind of soul-food to be unobtrusively and unostentatiously communicated to the young. Pupils should by no means be compelled, and in some cases they should not even be encouraged, to write essays or compositions upon the poetry they have read. Anyone who has had the misfortune to be obliged to read a number of such productions for examination or other purposes will feel the full force of this remark, and, I am sure, will agree with me in it. It is almost impossible to keep certain critical text-books and histories of English literature out of the hands of the young, and their jargon is only too easily acquired. I believe that there are thousands of miles of criticism, plausible, glib, and even correct enough in a sense, written every year in the English language by young people who have not read a line of the works they criticise. And I cannot but think this is undesirable, dishonest, and hostile to the best interests which the best teacher should have at heart. I do not myself think that any criticism of poetry should be required under any circumstances from the young. Critical taste is, as is well known and acknowledged, an exceedingly rare gift; and I do not think that the formation of a good taste in poetry, a thing so much to be desired, is likely to be assisted by encouraging the young to write or repeat the judgments of others, or to give expression to their own naturally crude and immature judgments. Good critical taste in poetry, I take it, if it can be acquired at all, is to be acquired by long, patient, loving, and silent study of the best poets. How can we expect this from schoolboys and girls? I must remark, in case of misunderstanding, that I am here speaking of poetry itself and its study, not the history of poetry or of literature, which is an entirely different thing, and, in fact, may be called one of the inexact sciences.

To sum up: I have now endeavoured to show that poetry should play a very prominent part in the education of the young of both sexes; that its effects are beneficial to the mind, and more still to the soul and character of the young reader; that great care should be exercised in the selection of poetic works to be studied by the young; that English literature is peculiarly rich in those great wise natures whose expression in poetry is calculated to have the very best influence upon growing pliant minds; that there are very great and mischievous faults (which are tending to correct themselves however) in the methods of "teaching poetry" in our schools at the present day; that, in my opinion, the reading of good poetry should be encouraged, not enforced; and that, lastly, pupils should be encouraged to read solely for their own pleasure and delight, without being afterwards subjected to an annoying and wearisome examination in what they have read, or being obliged to write down their impressions, judgments, and opinions. Much of what I have been obliged to say here has been said very often before; and much that I should have liked to say, I have been forced to leave unsaid; yet I have ample justification in my own mind for both these facts. If I am right in complaining of the evils which have crept into our schools, I am sure I cannot speak too often nor too strongly against them. I, like many others, am anxious that these evils should be corrected, and I have this matter at heart. On the other hand, it would have been unwise in me to say all that I might have said on the examination system, for example, for I should then have defeated my object by wearying my hearers.

I have only now to put before you the following curriculum, naturally merely an outline, which I recommend as a preliminary course of reading for the young in English poetry. I have been obliged to make it a strictly preliminary course, and I have designed it for the use of pupils between the ages of 12 and 17. Those who continue their studies after their 16th year usually read for some University Degree, and it is not with students of this age, and their requirements, that this paper primarily deals. I would also have it understood that the age of the pupil is not a matter of the first consequence, but rather his capacity and especially his bent or inclination towards such subjects as that I am dealing with. I am well aware that many children have no natural taste for poetry or for anything allied to it, yet I cannot recommend any compulsion, mild or severe, in these cases, for I am sure it can only replace indifference by dislike, and want of taste by distaste. Very much must be left to the personal influence and judicious methods of encouragement of the teacher himself.

I must add that the scheme here proposed is by no means comprehensive. My object has been rather to indicate the class or grade of poem suitable for each period than to give a complete list of works to be read. Many old favourites will be missed, some omitted simply because to mention all would be beyond the scope of this paper, and some because I have hardly thought them eligible, in spite of their popularity.

FIRST YEAR (12th to 14th years).

Blake: "Songs of Innocence."
Wordsworth: The simple Ballads of 1798 to 1807.
Percy's Reliques: "Chevy Chase," "Sir Patrick Spence," &c.
Coleridge: "Ancient Mariner."
Henley's "Lyra Heroica."
Scott: The Romantic Poems.
Macaulay's "Lays of Ancient Rome" and "The Armada."
Tennyson: Patriotic Ballads; "The Revenge," &c.

SECOND YEAR (14th to 15th years).

Tennyson: "Idylls of the King"; "Enoch Arden."
Shakespeare: "Henry V."; "The Merchant of Venice"; "Julius Cæsar"; "Coriolanus."
Coleridge: "Christabel"; "Kubla Khan."
Barham: "Ingoldsby Legends."
Wordsworth: "Peter Bell"; "The Waggoner"; "Hart-Leap Well."
Chapman's "Odyssey."

THIRD YEAR (15th to 16th years).

Wordsworth: "Resolution and Independence"; "Michael"; "The Brothers."

Tennyson: "The Princess"; "Becket"; "Harold."

Herrick:
Vaughan:
Crashaw: } Selections.
Herbert:

Shakespeare: "As You Like It"; "The Tempest"; "The Midsummer Night's Dream"; "Richard II."

Burns: The non-amatory songs and "Tam o' Shanter."

Byron: "Prisoner of Chillon."

Milton: "Lycidas"; "L'Allegro"; and "Il Penseroso."

Dryden: "Ode on St. Cecilia's Day."

Matthew Arnold: "Balder Dead"; "Sohrab and Rustum."

FOURTH YEAR (16th to 17th years).

Tennyson: "In Memoriam"; "Maud."

Wordsworth: "Ode on Intimations"; "Tintern Abbey."

Shakespeare: "Macbeth"; "Hamlet"; "Lear"; "Romeo and Juliet."

Marlowe: "Dr. Faustus"; "Edward II"

Chapman's "Iliad."

Milton's "Comus."

Chaucer's "Prologue" and "Knight's Tales."

Sir Henry Taylor: "Philip van Arteveldt.'

Crabbe: "The Village."

Blake: "Songs of Experience."

Palgrave's "Golden Treasury" (a good deal of which might be selected for the earlier periods).

Keat's Poems.

Matthew Arnold: "Lyrics"; "The Scholar Gipsy"; "Thyrsis"; "Empedocles on Etna."

Spenser: "Faery Queen."

THE THEORY OF USE-INHERITANCE, PSYCHOLOGICALLY CONSIDERED.

By Professor H. Laurie, LL.D.

The large subject of the hereditary transmission of characteristics acquired during the lifetime of an individual has been treated from two points of view. It has been asked whether the effects of use and and disuse may be thus transmitted. And, again, inquiry has been made into the transmission of individual modifications resulting directly from the action of the environment. These questions, however, are very closely connected, and cannot be discussed in entire independence of each other.

The biological aspect of the theory of use-inheritance is the most prominent. If it can be proved that structural and physiological characters acquired by the use or disuse of different parts of the organism are handed on, a similar principle may be applied to mental traits; and, on the other hand, the disproof of this principle, biologically, would lead us to discard it in psychology. At the same time, the subject deserves, and demands, a separate psychological treatment. We know that a limb is strengthened by use and weakened by disuse; and we may ask, as a question of fact, apart from various theories of the mechanism of heredity, whether the effects of such use and disuse are transmitted to descendants. On the psychological side we know, equally, that a benevolent or an envious disposition may be confirmed by habit, and the question of transmission recurs. We cannot, however, answer this psychological question by any biological investigation; we cannot trace the nervous changes which accompany these altered dispositions; and our belief in such concomitant changes springs, not from direct observation, but from our conviction of a thoroughgoing correlation between the mind and the nervous system. When we inquire whether mental dispositions acquired or strengthened during a lifetime are transmitted hereditarily, our observation can extend only to the feelings of parent and child, as manifested in conduct. It is clear, therefore, that the psychological inquiry cannot be neglected.

Since the appearance of Weismann's Essays on Heredity, the literature of the questions raised by him has grown to so vast a size that only a specialist can lay claim to be fully acquainted with it. Without entering on the theory of germ-plasm, or rival hypotheses as to the working of heredity, I may roughly divide those who have taken part in the controversy into three classes.

The *first* comprises those who maintain, whether on philosophical or on scientific grounds, the theory of the gradual transmission, from generation to generation, of characters acquired in the lives of individuals. The philosophy of Herbert Spencer, who adopted this theory from Lamarck in pre-Darwinian days, is saturated with it. Haeckel, too, has nailed his colours to the mast, affirming that "the inheritance of characters acquired during the life of the individual is an indispensable axiom of the monistic doctrine of evolution." The acquired characters here spoken of include those resulting from use or disuse.

A *second* class is composed of those who believe, with Weismann and Wallace, that there is no evidence of such transmission. Darwin, while accepting the transmission of variations resulting from use and disuse, saw that, if true, it would account only for a small part of the facts. His theory of natural selection was satisfied with the truth that variations do make their appearance in the course of descent, no individual being exactly like another; and he showed how these variations were naturally eliminated if prejudicial, or conserved if beneficial, thus giving rise to new species. The ulterior question—whence the variations?—though by no means neglected by Darwin, lay beyond the limits of his special inquiry. Neo-Darwinians call attention more emphatically to his theories of natural and sexual selection, leaving the original variations to be accounted for in other ways. One of the latest utterances on this question is by Professor Ewart, in his address as President of the section of Zoology at last meeting of the British Association. He lays stress on maturity, habitat, nutrition, and temperature, as causes of variation; but does not believe there is any trustworthy evidence that definite somatic variations are incorporated in the germ-cells and transmitted to offspring. The general tendency of recent thought has undoubtedly been to diminish the importance formerly attached to the doctrine of use-inheritance.

In a *third* or intermediate class may be placed those who do not reject the transmission theory *in toto*. They retain it as a provisional or working hypothesis, using it in cases where other explanations are not readily forthcoming, or appear to be unsatisfactory. Further light will doubtless be thrown on the subject by experiments which are now being conducted on plants and on some of the lower forms of animal life.

In this state of doubt, it is worth while to ask whether psychical facts, taken by themselves, confirm the hypothesis of use-inheritance. There is no longer any excuse for the prejudice that a negative answer must be hostile to the doctrine of evolution. Whatever may, or may not, be the effect of habits acquired in the lifetime of an individual, we may still believe in the development of psychical life, the higher susceptibilities and powers having been superimposed on the lower.

The influence of heredity is too patent to be denied, though it may be variously estimated. In the beginning of the nineteenth century, the prevailing tendency was to make too much of the levelling power of education, and too little of the original differences between individuals and races; towards the close of the century it had become the fashion to exalt nature unduly over nurture. Recently, the pendulum has been swaying back again; greater importance is now attached to the life-history of the individual; and the new century opens with brighter hopes for the prevention of disease and vice, in spite of an adverse heredity. Nurture, however, can work only on the materials which nature has given, and which, to no slight extent, are inherited from past generations. It is interesting to watch the qualities of parents repeated in their children, or to trace peculiarities back to grandparents, or remoter ancestors. And when any one resembles one or both of his parents in some particular trait, it may easily be supposed that this is due, in part, to a habit which was formed before he was born, and which has influenced him through heredity. The father, for instance, may have fostered in himself a generous or a grudging habit; the son follows in his steps, and becomes beneficent or penurious. But there is no evidence here of the inheritance of an acquired character. The constitution of the child may have been similar to that with which his father began, requiring only the incitement of circumstances to evolve a similar habit; nor can we overlook in such cases the effects of precept and example. It is not uncommon to find a son resembling his father in being extravagant in his youth and covetous in his old age. This is easily understood if we suppose both to begin with a similar constitution; the tendency to covetousness may be latent, like the tendency to gout or obesity, or it may follow by way of revulsion from the consequences of extravagance. But I am not aware of any facts which show that a son born in the extravagant period is likely to be more extravagant than a son born when the covetous period has set in; and, even were it so, this might be accounted for by the force of example in early years, or by the greater vigour and more sanguine temperament of a son born when the father was in his youthful prime.*

Let us take, as a crucial instance, the use of language. Urged on by the imitative impulse, the child begins to speak before the end of his second year, and soon acquires the use of his native language, with a vocabulary which is very limited at first, but which he may enlarge in accordance with his need. The power of understanding and using language, in some one or other of its forms, remains with him to the end of life. Even in silence, he usually thinks in words. His mental associations between words and sentences are connected, on the psycho-physical theory, with subtle but well-worn paths in the mental structure of the brain. The use of language, thus pervading the conscious life of each individual, has been going on through countless generations. Language changes, it is true, but the change which takes place in the course of centuries is gradual, and the roots of words run back to a hoary antiquity. If use-inheritance were a reality, we should expect to find it exemplified here. But there is not the slightest sign of it. The language which a child learns—English, French, or German, or what not—depends on his environment. He has simply the power of acquiring the tongue which he is taught; and in this respect he shows no advance on his parents or on his remote ancestors.

Turn now to instances of genius or exceptional talent. Here we have such examples as the Bach family, which during two hundred years produced musicians of a high order; and the Gregories, who made their mark for generations in various departments of science. On the other hand, we have men who shone as single stars. In these last cases, the evidence is opposed to the theory of use-inheritance. We find no traces, as the theory would require, of succeeding generations cultivating some gift which gradually increased with use, and as gradually decreased with disuse.

* When I speak, here or elsewhere, of an original constitution or disposition, I do not mean to say that this consists of definite psychical facts, known to exist, and capable of being pointed out from the very beginning of mental life. It is only the subsequent development which makes known to us the original tendency; and thus, as Mr. Bradley has remarked, statements about native psychical dispositions or tendencies are only "statements as to what will happen under certain conditions." The awakening mind, like the physiological germ, exhibits certain characteristics as it develops, and in this sense, and this alone, I speak of an inherited mental constitution.

The great poet may come of folk who never cultivated their imagination or turned a verse; the great composer, perhaps, is the child of some mediocre executant. Shakespeare, Goethe, left no genius to succeed them; the son of Mozart found more music in the chink of coin than in symphony or sonata. And even when we find a similar gift or talent repeating itself in generation after generation, it is not proved that the practice of this talent has so impressed itself on the germ as to cause hereditary transmission. Thus Weismann points out that, just as a child in acquiring a language starts where his parents began, so also, if he inherits his father's talents, musical or otherwise, he has only a predisposition which cannot dispense with instruction. The greater talent which the son sometimes exhibits may depend on training in a congenial atmosphere; or it may spring from "fortuitous variations" in the sense of Darwin—"variations which seem to us, in our ignorance, to arise spontaneously." And in some succeeding generation, a decline in the particular talent may be the result of other variations, or may be explained by the natural law of regression towards mediocrity.

The alcoholic habit acquired by a parent may possibly be transmitted. Mr. Francis Galton, who preceded Weismann in his scepticism of the transmission of acquired characters, is willing to admit an exception here, on the ground that the alcohol may so permeate the tissues as to affect the germ. This, of course, is a different thing from the inheritance of definite somatic characters. But it is equally legitimate to suppose that a son, if he too acquires the alcoholic habit, has inherited the parents' original tendencies. An impaired constitution may also have fallen to his lot; for no one doubts that badly nourished parents are likely to produce weakly children. If the mother be a drunkard, the child may be injured by the action of alcohol before birth; but this is an instance of the influence of environment, and ranks with the evil influences to which he may be afterwards be subject in a drunkard's home. There are some repetitions of the drinking propensity which cannot be explained by the theory of the transmission of acquired habit. We find such strange coincidences as the following:—A man, after the birth of his children, becomes a drunkard, and deserts his wife and family. His son, long a total abstainer, marries a charming girl, to whom he is sincerely attached, and yet he too becomes a chronic drunkard, and wanders forth into space. In such cases, the hypothesis of the transmission of acquired habits will not apply, and we can only conclude that a similar constitution, nervous and mental, has issued in like conduct.

Insanity runs in families, and is transmissible by heredity. But it does not follow that an acquired character is transmitted. The parent may bequeath his original tendency to insanity, which is developed by the child; and even then its appearance may be due, not only to the inherited predisposition, but also to surrounding circumstances. And it is not as if a definite kind of insanity, acquired by the parent, were transmitted to the child. In the offspring, the malady may take a form differing widely from a psychological point of view, from that of the parent. It would rather seem that what is really transmitted is a nervous weakness or instability, which may issue in one of many forms; and idiotcy or insanity may result from tuberculosis or epilepsy, as well as from defective intellect or insanity in parents. We need not doubt that a lowered nervous and mental vitality, whether original or acquired, is transmissible to descendants; but this is a very different thing from a definite form of disease being stamped on the brain-cells and exhibited mentally, and then transmitted by heredity. On the subject of disease generally, the growth of medical opinion, as Dr. Jamieson remarks in a recent article, has been to minimise the importance of heredity. One reason for this is to be found in the germ theory, which has shown that illnesses are acquired through infection, in the lives of individuals, to a far larger extent than was formerly supposed.

The theory of use-inheritance has been employed to explain our knowledge of space, our conviction of the universality of cause, and our moral intuitions. Let me briefly consider these as test-cases.

At one time it was held by empiricists that our knowledge of space was derived, in the lifetime of each individual, from motor sensations. More recently, those who combine the theories of empiricism and evolution have thought that our idea of space is too great to be achieved in a single life, and that it is chiefly due to a succession of ancestral experiences. Thus, it has been held, the *a priori* and the *a posteriori* accounts of space may be reconciled, the knowledge of space being nativistic for the individual, though acquired in the experience of the race. The lion of empiricism and the lamb of *a priori* philosophy lie down together; but, as has been wittily remarked, the lamb lies down inside the lion. For the foundation of the theory is empirical. It is supposed that, at some remote time, motor sensations contained, in germ, the knowledge of space; that this knowledge has grown with the correlated structures of the brain, which condition sensations and their connection; and that thus at last our present knowledge of space has emerged. Here, it is the first step that costs. The initial difficulty of this hypothesis, as of the empirical theory which it has supplanted, is to show that our knowledge of space can be analysed into sensations. The motor sensations are, no doubt, conditions of our knowledge of space, and of objects as spatial; but I cannot see that sensations, which are mental facts, and therefore non-spatial, can contain in themselves either space or our knowledge of it. The question is too large to be discussed here; but the burden of proof lies on those who maintain the theory, and in any such account of the genesis of our knowledge of space it is easy, I think, to detect the *petitio principii.* There has been a recurring tendency to suppose that, because sensations are the "first things in consciousness," all that follows can be resolved into sensations. But, however true it may be that motor sensations precede, and condition, the knowledge of space, the analysis into sensations fails. And this difficulty is not overcome by pushing it into the obscurity of the past.

Again, it has been held that our belief in the universality of causation has resulted, not only from orderly sequences observed by the individual, but from similar sequences which have impressed themselves on the nervous systems of our ancestors, the expectation of the recurrence of phenomena growing stronger as it is transmitted through generation after generation. It is here assumed that the extraorganic world, the organism, and the mind itself, obey the law of cause and effect. The law of universal causation is thus taken for granted as clearly as it is by the physicist or the *a priori* philosopher. It is evident that the law cannot be validated by a theory which presupposes it. But, assuming the objective validity of the law, is it possible to account thus for our belief in it? I think not. The occurrence of observed sequences, however uniform, could give no security for their orderly recurrence in the future and the remote; and a blind expectation, based on habit, whether personal or ancestral, is really not what we mean by our belief that every event must have a cause. And it is far from the truth to represent the orderly sequences of nature as simply mirroring themselves in the mind of man through sense, and thus, through frequent repetition, being recorded in the organism. The orderly world of our experience is due, in no small measure, to our own construction. The sensations which we encounter from moment to moment. considered merely as sensations, present the appearance of being abrupt, undisciplined, chaotic; to use Hegel's expression, they are, as it were, fired at us out of a pistol. As J. S. Mill says in one passage—"The order of Nature, as perceived at a first glance, presents at every instant a chaos followed by another chaos." Even Herbert Spencer speaks of external phenomena as "mixed in the most heterogeneous manner, and presented to the moving organism in combinations never twice alike." Yet he regards all psychical relations, including every necessity of thought, as resulting from experiences of external relations, on the principles that frequent external sequences must produce corresponding mental sequences, and that the effects of these are transmitted to descendants through the nervous organism. Is it not clear that we should never be able to discern a cosmos if we were wholly dependent for our knowledge on the ever-varying impressions pelting in upon us from all sides through every avenue of sense? Nothing could be more ignorant or more helpless than a mind doomed thus only to reflect the environment. It is only by neglecting some of the materials given to us in sense, selecting others, and adding to them from the store of our past experience, that we can even perceive material objects, and, on a higher plane, it is by a similar selection of attributes that we become aware of classes and of laws.*

It is a mistake to suppose that what we have gained by our explorations has been before us all the while, and that we have only received its impress, deepened by repetition and by heredity. The ordered world which we have won from the inane implies on our part discrimination, assimilation, and a desire to possess the environment for our own uses. Instead of laying ourselves open indiscriminately to every sensation, we have adventured in quest of a world which will suit our needs and accommodate itself to our

* As Professor James has said—"The world's contents are *given* to each of us in an order so foreign to our subjective interests, that we can hardly by an effort of the imagination picture to ourselves what it is like. We have to break that order altogether, and by picking out from it the items which concern us, and connecting them with others far away, which we say 'belong' with them, we are able to make out definite threads of sequence and of tendency; to foresee particular liabilities and get ready for them; and to enjoy simplicity and harmony in place of what was chaos. Is not the sum of your actual experience taken at this moment and impartially added together an utter chaos? It is an order with which we have nothing to do, but to get away from it as fast as possible. As I said, we break it: we break it into histories, and we break it into arts, and we break it into sciences; and then we begin to feel at home."—*The Will to Believe and other Essays*, pp. 118, 119.

powers; and we have to some extent succeeded. In so far as our science is true, we have found a reality behind the veil of appearance. The world which we have thus discovered is very different from the weltering chaos which it presents to mere sense. On these grounds, we must reject the theory that our belief in the universality of causation, or in the orderly sequences of Nature, is due to the hereditary transmission of a nervous record of sense-experiences in the lives of innumerable generations.

Our moral intuitions, it has been said, are due to ancestral experiences of utility, similarly recorded in the cerebral hemispheres, and transmitted. An intuition, thus understood, is not an immutable belief; it is a belief inherited in the way supposed, and subject to criticism in the light of further experience. Whatever may have been the origin of the moral ideal, it is undoubtedly true that there is such an ideal, and that it has undergone changes in the development of the individual and of the race. The question to be decided is whether these changes require for their explanation the theory of the transmission of acquired characters. May they not be explained by conditions which are sufficiently obvious, without bringing in this hypothetical influence? Moral precepts are handed down orally and in writing from generation to generation; they are impressed by example, and enforced by penalties. Codes of life are embodied in laws and institutions. Everyone breathes the moral as well as the intellectual atmosphere of his time. Opportunity for progress is given in the conflict of ideals, the law of the survival of the fittest holding good here as in organic evolution. There is, also, a natural selection of individuals, tending to the elimination of those who fall below the level of their time, and conserving those who live more nearly up to its ideal. Sexual selection is shown in the choice of those who are unselfish, and who try to do their duty. The kindly and the moral are more likely to survive, and leave descendants, than those who defy morality. Whatever tendencies towards moral progress exist in a community may be transmitted in the known and obvious ways of social intercourse. What residue is left to be explained? With these influences at work, there is neither need nor room for the supposed transmission of the results of moral action through the nervous organism. Darwin parts company with Spencer here, remarking that, on his principle, senseless customs, superstitions, and tastes, such as the horror of a Hindoo for unclean food, ought to be transmitted, and that there is no evidence of this. Wundt, in his work on Ethics, criticising Spencer's theory of moral intuitions from a physiological point of view, is more disdainful. "Actual neurology," he says, "has about as much connection with these assumptions as actual astronomy and geology with Jules Verne's voyages of discovery."

My survey has been far from exhaustive, but I have at least considered some important cases in their bearing on the theory of use-inheritance. Psychology, it appears to me, lends no countenance to the theory. From the facts of human progress, we know that variations have come in from time to time. In accordance with the hypothesis of evolution, we may believe that similar changes have occurred along the whole line of mental life, and that, connected as they are with nervous modifications, they have been hereditarily transmitted. It is a legitimate task to inquire into the conditions of such psychical variations, and to reduce them to their elementary constituents. But the principles of heredity and of evolution do not necessarily imply the hereditary transmission of characters acquired by use or disuse in the lives of individuals; and the theory of use-inheritance, worked for all that it is worth, has been found to be misleading.

THE PROFESSIONAL TRAINING OF TEACHERS.

By Miss Margaret Hodge, M.A.

If there is one cry that has been heard more loudly than another amid the clamour of conflicting claims on our attention during the past ten years, it has been the cry for technical schools and technical training. We are told in no uncertain accents that we are, as a nation, losing our commercial supremacy; and that this loss, when it is an accomplished fact, will be mainly due to our remissness in the matter of technical education. Among all English-speaking nations the cry is taken up, and throughout an Empire, on whose bounds the sun never sets, the County Councils, the Parish Councils, and municipal bodies are all eager to promote, and ready to subscribe to, one cause—that of technical education.

England took the lead in trade and commerce in times past, it is urged, because she had the apprenticeship system, which offered a technical training superior to any on the Continent; she shall still take the lead in times to come, by having the best built, best equipped, and best staffed technical schools in the world. When Mr. E. Williams, in his clearly-written little book "Made in Germany," pointed out that Germany was spreading her trade and influence far and wide, and would soon drive us out of the field, his readers professed to disbelieve his statements; but they, nevertheless, were affected by them, and formed part of that vast band who cry out for a system of technical education, utterly ignoring or wilfully misunderstanding the real drift of his statements.

It is not because Germany has an excellent system of technical education that she is placing herself at the head of the commercial nations of the world, but because she has, for generations, had an admirable system of general education upon which to base her technical training. You cannot make an utterly ignorant man into a good builder or plumber by teaching him the mysteries of his craft, any more than you can make him into an admirable University Professor by a short course of lectures on the special Faculty he is to teach. There must be firm foundations to build upon, and it is because England is trying to build her technical training upon insecure foundations that it never can be equal to the training given in such a nation as Germany.

It seems to me that the excellence of the German educational system, elementary and secondary, is based upon two essential qualities:—

(1) The great value set by the Germans, since the Napoleonic wars, upon a really sound literary education, and the strenuous efforts made by the German nation since its birth to secure uniformity and thoroughness of teaching throughout the Empire.

(2) The intense belief that exists among them in the science of education; the profound contempt they feel for mere empiricists, who stumble on complacently, delighting in their discoveries in the art of teaching; discoveries which only appear to them as new because of their own ignorance, and overlooking their defects and shortcomings because they have no standard with which to compare themselves. The intense belief of the Germans in the need for a sound scientific theory to aid and to correct personal experience leads them to insist on the training of every teacher in the science and art of education. Their greatest philosophers have not hesitated to devote much time and thought to methods of teaching, and their most gifted teachers are all bound to go through a regular course of training for their profession so severe and so thorough that all English untrained teachers, however great their practical experience, appear to them in the light of presumptuous amateurs. The question of the adequate training of teachers, which has lately been a subject of much controversy in Sydney, is one of world-wide interest. It is a branch of technical education which is all-important, for it affects not one portion of the community only, not one branch of its trade, but the whole nation. It affects not only the intellectual, but the moral and physical well-being of a whole people; and it seems to me extraordinarily short-sighted to spend lavish sums on the foundation of technical schools for any or all of the crafts, while the great majority of teachers are exercising their craft without any adequate training at all; while, from their ignorance of physiology, they are lowering the standard of physical health, from their ignorance of psychology they are deadening the minds, and from their ignorance of ethical principles they are lowering the moral tone of their pupils.

"There is no more pathetic sight in creation," says Edward Thring, "than a slow, good boy, laboriously kneading himself into dulness just because he is good"; and it is a sight that we are often called upon to witness in our present system, where the method of teaching, if it deserves the name of method, is not founded upon any principle except that of saving the teachers as much trouble as possible, and of producing the maximum apparent result in the minimum of time, utterly disregarding the effects of such a process upon the natural development of mind.

The method, which is most irksome to the intelligent, thoughtful pupil, easiest though unprofitable for the superficially sharp one, and agonising for the so-called dull boy, is the method of rote-learning.

Such learning has been condemned for generations by the greatest thinkers on education—we can glibly cite their words, but utterly ignore their significance. Montaigne's "Savoir per cœur ce n'est pas savoir," would be in reality as much a new gospel to this generation as it was three hundred years ago, and Comenius' strictures on the verbalism of the 17th century might be directed with equal justice against the 20th. Our own experience as teachers, and the experience of the world outside the walls of the schoolroom, tend to show the futility of rote-learning. The process of manufacturing "elaborate" parrots, of which Mr. Thring speaks, is not gone through without some risks to the unhappy individuals under torture. How frequently do we hear the complaint that a boy who did so brilliantly at school could not get on at the University, or of one who, having taken high University Honours, did not succeed in after life. Yet teachers still cling to a system which has been proved even from their own utilitarian point of view to be a failure, and they are ready to champion it because it is a cheap, though temporary, advertisement of their work. Sir Joshua Fitch, in his Lectures on Teaching, says, "Many men have been saved by the badness of their memories from the ruin of their understandings," and we can realise the truth of this when we come across cases, by no means uncommon, of boys who commit the propositions of Euclid to memory, without having the slightest apperception of the terms they use.

One illustration will recall similar incidents to the minds of many teachers. Two boys on their way to school. *A* says to *B*, "Just hear me this proposition—Construction, Drop a perpendicular." *B*, who has still some glimmerings of ambition to understand something of what he is talking about, "But what is a perpendicular?" *A*, indignant at the interruption, "How should I know?—oh, where was I? Drop, &c."

The schoolmen, as the educators of the Middle Ages, were accused of discoursing of matters incomprehensible in unintelligible terms. Are we so much in advance of them now, when we persistently, as Thring declares, talk Chinese to our classes? It is a curious fact that while all the educational world is willing to acknowledge the need for technical training in every department, the cause of professional training for the teacher meets with very little sympathy; indeed, the majority of teachers are quite hostile to it, covertly if not overtly.

The untrained teacher has, as a rule, an excellent opinion of his own powers; he has never been taught self-criticism, and he has to consort persistently with his intellectual inferiors, whose attitude to him tends only to foster his own self-complacency. Charles Lamb has shown us how difficult it is for a teacher to be humble-minded. To assert the need for training to one who has dispensed with it with admirable results in his own estimation, is to provoke a long and hopeless discussion, and to leave the untrained teacher as convinced as ever of the truth of the curiously perverted version of the old adage about poets, "The teacher is born, not made."

Mr. Thring declared that when he left college, triumphant in a successful university career and filled with an intense belief in the grand possibilities of the new epoch that was dawning for elementary education, he never felt so utterly helpless as when he found himself face to face with a large class of unruly boys in a national school. His learning helped him not at all in restoring order out of chaos; his energy and enthusiasm made him determine to undertake the laborious work of training himself. He succeeded in making himself an admirable teacher; but he did this because he had a real genius for teaching, and he did not grudge any trouble that would result in profit for his pupils. His training cost him much in time and effort; both of these he gave freely; but what grieved him was the fact, that he soon recognised, that he only gained skill as a teacher at the expense of his pupils; and he looked back on his early years of teaching with deep regret when he realised how much more would these pupils of his have profited if his training had preceded, instead of succeeding, his practical work with them. Two lessons he learnt in these years which some teachers never learn—one was to despise mere information, and to distrust all informationists—"who empty knowledge lumps by the wayside, and call it teaching," and the other was to discard altogether the language of fine words. He felt very keenly that the Millenium for teaching would never dawn until "lesson-books and lesson-hearers depart, and reading-books and teachers come in—exit paper, enter life." He realised, as none but a genuine teacher can, that teaching is a living, inspiring force; that the function of the school is to rouse and stimulate every one of his scholars; and if it fail in this work, it is no true preparation for life—it is a mere sham, and had better be dispensed with altogether.

From what has been said, it will at once be seen that the adequate teaching of the elements, the three Rs upon which Ruskin says we set a purely conventional value, is really of vital importance. It is from a vague consciousness of this that we do attempt to give training to some teachers in the elementary schools, and we provide a fairly adequate equipment for our Kindergarten teachers. But such training is by no means compulsory, and many teachers of young children enter upon their work with no special preparation for it.

Mulcaster, a great educational theorist and a successful practical teacher, urged, in 1581, that, "The first groundwork should be laid by the best workman," and adds, in magnificent scorn of those who would consign young children to inferior teachers on the plea that any one can teach the elements, "It is not that small skill that he hath, that can do the thing well, but your skill is small to think any small skill can do anything well." We do, it is true, occasionally give training to our Kindergarten teachers, and to teachers in elementary schools, not from a real appreciation of the need for good workers in the early stages, but because it has been found impossible for the untrained teacher to secure sufficient order and attention from large numbers of active and intelligent little beings to give them any sort of instruction.

The trained Kindergarten teacher has learnt to be interested in the child to be taught, as well as in the subjects. She knows how to adapt her teaching to the child's powers, and under her the little one learns to look upon work as a joy, and to put his whole energy into the performance of it. The child passes from the Kindergarten into the school; here is a transformation. Work, hitherto a delight, because it has been adapted to his taste and his capacity, becomes suddenly a toil and a burden. The teacher, unless she be trained for her work, does not know what to make of the eager, active, little creature placed under her charge. The child is bewildered in the new world of school, with its moral and intellectual ideas so different from those of the little world he has left.

In the Kindergarten, co-operation was the magic principle which drew the children together to sympathise and rejoice in work; in the school, competition introduces the child prematurely to the struggle for existence, and leads him to look upon his fellows rather as rivals than fellow-workers.

In the Kindergarten the child used no words that were not represented in his mind by corresponding ideas; in the school he is bewildered and disgusted by the amount of rote knowledge he is expected to acquire without having assimilated it.

Would it not be possible, by employing highly-trained teachers in the school, as in the Kindergarten, to make the transition from Kindergarten to school less of a break in the child's intellectual and moral life? If all teachers were trained to consider carefully *how* to teach, and a uniform system of education, that is, of intellectual development, were pursued from the Kindergarten to the university, and even in the university course itself, much time and much effort might be saved; all our children might be bred up in a sincere love of learning, finding infinite pleasure in the exercise of intellectual power. In England, the three leading universities have already seen the need for some practical training for all teachers, and offer to all, who will avail themselves of it, an admirable examination in the theory and art of teaching. That none but those who voluntarily submit themselves to the test should be subjected to it is distinctly a misfortune, as those who are most eager for criticism on their work are not generally those who need such criticism most. Yet the examination exists, and year by year more and more candidates are enrolled as certificated teachers. Beginnings have already been made in Sydney, and the enthusiasm of the teachers who have already gone through their course of training leads us to hope that the time is not far distant when it will be as impossible for a teacher to teach without a diploma as it is for a Doctor to practise without a medical degree.

THE STUDY OF CHILD-NATURE.

By E. I. Gower, B.A.

There is a quaint saying among the dalesmen of the North of England, "Gie us a good schoolmaster and nobbut a moderate parson 'll do," a saying which, without disrespect to the Church, tends to show that the canny auld Cumbrian is ahead of his generation in the importance he attaches to education in its formation of character. The schoolmaster has suffered much in the past at the hands of novelists and others, who, no doubt, found an unholy pleasure in meting out measure for measure, and paying back some of the debt they owed for harsh treatment in the past. We are told of Prince Henry, eldest son of James I., that he was very fond of outdoor games, and on one occasion, as a bystander records, while playing at golf, his schoolmaster standing talking to another, the Prince, thinking he had gone aside, lifted his club to strike the ball; meantime, one standing by him said, "Beware that you hit not Master Newton"; wherewith he, drawing back his hand, said, "Had I done so I had but paid my debts." The world, however, is growing saner in its judgment, and is beginning to recognise the most obvious fact that the profession of a teacher is a noble and responsible one, and unique in its far-reaching and permanent results on the well-being of a nation. The inscription over the door of the public library at Boston furnishes a motto worthy to be adopted by every enlightened Government—"The Commonwealth requires the education of the people as a safeguard of liberty and order." Public opinion is being every year more and more roused to the necessity of a thorough and systematic supervision of the method and means of education; and a determination is showing itself among the people to refuse to hand over their children at the most susceptible period of life to the care of educational quacks and empirics. The old type of schoolmaster familiar to our fathers and grandfathers, who, flanked by birch or ferrule, sat in splendid isolation frowning portentously on benches of cowering pupils, is extinct as the mastodon; and "Nature brings not back the Mastodon, nor we those times." As is usual in such reactions, the pendulum has swung to the opposite extreme; and there is to-day a very real and pressing danger of the teacher doing too much for his pupils; of his losing sight of the fact which every true educationalist endeavours to keep before him, that it is his duty to train his pupils to do without him. Oral teaching, of which there was far too little 50 years ago, is in danger of being carried too far, and lessons are degenerating into lectures. As a result, the pupils tend to become mere parasites, feeding on the brains of others, and lack that mental discipline which comes of grinding away at a subject until they have mastered it and made it their own. Education, properly regarded, is both a science and an art. A science because it is dependent upon a systematised set of valid principles, and an art because it contains general directions as to how to do things. But the science of education does not stand alone; if it did, it would be unique, and concern nothing else in the world. All sciences are connected more or less closely with one another, and the science of education, dealing as it does with the formation of men's characters, and general moral, mental, and physical well-being, is intimately allied to all those sciences concerned with the life of mankind. It is related, for example, to (1) Physiology, *i.e.*, the connection of mind and body; (2) to Ethics, the science of men's actions and motives, telling man what he should aim at being; (3) to Psychology, wherein we learn how man *thinks*, *feels*, *reasons*, and *desires*. Then, since man is gregarious, there is his social life to consider; and the science of education appeals to such sciences as Sociology, History, and Politics. The question of proper food for the mind has to be considered and discussed, and the science regulating this is that of Logic, which deals with systematised instruction and correct thinking. From this brief summary, it is evident that the mental equipment of a good teacher is, to say the least, not inferior to that required to produce a good doctor or lawyer.

Opinions have differed, and still differ, as to the aim of education; but all true educationalists will agree that the noblest aim a teacher can set before him is the harmonious development of his pupils (morally, mentally, and physically) to the highest perfection possible. Every man's duty is, primarily, to live in character as well as in body; and it is partly in the proper cultivation of the character that man is to be raised above the brute creation. It is really only the cultured man who can be said to live. The end of education, then, is to form a good character. This implies—

(1) The will bent on doing good.
(2) The knowledge of what is right.

It implies the power to think properly, and decide rightly. A teacher who insists on lessons being well learnt is training his pupils morally. If anyone does his work less well than he is able to do it he is acting immorally. "Whatsoever thy hand findeth to do, do it with thy might." The child's individuality, however, must not be sacrificed, for one result of such repression is to weaken character and destroy will. Man's will is man himself. A teacher, in order to be thoroughly equipped for his work, must have at least some elementary knowledge of Psychology, a science whose province it is to inquire into how the mind acts during the various processes to which it is subject. To obtain this knowledge, we must examine our own minds, for no one can examine another's mind in the direct way in which he can investigate his own. To do this is a difficult task, but that it can be done is evident from the fact that we give names to different states of mind. These introspective glances are naturally only momentary, as by the very act of introspection we alter our mental state. Memory is a better way of self-investigation, as we can recall and examine the same thing as often as we like. As, however, no two minds are alike, it is dangerous to generalise from one's own, besides which memory is apt to be treacherous, and personal bias destroys the true proportion of things. Therefore, we must supplement the knowledge of our own minds by the examination of other people's by indirect means. The minds of young children afford the best means for this purpose, as the child is more natural, and less able to conceal his feelings, than the adult. Mr. Card has already told us that at an early age he had learnt the lesson that language and facial expression were given to us to conceal our thoughts; but I think we must conclude that this awful example of infant depravity is an exception to the general rule. It is only within our own day that the study of child-nature has received anything more than a superficial attention on the part of educational authorities. It is not so long ago since it was considered that all a man needed in order to be able to teach was a knowledge of his particular subject. But the century which has recently closed, justly regarded as the century of scientific investigation, has witnessed the first steps of a movement in the direction of education, based on sound principles of Psychology. To this end the increasing knowledge of the science of Physiology has contributed a valuable share in placing on a logical and scientific basis the special needs of child-life, the necessity of healthy sanitary conditions, of lofty and well-lighted rooms, of spacious playgrounds, and of a due admixture of rest and recreation.

The province of Psychology is to interpret and, as far as possible, to explain the results of direct observation on the mind of the child; and anyone who would succeed in this branch of science must be gifted not only with a power of shrewd and accurate observation, but with a certain wide sympathy of mind, which will enable him for the time being to merge his individuality into that of the child. His power of imagination and of accurate memory must be of no mean order. Only people thus gifted can hope ever to obtain a clear insight into the laws which form the basis of the mental development of the normal child, and by means of which alone we can expect to reduce to a system what has up to now been confused and illogical. Then we shall be able to teach, not merely instruct; to develop harmoniously every faculty of the child, not merely cram his head with a mass of facts, "heaped up huge, and undigested like the chaos Ovid sings." Slowly but surely the results of such investigations are being collected, and will form a valuable legacy for the teachers of the future. In two books recently published, we have the records of a patient and minute observation of the early days of a child's life; and, although we cannot generalise from two instances, it is impossible to doubt that in the development of all children there is a close correspondence in the order of events. [I am indebted for the illustrations with which I have endeavoured to relieve the tedium of this paper to an interesting and valuable treatise on The Child by W. B. Drummond.] Comparing the early behaviour of the two children referred to above, we find that both babies first noticed their reflection in the mirror in the 17th week, and both laughed at it in the same week; both looked at an image, and then turned to find the real object in the 28th week; while both licked the image in the 61st week. One made grimaces at his own image in the 67th week, the other in the 62nd week. There are other striking similarities in the early mental condition of the child, to which Dr. Stanley Hall refers in a valuable treatise read in 1897 before the Illinois Society for Child-Study. "We have," he says, "223 cases, which show that children during their first year of life have an instinctive fear of fur. It is not because they see it, but because they touch it. . . . Another common cause of fear is big eyes. Making big eyes at children frightens them. Why should children be afraid of big eyes, of an owl, for instance? Another terror to a young child is a great display of teeth. If the teeth are false, and show a slight motion, the fear is more manifest. How can we explain such things? . . . I am persuaded, after a careful study of this, that here we have some of the oldest things in the human soul, that take us away back, so that we call those fears rudimentary organs. These fears are traces of a long struggle which we know the human race went through with animals with big teeth, big eyes, and fur, that were sometimes threatening to exterminate the human race."

In course of time these investigations will cover a wider and wider field, and will become consequently of more value to the educationalist. The statistics which Mr. Petersen has so carefully collected are not only interesting in themselves, but also valuable in this particular direction; and when the scope of such an inquiry as he has conducted shall be widened, and shall include a record of experimental tests of the hearing-power, of the sensitiveness of the eye to objects and to colour, of the rapidity of brain perceptions, and of other questions involving taste, temperature, &c., the results will be of far-reaching importance on the educational methods of the future. The Journal of Marie Bashkirtseff affords a striking picture of the working and gradual unfolding of a child's mind. The importance of such investigations to parents and teachers cannot be overestimated. In the case of the teacher, he will acquire an insight into the individuality of his pupils, and an interest in the general working of the class, such as he never had before; and this insight will re-act favourably on his methods of teaching and their application. By such observation he may also become aware of faults in his methods of teaching. For example, in an American school it was found on inquiry that 76 per cent. of the boys disliked geometry. Whereupon the teacher, concluding that the reason for this was that he was undertaking to do more than the class could stand, reversed his methods, and determined that he would cover the ground only so fast as his pupils could do it thoroughly. Three months later he polled the same class again, and 75 per cent. declared that they specially liked geometry. The earliest expressions of a child's individuality is by the emotions, and it is to the parents that we must look for that right control upon which so much of the child's future happiness depends. An inquiry into the origin, mode of expression, and meaning of the various emotions of human nature affords a wide field for speculation and investigation. In young children the emotions are almost entirely instinctive; that is, the inherited results of the experience of the race. For instance, fear and anger are respectively the passive and active expression of an effort for instinctive self-preservation. An unconscious reflection of this instinctive fear shows itself in the bad dreams which so often disturb a child's sleep, and which in many cases cannot be traced to distinct impressions experienced in waking hours. Such an emotion will yield in time to wise treatment, and to the natural accumulation of individual experience.

The emotion of surprise expressed by wide-open eyes and mouth, and by a cessation of movement, is usually aroused later in the child's life, as it implies more of an active mental effort. Curiosity is an outcome of surprise and fear, and may be said to consist "of a sort of chronic hunger for new sensations, which impels the child to handle, examine, taste, and otherwise experiment upon all objects which come within his reach." Darwin, speaking of himself, says. "the restless curiosity of the child to know the what for? the why? and the how? of everything seems never to have abated its force."

The emotions of love and jealousy, implying as they do some elementary sort of selection, are usually excited at a later period, and are less instinctive than the earlier emotions. Darwin noticed that his child showed jealousy when 15½ months old on seeing a doll fondled. Another child of the same age was jealous if he saw his father and mother kiss each other, and showed his disapproval with no uncertain sound.

The æsthetic emotions come very late (if at all) in most children, and only show themselves earlier in a love of bright colours. Music and beautiful scenery apparently affect very few young children. There is no doubt that the development of the emotions has been left very much to chance, and little if any attention has been paid to a proper cultivation of these earliest expressions of the child's character. In our own matter-of-fact unemotional age the necessity for such a training grows every day more obvious and pressing. If education is to be harmonious, the emotional side of the child's nature, his appreciation of, and wise enthusiasm for, whatever is good and noble and beautiful, and not merely his intellectual side, must be trained.

Darwin confesses in his own case that his intense absorption in scientific pursuits first weakened and then entirely destroyed his love of literature. He says, "Up to the age of 30, or beyond it, poetry of many kinds, such as the works of Milton, Gray, Byron, Wordsworth, Coleridge, and Shelley, gave me great pleasure; and, even as a schoolboy, I took intense delight in Shakespeare, especially in the historical plays. I have also said that formerly pictures gave me considerable and music very great delight; but now, for many years, I cannot endure to read a line of poetry. I have tried lately to read Shakespeare, and found it so intolerably dull that it nauseated me. I have also almost lost my taste for pictures or music. I retain some taste for fine scenery, but it does not cause me the exquisite delight it formerly did." To those whose emotional side has been uncultivated, we might repeat the saying of Talleyrand to a man who refused to learn whist "What an unhappy old age you are laying up for yourself!"

By means of a proper training of the emotions, we can stimulate and excite interest, so powerful a factor in the acquirement of knowledge.

The belief was at one time widely accepted that the mind of the child is at first a *tabula rasa*, or blank wax tablet, upon which, by means of the senses, the outside world produced certain impressions, which constituted the sum total of a child's knowledge. But a closer and more scientific investigation shows that the mind is by no means a *tabula rasa*, but, from the very first, has in itself inherited impressions derived from a long line of ancestry, and that when the more recent and individual impressions are formed, the brain is, as it were, a palimpsest on which, under the more obvious impressions of the present, can be traced those instinctive impressions which the child has inherited along with other subconscious peculiarities of the human species.

We have already spoken of the earliest impressions on the child's mind through the senses, and the outward expression by means of the emotions, by which we judge of those impressions, and we now pass to the next stage of mental growth, viz., the recognition and classification of sense perceptions, which constitute the first efforts of awakening intelligence. "The first act of the human intellect," says Preyer, "consists in the ordering of the impressions made upon the organs of sense." When a child recognises his mother's face, or any other familiar object, he has already unconsciously begun to classify his impressions, and to select those which are familiar to him. The growth of this power is very gradual, and begins long before the child is capable of expressing his feelings in word-language. This may be seen from the fact that the early mental development in the case of deaf-mutes is hardly to be distinguished from that of normal children. The most important factor in the early growth of the child's mind is curiosity—"that chronic hunger for new impressions," as it has been well called. Everything about him excites in turn his interest and attention. The furniture of the nursery, the faces and the movements of those about him, his own arms and legs, attract his eyes, and receive for a while his most serious consideration. With a face of absorbed interest, and with all the solemnity of a judge, he will observe, touch, and experiment upon any object within his reach. He soon learns to show approval or disapproval. The powers of observation are called into play very early in the child's life, and much may be done from the first in training and developing these important factors of education, and laying the foundations for inquiry and original research. Many of the great scientific authorities, such as Darwin, Virchow, Pasteur, and Paget, attribute their success in science to their powers of observation. Sir J. Paget, whose memoirs and letters were published a few weeks ago, tells us he owes his discovery of *Trichina spiralis* to this faculty. He says—"I may justly ascribe it to the habit of looking out and observing and wishing to find new things which I had acquired in my previous studies of botany. All the men in the dissecting rooms 'saw' the little specks in the muscles, but I believe that I alone 'looked at' them and observed them." Mrs. Hall, whose patient and minute observations of the first 18 months of her son's life have lately been published, tells us that, on the 216th day, he struck a cup with a spoon, and, liking the sound, repeated it. He then struck a saucer-plate; as this gave a clearer, more ringing sound, he at once noticed the difference. His eyes opened wider, and, with an absorbed expression, he hit first one and then the other as many as 20 times." Another baby, 319 days old, discovered that the sound produced by striking a plate with a spoon was dulled by placing the hand on the plate. This discovery in elementary acoustics afforded him infinite satisfaction, and he continued his experiments for some considerable time. The same child, in his 14th month, took off and put on again the lid of a can 79 times without stopping a moment, and with such concentrated attention that it was impossible to doubt that his intellect was at work.

There is no department of educational work in which the study of psychology has had more important results than the question of Memory. For an instructive inquiry into this particular function of the mind, I cannot do better than refer those who are interested in the subject to the works of Fitch, Lange, and Compayré. Memory is the power of the mind to recall mental images of previous sensations. These are mostly recollections of sight, sometimes of sound, rarely of smell or touch. No thought or action of our lives is isolated, but all are linked by a wonderful process to other thoughts and actions. Upon this process of association of ideas depends the retention in our minds of any particular idea; and the ease with which we can recall it is dependent not only on the vividness of the impression, and the amount of attention we pay to it, but still more on the number of other ideas with which we can associate it. There are, of course, two kinds of associations—those which are logical and natural, and those which are purely arbitrary and accidental; and it is the aim of the teacher to break down the latter and build up the former. In quite young children the beginnings of logical association can be perceived. Darwin records of one of his children (five months old) that, "as soon as his hat and cloak had been put on, he became very cross if not taken out at once." Of another child of eight months we are told that he had come to know that "the placing of a napkin under his chin was always followed by food, for he closed his eyes and opened his mouth." Darwin's boy at ten months had learned to look behind for the object which caused a shadow on the wall in front; and, in another case, of a boy 17 months old, it was noticed that, being unable to reach an object on some shelves, he fetched a portmanteau to stand on. Harrisson tells of a child two years old, who had been taught to bow ceremoniously to his friends, that he was seen one gusty morning looking with puzzled interest at the swaying branches of a tree. Suddenly his face cleared, and he too began to bow, calling out at the same time "How do? How do?"

Many stories are told of Macaulay's precocity. Mrs. Hannah More was fond of relating how she called at Mr. Macaulay's house, and was met by a fair, pretty, slight child, about four years of age, who came to the front door to receive her, and tell her that his parents were out, but that, if she would be good enough to come in, he would bring her a glass of old spirits, a proposition which greatly startled the good lady, who had never aspired beyond cowslip wine. When questioned as to what he knew about old spirits, he could only say that Robinson Crusoe often had some.

There is no such thing as an isolated image in the mind; and if we could recall the mental process by which we succeeded in reviving some particular piece of knowledge, we should find that it was by some links in a chain which connected it with other things in our mind. The process may of course be subconscious, or the result of a conscious mental effort. Fitch has illustrated the point in his usual clear and masterly manner. "Consider," he says, "for a moment the process which goes on when we try to remember a fact. You ask me the name of the statesman who tried so hard to set poor Louis XVI.'s finances in order, and I cannot recall it. . . . So I let my mind dwell for a moment on Louis XVI. As I do so the names of Calonne, of La Fayette, even of Burke and Pitt, recur to me. They are not what I want, and I refuse to let my mind dwell on them. I think of Madame de Stael. Stop! She was the daughter of the statesman whose name I seek. Of Gibbon: that reminds me that he had sought the same lady in marriage. Then Geneva and Lausanne, and Ferney and Voltaire—all names which are connected—come rapidly through my mind, and in the midst of them Neckar's name is suggested, and I fasten on it at once. It is what I wanted."

Every fact, then, which we wish to impress on a child's mind should be logically connected with the previous knowledge he possesses. Repetition, interest, and association are the three essentials in making any permanent impression on the memory. The memory of particular presentations is strongest in childhood, but, unless there is plenty of repetition, a child quickly forgets, especially as his knowledge, having few bonds of association, is less systematised. The boy who organises his knowledge is sure to retain it longest. The old Puritan divine, Fuller, has left us three maxims with regard to memory, which are worth recalling—

(1) Soundly infix what thou wouldst remember.
(2) Marshal thy notions into method.
(3) Overburden not the memory with details.

Allied in some respects closely to the faculty of memory is that of Imagination, the forming of mental pictures of sensations previously experienced in the absence of the original stimulus. These may be recalled as they were first experienced, or parts of different impressions may be combined in a single picture. The simplest form of combination is fancy day-dreams, which are determined only by the law of association. Fancy is strong, but definite imagination is weak, in childhood, as the will is necessary to the latter in keeping to the point, and rejecting unnecessary accompaniments. Memory, interest, and judgment all play a part in definite and connected imagination. Without it there could be no high effort, no result, no hope. The power of picturing something better stimulates effort. Every plan you form is an effort of constructive imagination. People who are lacking in one of their senses—for whom knowledge by one entrance is quite shut out—are reduced to think in terms of their other senses. A blind man finds it impossible to imagine or visualise objects which he can only touch or hear. One blind man asked if scarlet were not something like the sound of thunder. Children's fondness for dolls and "make-believe" games are expressions of their imagination.

We haven't got *wills*; we are *wills*. The will is not then a separate function of the mind, but is the mind active, for every mental activity of which we are conscious is an act of will. I say "of which we are conscious," as we must distinguish such actions from those of mere impulse (in which, however, there is a reflex or imperfect action of the will wherein intellect plays no part). A perfect exercise of will involves the intellect in so far that we have thought out the end definitely, and see a means of attaining it. A complete act of will involves five elements:

(1) Something which prompts us to activity, often a sense of discomfort.

(2) Conflicting desires, in which we are swayed by the strongest one.

(3) Deliberation—a short process if one desire is much stronger than the others. When questions of morality are introduced, the struggle may be prolonged, but is ended sooner or later by

(4) Decision, or choice, which may be rational or irrational. We have then the motor idea, which impels us to the

(5) Carrying out of the desire.

The first definite voluntary acts of a child are usually to be noticed about the third or fourth month. "The normal child's first exhibition of volition," says Professor Baldwin, "is found in its efforts to imitate something." He soon learns to distinguish what pleases him from what does not; his ideas become less vague; his desires more definite; and the number of acts of volition increases. As the child lacks the strength of purpose of the adult, acts upon impulse, starts energetically, is easily distracted, and has no power of concentration, care should be exercised from the beginning to develop these powers by stimulating the child's desires in definite directions, and by the formation of habits. "Don't say don't" is a good maxim of wide application.

There comes a time in the early life of most children when, through their dawning consciousness of their power of volition, they begin to realise that they are free agents; this excites what is known as the phenomenon of contrary suggestion. Punch has hit off this stage of development in his usual happy way, when he depicts a mother sending the nurse "to see what Master Tommy is doing, and tell him he mustn't." At this particular stage Master Tommy not only refuses to do what is expected of him, but takes a keen delight in doing the very opposite. Offer to shake hands with him, and at once he looks you straight in the face, and puts his hand behind his back. Put his cap on, and he throws it on the floor, and not infrequently stamps on it. Put his food before him, and he promptly proceeds to spread it over the tablecloth. All this is often done without a trace of petulance, and arises simply from a desire to exercise the newly-discovered power of will. If treated wisely and patiently, and not taken too seriously, this stage will soon pass, and Tommy will realise one of the great lessons of life—that everyone is the happier for having to obey. The expulsive power of a new affection is the best antidote to this condition, and the more you can exercise in a right direction the natural restlessness and craving for exercise of the normal child, the more will you be strengthening his will and his powers of self-control. But much must be left to the child himself, and the advice of Herbert Spencer on this point is worthy of the earnest consideration of all parents and teachers—"Leave him wherever you can to the discipline of experience, and you will save him from that hothouse virtue which over-regulation produces in yielding natures, or that demoralising antagonism which it produces in independent ones." The same writer says, in a passage of particular value—"Do not regret the exhibition of considerable self-will on the part of your children. . . . The independent English boy is father of the independent English man, and you cannot have the last without the first. German teachers say that they had rather manage a dozen German boys than one English one. Shall we wish that our boys had the manageableness of the German ones, and with it the submissiveness and political serfdom of adult Germans? Or shall we not rather tolerate in our boys those feelings which make them free men, and modify our methods accordingly?"

The natural impulsiveness of a child makes the acquirement of self-control a slow process. The sudden and uncontrollable outbursts of passion or emotion so common in the average child are merely instinctive and not deliberate expressions of itself; and a wise treatment of them will divert the activity of which they are the expression into other channels. By such means, too, right habits of thought will unconsciously be formed. The term Habits is often erroneously applied to actions alone, but habits of thinking and feeling are equally common and equally important. We may define Habit as a fixed disposition, due to practice, to act, think, or feel in a certain definite way. In course of time habit becomes, like Coleridge's north wind, "tyrannous and strong," as automatical as instinct: the former being the outcome of individual experience, is acquired; the latter is inherited from the experience of the race. Habit to a large extent does away with the necessity of thought, and therefore, in so far as a man acts habitually, he ceases to act rationally. A man should therefore be able if necessary to break his habits, especially those of thought and feeling, for habit dulls the power of feeling. Repetition of action is the beginning of habit; the more complex the action the greater the number of repetitions necessary. Unbroken repetition is essential if you wish to form a habit, unbroken discontinuance if you wish to get rid of one. For the formation of any habit, good or bad, some strong motive force is necessary, by means of which is produced an inclination in the child's mind towards the thing aimed at. Nature endows the child with a strong desire to imitate, and so the habits of walking and speaking are formed. As already pointed out, a long series of repetitions is necessary, in which no exceptions should be allowed to occur; for each exception makes the formation of the habit a longer and more difficult process. The actions which come most natural to us are those which are the result of long practice; and these in course of time are done without any conscious effort on our part. In the case of walking, we never have to pause to think of the different muscles employed.

There are two habits which should from the very first be impressed on young children—the habits of obedience and of truthfulness. Even in the smallest matters implicit obedience should be expected. In children well brought up obedience to proper authority becomes a habit, and one that will have a good and not a weakening effect on the self-respect and independence of the character; for it is strikingly true that he who knows not how to obey knows not how to command. True liberty consists in obedience, for to be a free and honest man one must obey both the civil and moral law. It is essential that this manly and self-respecting spirit of obedience should be evoked in childhood. "It is quite a mistake to adopt the modern system of allowing children to treat their fathers and mothers on terms of equality, to let them express an opinion whenever they please, and ask the reason of everything. There is no equality between a man and a child, between a father and his son. Any apparent equality allowed to exist is one wholly unfounded on truth." Children are much more observant and discriminating than is commonly supposed, and do not resent a firm and consistent but affectionate discipline. The present Archbishop of Canterbury is fond of recalling how, when he was a master at one of our large public schools, he overheard one of his pupils confide to a friend his opinion that Temple was "a beast, but a just beast." If you wish to make a child selfish, petulant, discontented, and miserable, indulge all his whims, humour all his weaknesses, and deny him nothing. In every way, and in all cases, there is no worse rule than a weak one. Above all things, should the parent and teacher aim at being consistent; avoid coercive measures so long as it is possible rightly to do so; do not treat the same offence at one time with leniency and at another with severity. Be sparing of commands, but when once given see that they are carried out to the letter. Again, to quote Herbert Spencer, "Consider well beforehand what you are going to do; weigh all the consequences; think whether your firmness of purpose will be sufficient; and then, if you finally make the law, enforce it uniformly at all costs. Let your penalties be like the penalties inflicted by inanimate Nature—inevitable." Carry this out in the very smallest matters; train your children to be regular in rising and in going to bed, punctual to meals, tidy and clean in their person and dress, polite to friends and acquaintances, simple and easy in deportment; thus, by kindly, firm, and consistent treatment, they will become thoroughly well-governed creatures, no longer swayed by their own whims and fancies.

Children know nothing about the transcendental distinction between right and wrong; and very little good, and possibly much harm, will arise from an attempt to inculcate in a young child the necessity of truthfulness on definite religious or moral grounds. Just as in the history of the race conscience and the ethical idea was one of the latest of human attributes to be evolved, so in the individual history of each child the idea of moral obligation is one of comparatively late growth. The idea of morality is altogether too abstract for his comprehension. To him a lie conveys no idea of shame; it is often merely the shortest way out of a difficulty; and a great mistake is made by those who expect the same standard of morality from a child as from an adult. Try to explain to him the direct results of untruthfulness—its cowardice; make him see how contemptible lying is, but do not attempt to arouse in him a precocious and therefore unhealthy sense of sin. Insist on accuracy in the smallest details, and, slowly perhaps, but surely, the habit of truthfulness will become a second nature to him, and that perhaps long before he understands the morality of the question. Of course, the most you can do is to help or hinder the child; for the ultimate end must depend on himself. He will have sooner or later to fight his own battles. and win his own spurs. It is a noble and inspiring idea which Emerson has expressed—"God gives every man the choice between truth and repose. Choose then one or the other; you can never have both." We are told that the truth requires two people—one to speak, the other to hear; and to the parent sensible of his great responsibilities the words of Carlyle will come home pregnant with the most serious thoughts—"Ill stands it with me if I have spoken falsely; thine also it was to hear truly. Farewell."

It may be that, in dealing with this subject, I shall be judged by married people to have trespassed on their special preserves; and to be showing great audacity in expressing an opinion on a subject of which, in the nature of things, I must be about as conspicuously ignorant as a Hindoo is of skating, or a Kaffir of wireless telegraphy. Charles Lamb, in one of his most delightful essays—"A Bachelor's Complaint on the Behaviour of Married People"—pathetically calls attention to the same contemptuous treatment. As, however, I am convinced of the profound importance of the question to all teachers, I am willing, in the interests of my profession, to run the risk of being told that "fools rush in where angels fear to tread"; and, with much trepidation, but in all earnestness, commend the subject to the thoughtful consideration of parents and teachers.

OBSERVATIONS IN PSYCHOLOGICAL PATHOLOGY.

By the Rt. Rev. Dr. Delany, Bishop of Laranda.

[*Abstract.*]

This paper deals with certain phenomena which have been observed to emerge into consciousness in states of high fever, but short of delirium. It would seem, too, that, as a necessary condition to their appearance, the fever must have been due to, or at all events accompanied by, acute inflammation of the right face under the eye and along the nose. Then, on closing the eyes, objects spontaneously appear, as if located just where the floor or wall, or other obstacle, would intercept the line of vision were the eyes open. These visual phenomena reveal a character which appears to distinguish them specifically from sights recalled by a conscious effort of memory. They come without effort, whereas the attempt to recall the same objects when recognised is accompanied by effort, and followed by extreme lassitude. They seem steadily fixed, whereas those consciously recalled are unsteady; they are as distinct in detail as objects actually before the sense. Sights of conscious recollection, on the other hand, are vague and shadowy, but chiefly they appear actually present to hand, whereas the other class of phenomena always appear not present. The mind is conscious of going out to them—of their being past, and having been elsewhere. The result of these and other comparisons appears to justify the conclusion that those abnormal spontaneous phenomena are due to impressions made through the external senses, but unattended to, and so not at all perhaps affected by reflex consciousness. Their emergence later on would be due to purely physiological action, induced by high temperature. And the fact that they reveal a character specifically distinct from presentments of the same external objects, as an act of conscious recollection, seems to justify the inference that mentalisation accompanies and determines conscious impressions; and hence that knowledge of external objects must postulate a factor—the mind—over and above the objects themselves, and the merely material organ of sense impression. The argument is not advanced as necessary to establish the action of mind, but as a concession to the lowest form of sensism.

A PLEA FOR ENGLISH LITERATURE IN PRIMARY SCHOOLS.

By Percy Fritz Rowland, B.A., Oxon., Late Lecturer at Canterbury College, University of New Zealand.

[*Abstract.*]

In the culture of the fields with a view to their yielding in due season the earth's kindly fruits, no uniform standard is, indeed, attempted. It is admitted as a condition precedent that there is good land and land less good—land under any given economic conditions suitable for the highest culture; other land, suitable only for humbler uses. But at least that amount of culture is given to each kind of land, by which the community (so far as is foreseen by the individuals to whom the initiative is entrusted by *Fors Clavigera*), is likely to reap the fullest benefit.

Now, of all fields, there is none so rich as that unfathomable marvel of the universe, the human mind. And however greatly it differs from all phenomena of the creation, rooted as deeply in the spiritual as it is in the physical world—it comprises, like the earth, rich soils and poor; soils that will only pay for cultivation up to a certain point, soils that will repay with more than even Tasmanian fertility, the highest culture which can be given.

A community can never attain the Platonic ideal of Justice—each man doing that for which he is best fit—nor the Christian ideal of Duty—each individual making the best use of his talents—until every child in the State receives as much culture as he requires if he is to render to the community the most efficient work of which he is capable.

Now, of whatever parts right culture consists—and right culture for a carpenter is admittedly different from that for a Professor of Latin—it will not generally be denied that in many respects *the best way* of teaching all to think and feel, is by teaching them something of what the best men and women have thought and felt, set down in the best way. The record of a nation's best thought and feeling, set down in the best way, is called its literature.

And yet to-day, in Australasia, as in other parts of the English world, ninety-nine hundredths of the children leave school without the slightest attempt having been made to give them this most vital part of culture. In secondary schools the teaching of English literature is a scandal; in primary schools there is none.

Far be it from me to advocate the thrusting of elaborate literature manuals into the over-crowded curriculum of over-crowded Australasian schoolrooms, where there is already so much teaching and so little taught. The cramming of literature handbooks for examination purposes, seems to me about the least-worthy employment of time that could well be devised. And, even if it were desirable, it would clearly be impossible, to cram the lower classes of primary schools in the way in which it is unfortunately possible to cram the higher classes of secondary schools. My proposal is much more modest. It is simply that in all classes, except those for infants, an hour a week should be devoted in primary schools to a brief talk upon the life of a chosen author, followed by the reading aloud *by the teacher** of such passages from the author as seem most likely to hold the children's attention, stimulate their imagination, and form their character. At the end of the hour might perhaps come one or two questions, a test of the lesson's success, and for the next lesson the name of the book read, its author, the place of his life, and the date of his death—nothing else—should be committed to memory by the class.

Thus, young children would be told the story of the life and times of Æsop (and here, surely, a little fable might be allowed concerning the father of them), of Defoe, of Hans Andersen, of Charles Kingsley, "Lewis Carroll," George Macdonald, and Rudyard Kipling. Then they would hear, and, if I know anything of children, would hear with delight, the best of the "Fables," a passage or two from "Robinson Crusoe," the "Fairy Tales," the "Water Babies," "Alice in Wonderland," "At the Back of the North Wind," and the "Jungle Book," read in consecutive weeks as the literature hour came round. Older classes of children would learn more of Kingsley, through extracts from the "Heroes" and "Westward Ho," each of which books would, I suppose, require some three or four lessons. They would find rich food for fancy in the "Arabian Nights" and "Don Quixote"; and would learn to love Shakespeare and Homer through Lamb's "Tales from Shakespeare" and "Adventures of Ulysses." "Tom Brown's School-Days" would give an insight to all that is best in English public school

* This differentiates my proposal from the spasmodic efforts to introduce good literature into schools by the medium of school reading-books. The best literature loses its effectiveness when made the battle-ground of spelling urchins.

life; a scene or two from "Ivanhoe" would introduce Scott; and the shooting party from "Pickwick" would cause our youngsters to look with proper friendliness on the name of Dickens. Thackeray's "Rose and the Ring," Longfellow's "Hiawatha," Stevenson's "Treasure Island," might all be pressed into the service, and good material might still be found in Miss Edgeworth, Mrs. Gatty, and Mrs. Ewing. The early chapters of the "Vicar of Wakefield," extracts from the "Life of Nelson" and the "Critic," would fitly introduce Goldsmith, Southey, and Sheridan. An incident or two from Boswell's great biography I know to be quite capable of interesting boys and girls in the higher classes of primary schools. The "Pilgrim's Progress" and "Gulliver's Travels" would open for them new worlds. Mrs. Haweis' "Chaucer," together with the life of that most human of poets, might well afford happy subjects for a month or more; while a volume of Greek and Roman stories would familiarise the children with some of the great names, without which English literature would have been impossible.

If it be maintained that even the small amount of time suggested—an hour a week—cannot be given without sacrificing something already in the curriculum, I am prepared to meet this by suggesting the entire or partial sacrifice of **history**, which is at present taught in many Australian primary schools; but which, as a part of literature—the part which deals, to use the Aristotelian distinction, with "what has happened," not, as poetry, with the higher truth of "what may happen"—seems to me, however important, less important than the whole of which it is a part.

As to the desirability, if practicable, of teaching literature in our public primary schools, I hardly think there can be any difference of opinion among those who realise the present state of public literary taste.

For in truth, Demos as Mæcenas cuts but a sorry figure. And this is as sad for literature as it is for Demos. From the standpoint of literature the condition of the popular taste mattered comparatively little in Horace's or in Spenser's day, when the general public did not read, and literary men were supported by a wealthy cultured minority. Now when the general public does read, and when we buy books to read, not because they are recommended by the Dr. Johnsons of the day, but because 50,000 other people have read them, it does matter very much to literature that the public taste should be sound and healthy.

How far it is from this, alike in England and Australia, may be seen at once by the great literary successes of the past few decades—"Trilby," "In His Steps," "The Sorrows of Satan," "The Christian," and the "Master Christian." These books sell in their thousands, while Meredith is almost unread, Shakespeare is seldom played (except as a clothes-prop), and Fielding, Scott, Thackeray, and Jane Austen are only saved from oblivion by a small band of zealots who keep the laurel green upon their sepulchres.

If we turn to the writings of Australian authors, we find that, largely through the influence of one magazine—accepted, through lack of proper school-training, as the dictator in such matters—the literary output of one of the most honest, healthy, and hopeful nations of the world is becoming notorious for its strident affectation of unaffectedness, its morbid brutality and its sordid pessimism.

What can be expected when the children who grow up to form our reading-public leave school without so much as learning even the names—let alone the love—of the leaders of our race in thought and fancy; and possessed by the pernicious fallacy that anything between covers is a book?

It seems abundantly evident that Australian primary education requires reform; reform in the direction of smaller classes, better educated educators, a wider and wiser course of study. In that course of study, as put before smaller classes by better-educated educators, I put in this earnest plea for English literature.

INDUSTRIAL FARM COLONIES FOR EPILEPTICS.

By Miss Alice Henry.

[*Abstract.*]

Epilepsy may be considered the most terrible of all maladies that afflict humanity. It is the most cruel to the patient himself, the most dangerous to society, and the most far-reaching in its results.

It is through its secondary effects that the patient chiefly suffers. He is subject to attacks of an exhausting nature, and runs the risks of accident to life and limb during such attacks; and, in addition, others so shrink from him on account of these fits that he is turned into a social outcast, a victim to all the degrading influences that surround the outcast.

It is the most dangerous to society because the epileptic may, during his attacks and in absolute unconsciousness injure others by setting fire to dwelling-houses, by striking aimlessly with edged tools, or in any one of a hundred other ways. Many crimes even, so-called, have been committed during the periods of dream unconsciousness that in some cases form one of the phases of this protean disease, and society is at present quite unprotected against such risks.

Epilepsy is also the most far-reaching in its effects, for it is not only to his own generation that the patient is a danger. Affected by a transmissible degeneracy of the nervous system, the epileptic in many cases leaves behind him offspring even more abnormal and nervously unstable than himself.

The medical definition of epilepsy is that it is a nervous affection, with seizures of loss of consciousness accompanied by convulsions. In a typical fit the patient is in ordinary health. He may be at a meal, coming down stairs, sitting alone by the fire, or walking along the edge of a pier. Instantly, without any warning, he falls down wherever he may happen to be, so that broken limbs, burns, and other physical injuries are not at all uncommon. In most cases, however, after the violence of the paroxysm has exhausted itself, the patient falls asleep, and wakes a few hours afterwards able, to all appearance, to take up his work where he left it off. And then the trouble begins, for no one will have him.

So one of the most recent movements, having for its object the alleviation of human suffering and the wise utilisation, too, of human energy, is to be found in the new methods of dealing with epileptics. A class within a class are they. Those afflicted with this malady are found in every climate, are of both sexes, of all ages, from the tiny child to the old, and of every rank in life, and their affliction is of such a nature that it debars them from fitting into any ordinary niche in the social edifice. As matter in the wrong place means waste, trouble, and harm, so human beings in their wrong place, or not allotted their right place, necessarily deteriorate, are a misery to themselves and their immediate surroundings, and sooner or later, directly or indirectly, become a source of expense to someone, probably degenerate into insanity or sink into crime.

The epileptic in society is an anomaly. Speaking roughly, he is not an invalid, except as all may be invalids sometimes; he is no fit subject for the somewhat expensive mercies of a hospital; he cannot be put to bed and nursed perpetually on the lines of, say, typhoid-nursing, for between his attacks he may be perfectly well and strong. For the same reasons, there is no good object served even by shutting him up, supposing the law would allow it, in the semi-imprisonment of a benevolent asylum. He needs care whenever an acute attack occurs, whether that be every few hours or only at intervals of many months; but in the intervals, in the far larger part of his life, when he is like other people, if he has nothing to do, the same result happens as would happen with any of ourselves relegated to such unwholesome idleness; he either falls into hopeless despair or he gets into mischief. Imagine a working mechanic attacked for the first time just as he is starting in life, or perhaps later still, when two or three children look up and call him father. Perhaps he is a carpenter; a good workman, but with nothing to live on except his weekly-wage. Once he has a fit during working-hours, no employer will keep him. To have a man fall down with a scream and struggling in violent convulsions, scares away custom. So he must go. He gets employment in some poorer shop, where nobody troubles over references. The same thing happens again. He is becoming poorer and poorer. At last an occasional job, with weeks of idleness intervening, is all that comes his way. One stamp of man feels the misery and degradation acutely, and broods over his poverty and dependence; others, idle compulsorily, learn to consort with those who are idle voluntarily, and often become criminals. In other cases, again, the disease so shatters the nervous system that, helped on by bad food and bad habits, insanity is added to the other trouble, and the asylum receives a life-inmate.

With a woman, the risks are not less, though they are slightly different. She, too, is debarred from any money-making employment, and must be dependent on the often grudging charity of some relative. She is not, however, debarred from marrying, nor protected from becoming the prey of vicious men, and her own ailment is often a legacy bequeathed to her children. Dr. Knight, of Connecticut, quotes the following as an extreme instance of what may occur:—"An epileptic woman became the mother of 15 defective children; 8 died in infancy from lack of vitality, 2 inherited the epilepsy, 3 were fairly teachable imbeciles, and 3 had sufficient intelligence to marry and reproduce according to the laws of heredity the mother's experience."

Echeverria tabulates the condition of the offspring, as far as known, of 62 male and 74 female epileptics. Of 535 children—

4	per cent.	were still-born;
36	,,	died in infancy from convulsions;
5	,,	,, ,, ,, other diseases;
15	,,	became epileptic;
2	,,	became insane;
7	,,	suffered from paralysis;
9	,,	became hysterical;
1	,,	became choreic;
1	,,	had strabismus;
20	,,	were normal.

Dr. Wildermuth adds that, making allowance for our great ignorance of the nature and actual causes of epilepsy, in at least 60 per cent. of cases the disease develops as a result of morbid hereditary tendencies. In short, we are caught in a vicious circle, which it is partly the mission of the colony-system to break. And while there is as yet no educated public opinion to support legislation which would prohibit the marriage of the epileptic, the colony-system, wherever it is introduced, acts as a very strong and wholesome check upon such marriages. In passing, however, I may mention that the State of Connecticut now actually has such an Act upon its statute books.

Many scientifically-trained minds, when their attention is first directed to the education and employment of the epileptic or the feeble-minded classes of society, take the view that any care, attention, or money spent upon such is misdirected, and had far better be expended in the development of the normal citizen; but that view, we are all coming to see, is not supported by facts. Apart from the great impulse that such efforts have given towards preventing the reproduction of the unfit, the present generation of the unfit is with us already, and unless converted into useful citizens—that is, factors for good—they remain with us as factors for evil, active and unceasing workers of harm.

The colony system is a plan of making for these poor people a society within society; of furnishing them with a social life analogous to the life of that outside world which will have none of them; of helping them in the widest sense to help themselves. For its beginnings we have to look back to the early sixties, to La Force in France, and Bielefeld near Hanover. But these have often been described, and so, I think, for our practical needs we would do well to familiarise ourselves with the conditions under which a number of farm colonies have sprung into existence in England and the United States within the last dozen years. The most remarkable and the most hopeful characteristic of the colony plan is its elasticity. An industrial colony can make a beginning with three or four patients. It can be added to and increased by degrees without upsetting the original design, without extravagant expenditure, or rendering useless existing buildings. The Maghull Home, near Liverpool, began in 1889, in a rented house, with three acres of land. With some money-help for a start, and by taking three classes of patients, at £100, £50, and £20 respectively, Maghull has been self-supporting almost from the first. At latest accounts it contained 121 residents, engaged in gardening, basket-making, carpentry, cooking, sewing, and so on. They have a tennis-court, and occasionally challenge the village cricketing team.

The Chalfont Colony, founded by the National Society for the Employment of Epileptics, occupies a farm of 135 acres, about 20 miles out of London. It has 134 colonists, and these are of all occupations—teachers, chemists, bricklayers, even a policeman and a lady's maid. The colony is intended, like Maghull, for three classes of patients; but up to the present only third-class patients have been taken, the feeling being that it was they who needed help most desperately. It is an open question, however, whether it is not, in the long run, wiser to attract rich patients from the first, as the justifiable profit made out of one wealthy patient would help to support, and therefore to admit, one or more poorer ones.

A rough analysis of the last balance sheet shows that the income and expenditure for the year 1900 just about balanced, thus—

Income—

	£
Subscriptions	920
Payments for patients...	2700
Profits, farm, &c.	290
	£3910

Expenditure—

	£
Housekeeping	2050
Salaries, repairs...	1720
Balance	140
	£3910

a balance that is probably more apparent than real, as it is too small and uncertain to reckon upon. But the important fact remains, that with careful financing and a not extravagant amount of charitable help such an institution can pay its way. There is no pretence of providing initial expenses, or finding interest on capital so invested. Land, buildings, and planting must be a gift from somewhere. On the other hand are two facts not to be lost sight of. One, that the smaller the colony is the more expensive it is in proportion. The ideal to look forward to is that of a self-contained industrial village, embracing many trades and taking advantage of all the assistance that can be gained from modern methods of cultivation and manufacture. The other, that this class of citizen, whose partial dependence upon society is, when he lives in a colony, open and admitted, would cost far more while living a life of aimless idleness; only then, the load is like indirect taxation, so distributed and concealed that no one realises its weight; not to speak of the secondary burdens laid on this generation and on future generations by the criminal practices into which the epileptic so often drifts, and the legacy of helpless progeny he so often leaves behind him.

Of all the recently-established industrial colonies, the Craig Colony of New York is on by far the most extensive scale. Dr. Frederick Peterson, the eminent neurologist, on a visit to Europe in 1887, was impressed with the results accomplished at Bielefeld. Acting on his suggestions, the State Charities Aid Association, working chiefly through Miss Louisa Lee Schuyler, the woman who has helped so much in placing the State of New York in the van of progress as regards its treatment of the insane, took the matter up. The Commissioners, Messrs. Letchworth, Craig, and Walrath, purchased the property of a moribund Shaker community. It contained 1875 acres, and the price was £35,000; but a large part of it had been under cultivation, and there were included buildings fit for occupation, and other improvements, valued at £15,000. It is approached by good roads, and not far from a railway. When the necessary alterations were made, the managers were able to open at once with accommodation for 200 patients. There are now 840, and as a proof of how greatly the need has been appreciated, there are on the books 900 applications for admission, which cannot be granted on account of the want of money to extend the buildings. The cottages, which are widely separated, are built to hold from 12 to 30 patients. It is generally agreed, that over that number the home-feeling ceases. The women and children are provided for in distinct cottages at the other side of the estate from the men's dwellings, and across a creek. There is a small hospital for any one suffering from acute illness, and innumerable buildings and sheds for carrying on indoor trades. The colonists build outhouses, make bricks, carry on printing, harness-making, and numberless other mechanical occupations, while the great area planted with fruit trees or laid down in crops, or for feeding the small army of cattle, horses, sheep, and pigs, provides healthful occupation for scores more. Dr. Peterson and Dr. Spratling have great ideas as to the wise economy of energy. In engaging teachers of any trade, for instance, they urge that it is less expensive to engage one first-class man and let him spend his time in instructing the patients to become qualified workmen, and therefore self-supporting colonists, rather than take the immediately cheaper course of engaging second-rate tradesmen (several of them), and to have to go on employing them permanently doing work for the colonists, while these untaught stand by incapable of doing it for themselves. On the same grounds the managers strive to make as many of the colonists as possible expert in the higher trades, on the ground that the man with a skilled trade at his fingers' ends is a more valuable product economically, produces more for the colony and for his country than the mere labourer, useful as his work may be.

I have taken these three establishments as typical, but time would fail me to tell of the large number of institutions on the colony plan scattered over the Continent and the United States. In England two great movements are under way. The first under the auspices of the London County Council, which, going further than any other body as far as I know, is planning a huge colony for the insane epileptic population of London and surroundings; the second will provide for the epileptic population of the northern counties. Mr. B. Levy, who has been conducting the preliminary inquiries for the promoters, has been so generous as to forward his reports and plans to Melbourne, in the hope that we may be able to establish something in the way of an epileptic colony there.

Among collateral benefits the colony-system affords unequalled opportunities for the scientific study of the disease. No medical man in ordinary practice sees enough of it to be able to observe its varied manifestations, or to study it in any wide scientific spirit.

In preparing to establish an epileptic farm colony in any of the Australian States, the first step is to collect statistics, and in this I would urge you to ask for the co-operation of the Government statisticians, in order that you may be able to lay certain definite facts before the public.

Then there are two or three initial points to be by no means lost sight of. The land must be good; not too costly to clear or cultivate. You work largely under the handicap of untrained and irregular labour, and you cannot afford to burden yourselves with poor land. Land and buildings must be clear of debt before any colonists are received. Epileptics are not a sensational class of patient, so that the public could be readily appealed to to clear off any debt incurred; therefore, it is absolutely necessary to ensure success from the first. Next, the greatest care has to be taken in selecting the first cases, and in not filling up the place too rapidly. The bed-ridden and the insane must be barred. Nor are those, who through long years of indulgence have become completely spoiled and unmanageable, suitable cases with whom to begin the experiment, although these are just the very ones whom relatives are most eager to try and palm off upon managers. And epileptics are not at any time easy to manage.

Lest it should be thought that I have dwelt too exclusively on the economic side of the question, let me conclude by reading a short extract from the last report of the Craig Colony.

"*The Craig Colony is not a custodial institution in any sense of the word.* The law declares it is for the 'humane, curative, scientific, and economic treatment and care of epileptics.' Every patient is under scientific care and treatment; no patient is here as a mere matter of custody. This is not an idle institution; it does not exist solely to give food and shelter, and be a place where nurses and attendants bathe and dress patients, see that they are properly fed and not abused. If any one harbors any such opinions of the Colony, and the purposes for which it was created, we ask them to abandon them, or have them dissipated by reading the law that founded the Colony and by coming and spending sufficient time on the Colony premises to understand and appreciate the many lines of active medical and scientific work, of investigation, of study, and of inquiry always going on here.

"The civilization of a community is measured by the education of its people. When there are so many interests involved all at once, as there are now at the Craig Colony in its rapid growth and development, when progress is being forced so fast along so many lines as is now the case at the Colony, it might appear to be difficult to pick out any one or two things that need to be fostered and encouraged above all the rest; but that is not true in this case. Science and education stand out clear and distinct beyond all the rest. The Craig Colony for Epileptics was conceived along too high a plane to permit it to degenerate into a place of simple custody. That cannot be: Education and Science must ever play the most important part in the growth, development, usefulness, and welfare of this Institution."

I appeal to you, then, on national grounds, to consider this a national question. A considerable proportion of our people, say, two per thousand, are epileptic. I have faintly tried to indicate the national waste and crime which result from leaving them uncared for and unregarded. I have shown, I think, conclusively that the difficulties of dealing with this handicapped class, and placing them under conditions where they may be happy and useful and in part self-supporting members of the community, have been overcome. I desire to see in every State a beginning made towards this great work, and I feel sure that any State which makes some such provision for its epileptic citizens will, in the not distant future, reap a rich reward, not only in the increased happiness of its individual members, but in the very tangible relief felt in other branches of expenditure, in the lunacy department and in the administration of the prisons; so that when you apply to treasurers and to the charitable public for funds to start an Epileptic Colony, as sooner or later you are bound to do, you may do so with a clear conscience, assured that the money expended in helping the epileptic to help themselves will be saved by the State an hundredfold in other directions.

ON THE PSYCHOLOGY OF LANGUAGE.

By Hermann Ritz, M.A.
(University of Tasmania, Hobart.)

[*Abstract.*]

The Science of Language, as it is now understood, is of comparatively very recent origin, though philosophers and grammarians have studied human speech from every point of view since the dawn of history. Modern philology owes its origin to Sir William Jones, who, in 1790 A.D., enunciated the principle that Greek, Latin, and Sanskrit have sprung from some common source, which, perhaps, no longer exists. His successors have built and are still building on this foundation, and have obtained surprising results. The number of languages recognised as belonging to that group has become very large, and the original uniformity of human speech is no longer considered to be beyond the scope of scientific demonstration.

The keynote of a scientific treatment of the theory of language was struck by Herder, who clearly conceived the creative power inherent in the human mind, by means of which man is capable of evolving language from his natural faculties. The third great name in the history of modern philology is that of Immanuel Kant, who pointed out that experience and thought are indispensable to each other; that without understanding, experience is useless, and without experience, reasoning is baseless.

The student of language obtains his experience from the observed facts of human speech. He concentrates his attention on the spoken word, not on its written symbol; on the sound that is heard, not on the gesture that is seen. He endeavours to ascertain by every available means how sounds can be made to express thoughts, and how and why words change in sound and meaning.

The life-history of spoken words is the province of Etymology or Derivation; and this branch of philology, though the most recent of all in its scientific form, has made extraordinary progress, and has risen to the highest practical importance. It has become the key to the mysteries of human speech, and, through that, of human thought; for it is founded on the observation of facts which occur in progressive series, and the regularity of the successive changes enables us to ascertain the thoughts which cause those changes.

The sounds of the words are produced by the organs of the body which is the vehicle and servant of the soul; thus, to the student of language, the physiology of the organs of speech is the guide to psychology—to the knowledge of the soul itself.

It is customary in psychological investigations to denote by the word "soul" the sum of the facts that make up our inner world—the world of thought—without implying any views as to the nature and origin of those facts. But this limitation is by no means necessary. The investigation of the experience of the soul is evidently only the material or physiological part of the science of the soul; the philosophy of the actions and facts of the soul, the study of the reasons and causes of those phenomena, is the necessary complement of practical psychology.

The philosophy of psychology, then, is the ultimate goal of the philologist, as of every true student; but the student of language has this great advantage, that, in his science, the scale of knowledge is complete, and ready for his endeavour to ascend it.

In the sounds that make up the words he recognises the utterance of thoughts that exist in the soul. Every sound is the result of some physical action in the arrangement of the organs of speech affected; every muscular action is the result of nervous action; every nervous action proceeds from the soul, as the centre of action; and in every instance there is some impulse from without or from within to cause the soul to set the nervous force in motion. Thus, the soul expresses thought by sound.

But not only by sound. There is a subtle sympathy between the divers organs of the soul; each nerve is affected by all that affects another nerve of the group to which it belongs; thus, an impulse sent forth by the soul affects the whole of a group of nerves. We can observe examples of these sympathetic effects in our daily experience. Look at a little boy, when his father calls him to give him something he likes. His face, quite composed just before, is seen to change. The eyebrows rise, the eyes gleam, the lips open, the middle of the upper lip extends outward and downward a little, the lower lip leaves the teeth exposed, the vertical wrinkles near the corners of the mouth show that the horizontal dimension of the mouth is increased, the ends of the mouth curve upwards, the nostrils are expanded, the chin is raised. All these parts of the face—not to speak of other parts of the body—are affected sympathetically by the thought which the soul sent forth in response to a stimulus conveyed by the ears or the eyes. Now, if that boy answers to the call in words, could he say anything but "I am glad," or words of similar import, with that expression on his face? If he did, his words would contradict his face; and we should believe his face rather than his words.

We see, from this and similar examples, that a strong impulse proceeding from the soul affects a whole group of nerves and muscles. A weak impulse does so also, but in a minor degree. We all have seen series of pictures representing a child passing through the stages of pleasure or displeasure to the climax of laughing or weeping. Thus, the nerves of the vocal organs belong to certain groups of nerves that are affected by certain thoughts, and the effects on the nerves vary in quantity and quality with the intensity and the character of those thoughts.

Let us now consider a single sound, *e.g.*, *ah*. What thought does it express? Or, rather, of what *feeling* is it the audible effect? We have now to do with the primitive products of the soul, and these are sentimental, not intellectual. In proportion as reason becomes stronger, feeling becomes less evident, if not less strong. In a very young child, feeling is more energetic than reason. It is the first and simplest expression of the state of the soul, and its manifestation can be restrained only after habitual effort.

Now, what do *we* feel when we say *ah*? For the same thought that found its partial expression in the vocal effect *ah* can be partially reproduced by pronouncing *ah* first. Partially only, because the thought that prompted the *ah* affected other nerves besides those that caused the sound *ah*; and, unless all those nerves are again affected simultaneously, the reproduced effect on the soul differs in quantity or quality from the impulse that first produced the sound *ah*.

A very young child usually spends a considerable portion of its time in pronouncing *ah* with varying emphasis. It expresses by that sound a feeling of displeasure. When it is not displeased, it says nothing.

As we grow older, we no longer say *ah* when we feel pain; we learn to repress a portion of the manifestation of our feelings. But pain affects other nerves besides those that produce *ah*; for instance, we feel a distinct contraction about the heart, and we recognise this feeling when we speak of being overwhelmed or crushed with sorrow, and when we press our hand upon the region of the heart, as the seat of physical pain. We say *ah* when we feel surprise, joy, or anger, or, indeed, any strong emotion. Every disturbance of the equilibrium of the soul causes a disturbance of the equilibrium of the body, and may rightly be called a pain; and this pain finds ready expression and natural relief in the sound *ah*.

Let us now observe the nature of the sound *m*. It is the second sound pronounced by the little child, and indicates that its soul has become stronger; its thoughts have more control over the nerves, and the result is the sound *m*, the easiest to pronounce after *ah;* it is produced by deliberately closing the mouth, and letting the air pass out through the nose. What does this sound *m* mean?

When the child said *ah*, it felt pain, and thought of nothing else—not even of keeping its mouth closed; it gave up all to sorrow. But now there is evidence of an effort. The mouth is not only closed, but kept closed. What is naturally the most prominent thought now? It is a desire to be relieved from pain. The closing of the lip indicates that the feeling of desire is in the soul. If we watch the child as it cries, we shall see that, after the first attack of pain, it tries to close its mouth. The desire to be free from pain causes this reflex motion. But this desire is not strong enough yet. We can observe the conflict of the muscles of the mouth. The middle parts of the lips try to approach each other; the muscles below the corners of the mouth draw the lower lip downwards. Presently, the attempt to close the mouth succeeds for a time, and the child now says *am*, and, repeating the process, *amam*, till the small strength of desire or purpose it had is gone, and it abandons itself to grief with a final, prolonged *ah*, making the whole utterance, the history of its feelings, heard as *amamaaah!* This is the child's expression of pain, and of the desire for help, and it is almost universally adopted as the name of that human being which listens to the cry, and understands it, and soothes the feelings that called it forth. Precisely the same feeling is in our own souls when we say *m*. The sound is one of the effects of the feeling of desire or purpose. It is a matter of common observation that a loose upper lip and an open hand indicate a weak will, and a mouth firmly closed and a fist habitually clenched are marks of determination.

We have noticed that the sounds *ah* and *m* indicate certain states of the soul. If we examine the other sounds of the human voice, we shall find that each one is an effect of a certain feeling.

We have dwelt at some length on the phenomena exhibited by a very young child, because there the feelings are scarcely (if at all) restrained by reason. We may observe similar phenomena in all cases where sentiment prevails over reason. Moreover, in the case of the child, the phenomena are simple, for feeling is not yet modified and complicated by reason. From our observation of the child, we can best realise the nature of our language in its origin, for all human beings have to pass through that stage of existence. It is from the child that we learn that language is not, in the first instance, a thing that is taught or learnt, but it is a natural, spontaneous expression of the feelings that are active in the soul.

The first beginning of actual language occurs when the speaker realises that the sound indicates thought. He must understand his own speech before he can endeavour to make others understand it. But he will not seek to understand the sounds he utters until he desires to communicate his thought to someone else. Then he will find that sound is not only the most convenient means of attracting attention, but it is also more capable of expressing thoughts than any other means at his command. Even imitative gesture fails at a distance, and in the dark, and can at best express only a small number of simple thoughts.

Moreover, the speaker feels, though he may not be able to account for the feeling, that there is inherent in the succession of sounds a power of expressing and conveying feelings. A single tone may convey little meaning; but, as soon as two tones are heard, or sounded together or in succession, there is, besides the effect of the tones themselves, the feeling connected with the interval between them. If the second note is in harmonic agreement with the first, there is a corresponding feeling of harmony and pleasure produced in the soul of the hearer. If, on the other hand, the second note is not a "harmonic" of the first, there is a feeling of unrest, of disturbance, produced in the soul, and this feeling continues unless and until the discord is felt to be but a transition to another state of rest and concord. The ear, like every other organ of perception, remembers and expects, and the effect of sounds on the soul depends on this expectation being gratified or disappointed.

The conflicting vibrations of discordant sounds are received by the nerves of hearing, are by them conveyed to the central station of the soul, and occasion conflicting impulses which disturb the balance of the nervous system.

Conversely, rough and discordant sounds produced by the human voice indicate that the harmony within the soul is disturbed; while gentle tones convey to the hearer a sense of sweet peace within the speaker's soul. But all this is true only in the case of pure feelings. As soon as the speaker learns to reason, he learns also to hide or disguise his feelings by restraining their visible or audible expression. The angry man smoothes his brow and lowers his voice when he wishes to be considered calm and gentle; the weak coward blusters, to convey the impression that he is bold and strong.

Indeed, the poetical or ironical transference of meanings attached to sounds produces a very great variety of significant sound-groups, to which is to be added the practically infinite variety of sound-groups expressive of the feelings in themselves, and as modified by the influence of reason.

Each of these sound-groups represents a group of thoughts or feelings, and forms what is called a *syllable*. It is, indeed, most probable that the original speech of mankind consisted of a succession of separate syllables. Of course, these syllables could and would be gathered into groups of several syllables, to express more complicated thoughts or feelings. In such a case the predominant idea of each group would be indicated by special emphasis of sound, expressive of the relatively greater force of the impulse it conveyed. This emphatic sound is the "accent" of a word of several syllables.

When words are connected in meaning, so as to express a series of thoughts in a "sentence," the process is the same in principle as when syllables are combined into words. The thought becomes still more complex, and the whole sentence receives a tone or accent of its own, expressive of the feeling which prompts its utterance. For instance, the sentence, "Did you take my book?" conveys different meanings, according as the emphasis is placed on different words. Again, different impressions are conveyed by uttering any sentence as a statement, as a question, or as a command. The sound is prompted by the feeling, and sets up sympathetic vibrations in the hearer's soul, which in their turn may find utterance in sound.

The power of sound to indicate feeling is not limited to single sentences. These generally express only temporary states of the soul; but the character, or habitual set of feelings, of a person is also shown in the tone of all he says. We can easily distinguish the ruler from the slave by the sound of their speech, though they speak the same words to the same purpose. Take, for instance, the words "The weather is fine." The tone in which the slave pronounces these simple words indicates his fear of giving offence, and his desire to avoid ill-treatment. The ruler, on the other hand, utters them as the authoritative statement of a fact, "impugn it whoso list." Again, we know that a voice that is sweet and low is an excellent thing, as conveying the impression of sweet reasonableness in the soul of the speaker. The sounds that make up the speech of a man indicate not only his personal character, but also his character as a member of a community, a province, or a nation. Unless and until his character is changed by new surroundings, the peculiar intonation of his speech remains. It is a matter of common experience that children of foreign parents can learn to produce the exact sounds of the native language. Their feelings are easily influenced, and so is the expression of their feelings. But when the feelings have become habitual, it is very difficult to change the intonation of the speech. There is also a physiological reason for this. If feelings become habitual, the same nerves and muscles are continually set in motion, and acquire not only the habit of acting in certain ways, but the shape most conducive to ease in acting in those ways; the muscles, as well as the feelings that ultimately govern them, become set, and act automatically or sub-consciously. This is manifest not only with regard to the muscles that produce the sounds of speech, but generally. For instance, the walk and carriage of a man indicate very plainly the feelings that are most constant in his soul. The soldier's martial strut is characteristically different from the coward's slouching gait.

We return to the consideration of single words, and find further evidence of the influence of the soul upon the speech in the changes which words undergo in the course of time. These changes declare to the student of language the history of the nations that used the words; for the history or experience of a man or of a nation leaves its impression upon the character; and the character is shown by the sounds that are uttered most frequently, and therefore most naturally and most easily.

Modern etymology is not, as its older form was, a tissue of idle speculations, but an exact science. It rests on the fundamental principle that nothing happens without adequate cause, and that no explanation of a phenomenon is valid unless it demonstrates why the phenomenon is such as it appears to be. The etymologist must obtain his arguments from psychology—from the knowledge of the working of the soul; for all that man does, or thinks, or feels, is ultimately done, thought, or felt in his soul. And the characteristic actions of the soul of an individual or of a nation are manifested in the visible and audible expressions of their thoughts and feelings, the chief of which is language.

When we say that an English word is derived from the Latin language, we imply that substantially the same group of sounds expresses the same or an associated idea in both tongues. But the English word is the same as its Latin predecessor only so far as an old traveller is the same individual as the boy who left his father's home long years ago, to wander in strange lands. We can tell the life-history of the word from the changes it has undergone. It may fall from the lips of Cicero in all the perfection that the great scholar could give it. The time of Cicero and his compeers passes away, and the word sets out on its travels. It leaves the pleasant villa at Tusculum and takes up its abode in the camp of the soldiers of Augustus. They strip it of its neat ornaments, and ridicule its refined and precise gait; perhaps they compel it to perform mean tasks in their dislike of what is above their own level. Then they take it with them, while they follow the Cæsar to the wars. Some pass over the sea to Iberia, or to the province beyond the Alps, or even to Northern Gaul and into Britain. The word receives harsh usage during this time. In every resting-place it loses some of its garments, and makes up for the loss by mending or borrowing.

The soldiers of Rome depart, and take it with them, or leave it behind in the strange land. New masters come and find it there, dress it in their own barbarous garb, and let it live; and so the word continues to exist, through many changes of fortune, even to our day, being now but a shadow of its former self.

This illustrates the fate of such words. The garments and ornaments that Cicero gave to that word are the syllables and single sounds which clothed its meaning in his mind. These sounds have undergone many changes; some are lost altogether. But for every change, and for the loss of every sound, there was a definite reason; and to the etymologist the word in its varying form reveals all these reasons; and every one of those changes indicates the state of the soul of the man who was the first to make the change, and of those who made it after him. The change in the sound proceeded from a change in the mind; and in its turn it gave the impulse to a similar change in the mind of the hearer. In the fastidious literary circles of Rome every sound was pronounced with scrupulous care. In the camp the sounds that were the expression of refined feeling and thought were neglected, and gradually lost. In the mountain valleys, where the rustics gathered the word from the soldiers, further changes took place, owing to negligence or inability of ear or tongue, or because other sounds were more convenient to their organs of speech. These men had ample time for their conversation; they could afford to speak slowly. Speaking slowly, they found no difficulty in pronouncing a succession of harsh sounds; they were accustomed to take deep draughts of the bracing mountain air. And so the strange word assumed the garb of the hillmen's speech. Sharp hiss was followed by deep *ah*, or by croaking guttural. The meaning changed also. The ideas of the mauntaineers were not quite those of their soldier guests, and the word these left behind had to serve the local idea that seemed most like what the original meaning was supposed to be.

If the word was left behind in a flat country, its fate was different. On the plains the people could travel with ease from place to place; there was every facility for social and commercial intercourse; there was much to be spoken of when people came together; and the poor word had to change its sounds to suit its new surroundings. The harsh sounds, the sharp hiss, and the rough guttural had to give way to gentler sounds; where there is much speaking to be done, there is no time to spare for sounds that are difficult to pronounce; and, when business is to be done, reason must restrain feeling. The smooth sound expresses the assumed smoothness of temper.

All these circumstances, and many more, leave their impression on the spoken word, and this impression is made permanent by the wonderful invention of writing. The word continues to change, but the written records of the nations preserve the memory of its form at the various stages of its journey. And by studying these different forms we find in them the thoughts of the people who used the word.

Literature is a branch of philology which is in one sense parallel to etymology. When literature arises, the original distinctions of sounds as expressions of particular feelings have become so much obscured by the interference of reason that the constituent parts of the words are no longer the immediate reflex forms of the feelings of the speaker.

On the other hand, the words have become the reflex forms of the combination of reason and feelings. The words of the sentence now do the work that was done by the sounds of the word; and on this higher scale we observe the same phenomena that attracted our attention in the lower. Buffon was right in saying that the character of a man is shown by his style; that is, by his manner of speaking. And as each man has his own style, so each body of men, each nation, has its own style. So that, by a close study of literature, we learn to understand the character of a writer or of a nation. If Lord Tennyson had written in Spanish or Persian, the skilled philologist would discern that none but an Englishman, and, of Englishmen, none but Tennyson, could have uttered thoughts like those.

In every department of the science of language there is ample material for investigation, and in none is there any excuse for mere guesswork. The philology of our days is an exact science of engrossing interest; its study demands the keenest observation and the most patient research, for it is the avenue to the noblest and most secret realms of knowledge—to the full knowledge of the human soul. This is the beacon that illumines the path of the student of philology; and this is the ultimate purpose of the study of the Psychology of Language.

GROWTH AND DEVELOPMENT OF HOBART SCHOOL BOYS, WITH SOME NOTES ON ANTHROPOMETRY.

By CHRISTIAN BJELKE-PETERSEN.

[Plates.]

THE desire for a more exact knowledge about the physical development of Tasmanian boys, and the wish to compare them with other races, led me into the work, the result of which I am about to put before you. The Honourable the Minister of Education was favourable to my plan, and kindly issued a circular to the Head Masters of the Hobart State schools asking them to give me the opportunity of examining the children. My assistant and I examined over 500 boys.

The following were the data collected:—Name of pupil, age last birthday, birth-place, birth-place of father, birth-place of mother, weight, height; girths of neck, chest contracted, chest expanded, waist, right fore-arm, right upper-arm (with biceps contracted), left fore-arm, left upper-arm (biceps contracted), right thigh, right calf, left thigh, left calf.

When including so many girth-measurements, I was quite aware that this was unusual, but I was desirous of having material from which to work out a complete graphic chart that would be useful to teachers and parents interested in the physical development of the young. I have vainly looked for such a chart in the hand-books on anthropometry from other countries, and at last attempted to make one myself.

It has been proved in the science of anthropometry that the measurement of a large number of individuals is not necessary to show the rate of growth and development, as long as the group measured is complete. I decided to tabulate the measurements of school boys aged 8 to 15 years, both inclusive, taking 50 in each group, with exception of the last age (15 years), where I had 33; of course, no attempt at selection was made. All the boys are State school pupils, except a few in the last two groups; as I could not get enough of those ages, I augmented with a few from other schools.

From these measurements I have prepared some tables.

Table 1 shows the average weight and measurements of boys at each year of age from 8 to 15 years.

Let us first study what it teaches us about the increase in height and weight. You see the result of my investigations graphically represented on Diagram A.

The ordinates of the upper curve (the horizontal lines) express the average height for each age; the lower curve indicates the average weight of the boys; the row of figures on the lines of abscissas (the vertical lines) expresses the age; the column of figures on the left the average height in inches (corresponding to the upper curve); and the column on the right expresses the weight in pounds (corresponding with the lower curve). On comparing these lines you will notice that years of accelerated growth in height are also noted by a corresponding increase in weight. You will also notice the fact that years 11 and 14 show very retarded growth both in height and weight; while the year 15 shows the greatest growth.

It is interesting how closely our boys in this respect follow other races. Dr. Seaver (an American), who is one of the first authorities on anthropometry, says—"The period of the fourteenth year is a period of retarded growth, and is immediately followed in the fifteenth year by a period of greatly-accelerated growth, this being the period of prepubertal acceleration, and the retardation is seen to be as fully marked as the acceleration." This is true in the growth of the Tasmanian boys.

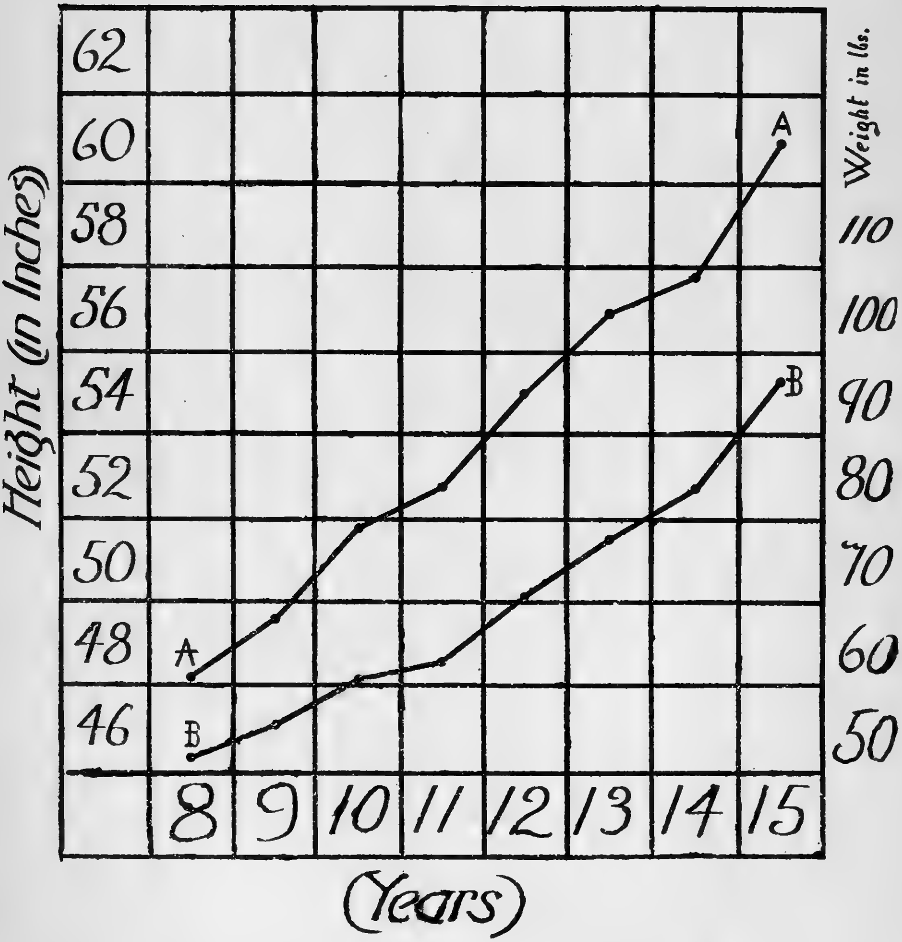
Diagram B shows the average annual increase in height for each year of Tasmanian boys during the period of observation. You will notice that increased growth during year 15 is large enough to make up for the retardation in the previous year. From this chart you see that the increase does not take place in regular mathematical progression, a fact observed by all writers on the subject. The average annual increase in height for all the years is 1·10 inch. A period of prepubertal acceleration of growth has been noticed by most students of anthropometry, and the tables of English, Swedish, German, and Italian writers confirm it. A point worthy of notice is that the very complete investigation of the health of European school children seem to prove that during the period of feebler development preceding the period of puberty the percentage of children suffering from ill-health is greatest. Professor Axel Key, of

Table 1. showing the average weights & measurements of Boys at each year of age from 8 to 15 years.

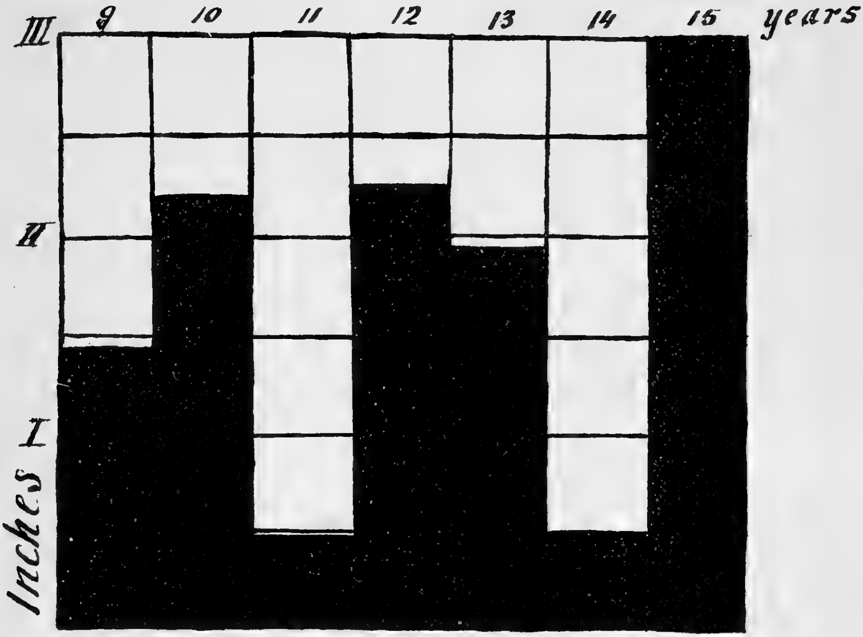
Age	8	9	10	11	12	13	14	15
Number	50	50	50	50	50	50	50	33
Weight	51·65	55·28	61·01	62·76	70·45	78·03	83·96	96·83
Height	48·19	49·62	51·78	52·76	54·99	56·89	57·80	60·89
Neck	9 65	9·76	9·95	10·14	10·34	10·74	10·76	11·32
Chest Contr:	21·61	22·58	23·17	23·87	24·44	25·18	26·04	27·41
Chest Exp:	24·21	25·14	25·62	26·49	26·86	27·55	28·70	30·12
Waist	19·53	20·08	20·88	21·33	21·93	22·73	23·51	24·26
R. Forearm	6·70	6·93	7·19	7·31	7·70	8·04	8·15	8·60
Left .	6·57	6·71	7·04	7·15	7·50	7·86	8·00	8·42
R. Thigh	12·69	12·88	13·57	13·91	15·02	15·57	15·76	16·25
R. Calf	9·05	9·30	9·60	9·71	10·35	10·86	10·89	11·48
L. Thigh	12·59	12·82	13·56	13·85	14·73	15·10	15·55	16·25
L. Calf	9·08	9·29	9·67	9·75	10·31	10·80	10·90	11·46
R. arm-up	6·60	6·78	7·08	7·30	7·75	8·10	8·44	9·00
L. " "	6·53	6·88	6·98	7·17	7·54	7·89	8·25	8·71

Diagram A

Height & Weight of Hobart Boys.



B.

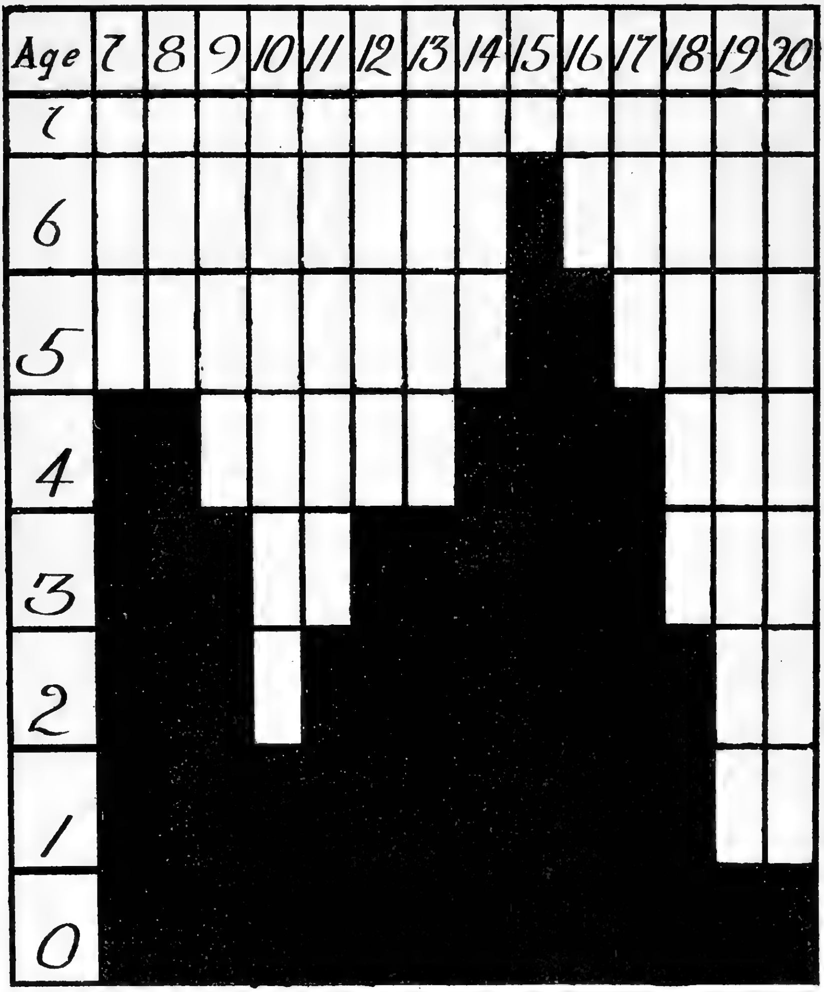


Annual Increase in Height

Hobart Boys.

Diagram C.

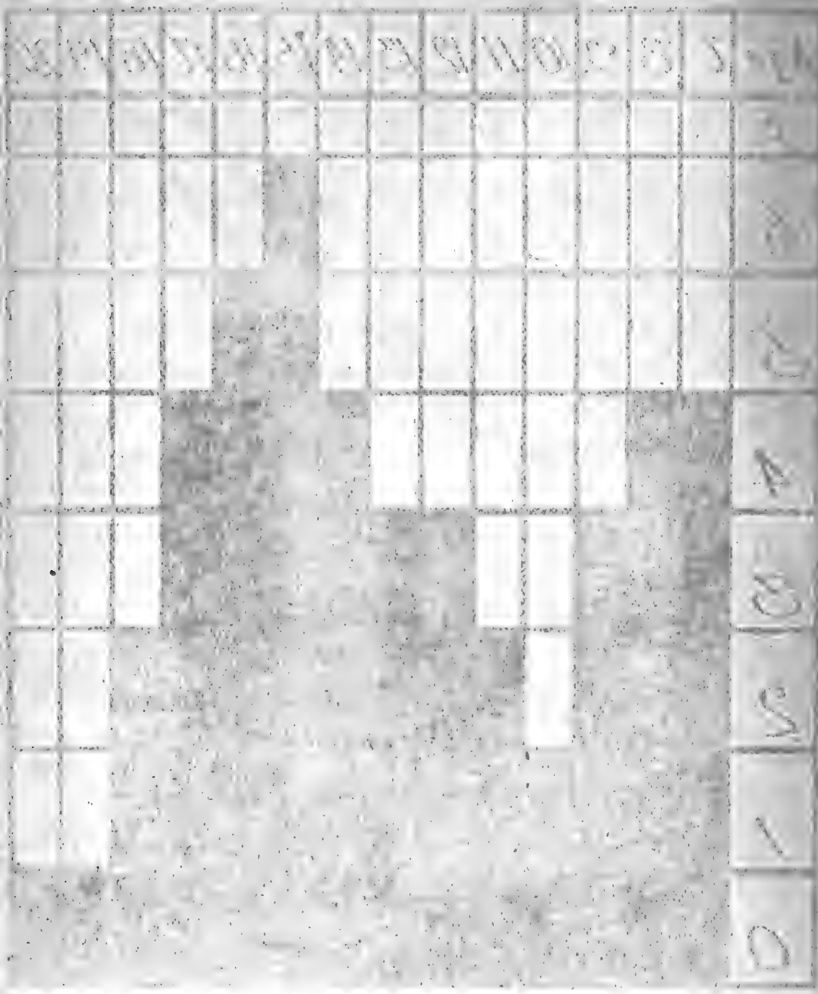
Rate of Growth of Swedish Boys.



Frof. Axel Key's table, showing the average annual growth of Swedish boys measured in centimetres. The year of retarded growth (ten) has the highest ill-health percentage in that country.

Diagram C.

Rate of Growth of Swedish Boys.



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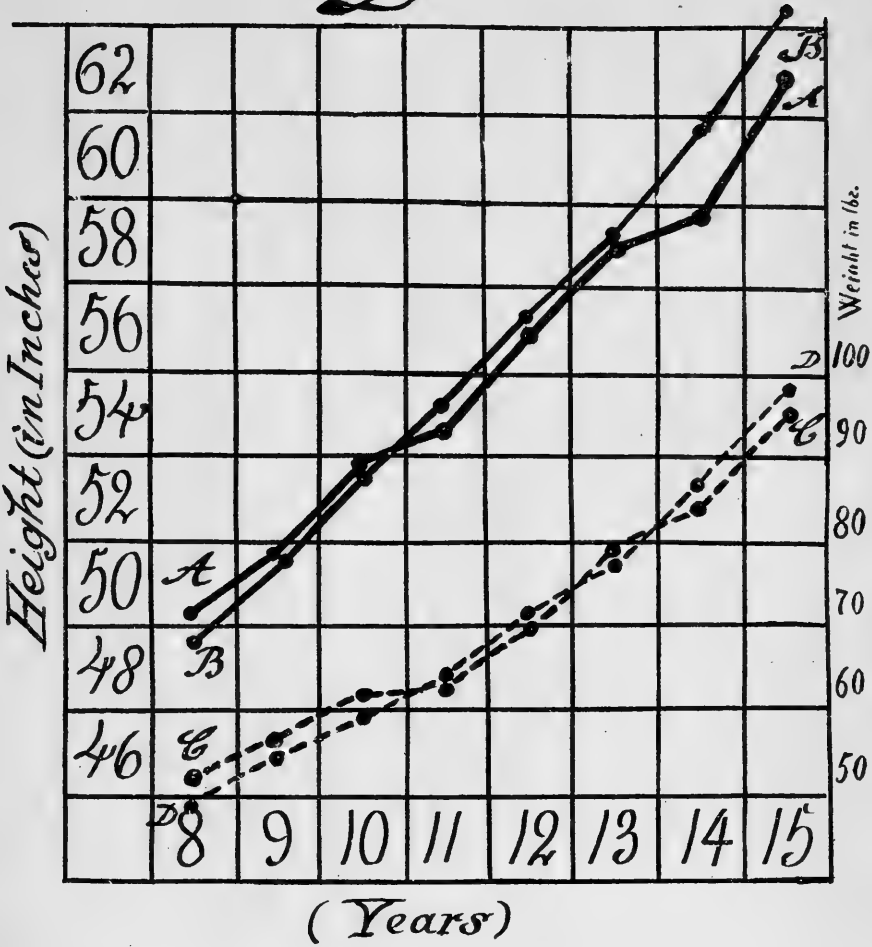


Height (in Inches)
62
60
58
56
54
52
50
48
46
Weight in lbs.
100
90
80
70
60
50
A
B
C
D
8
9
10
11
12
13
14
15
(Years)

Diagram E

Comparative Rate of Growth of Tasmanian American & English Boys.

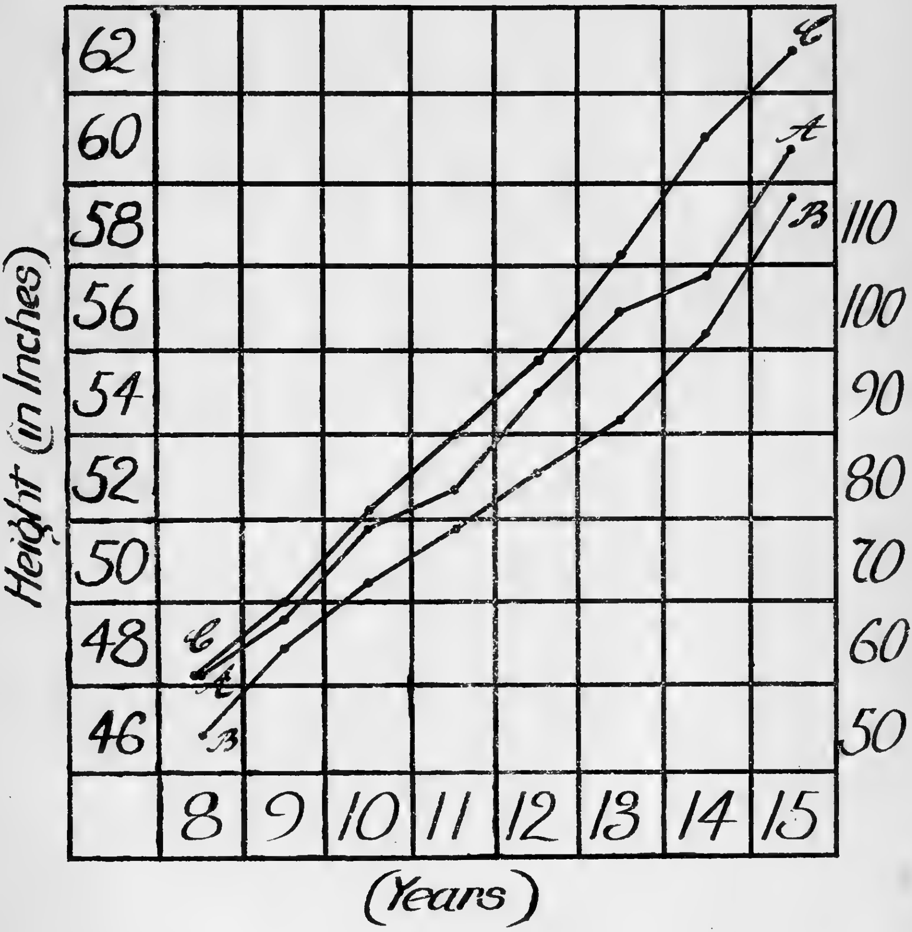


Diagram F

Comparative Rate of Growth of Tasmanian German & Belgian Boys.

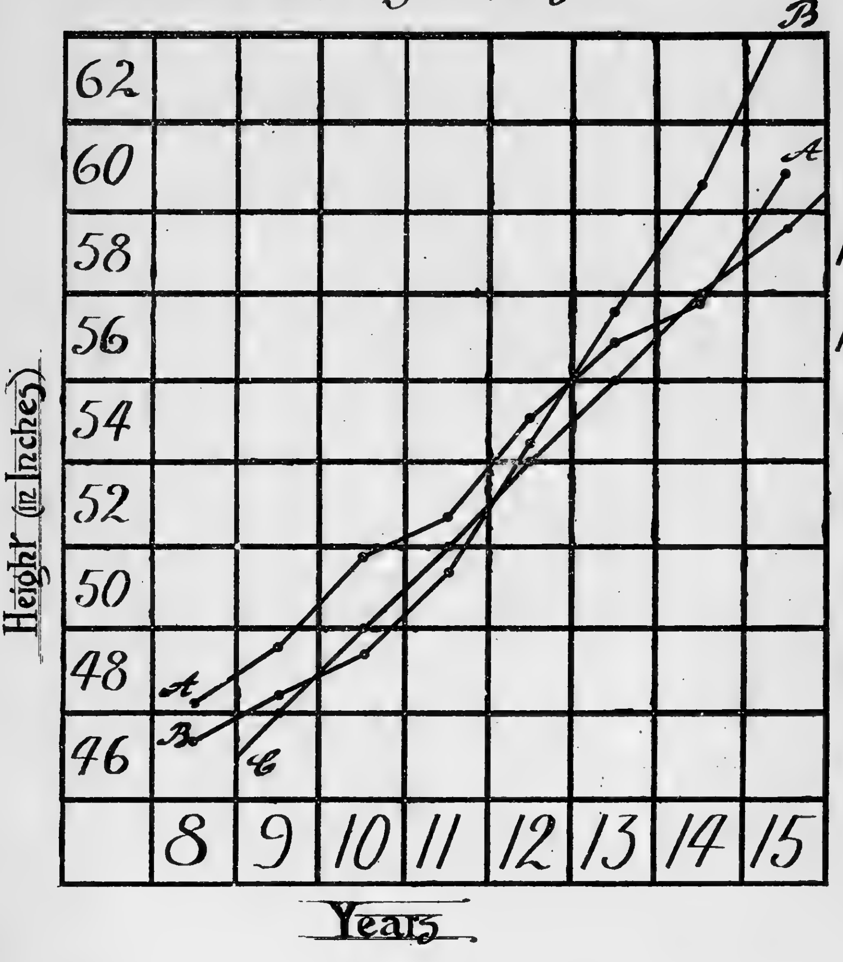
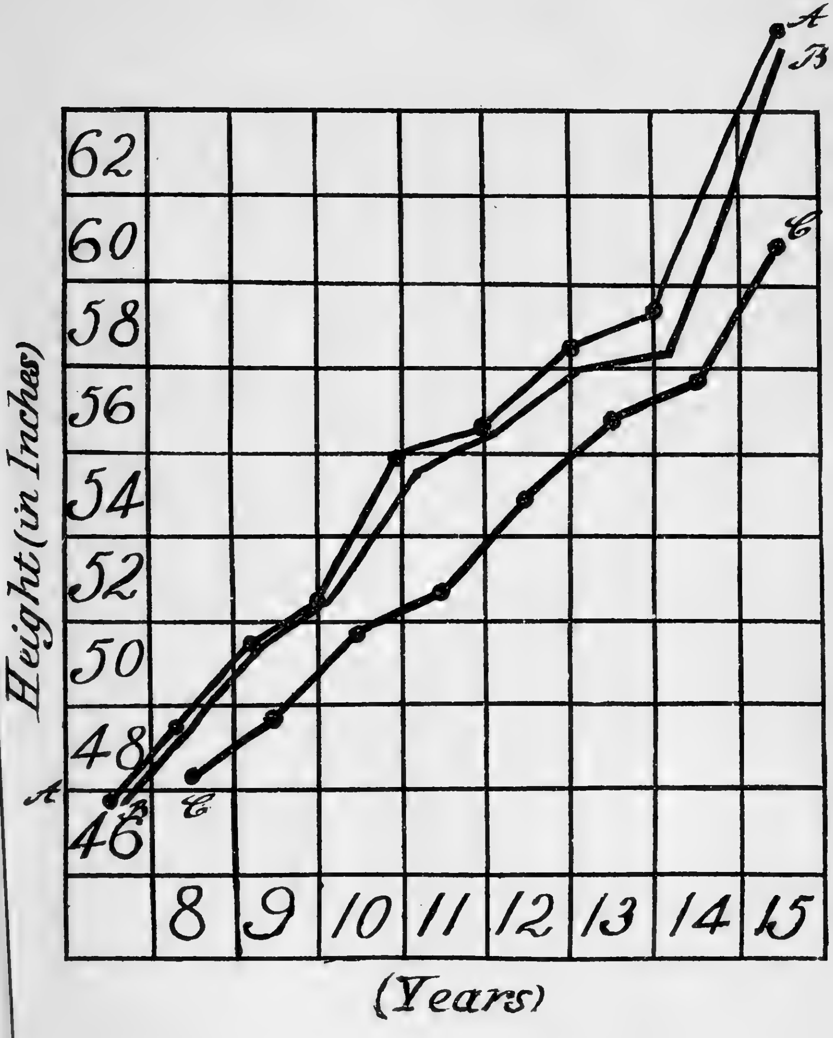
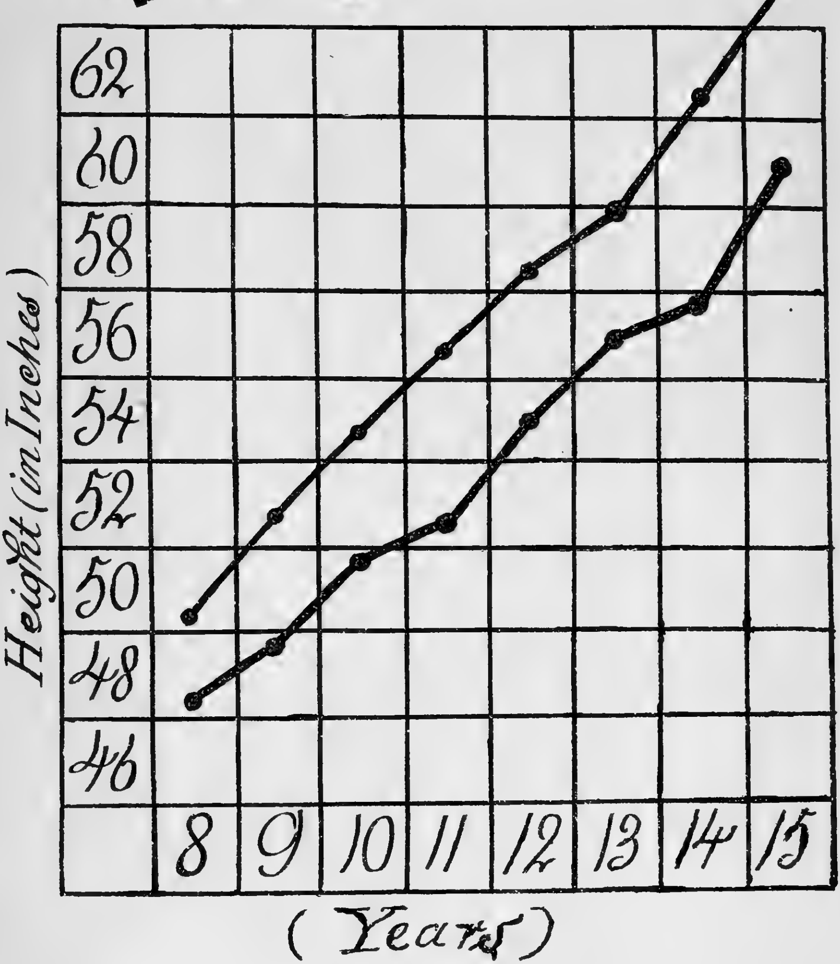


Diagram H



Height (in Inches)
62
60
58
56
54
52
50
48
46
A
B
C
8
9
10
11
12
13
14
15
(Years)

Diagram I Sydney & Hobart Boys.



J.

Graphic Anthropometric Chart of Hobart School Boys.

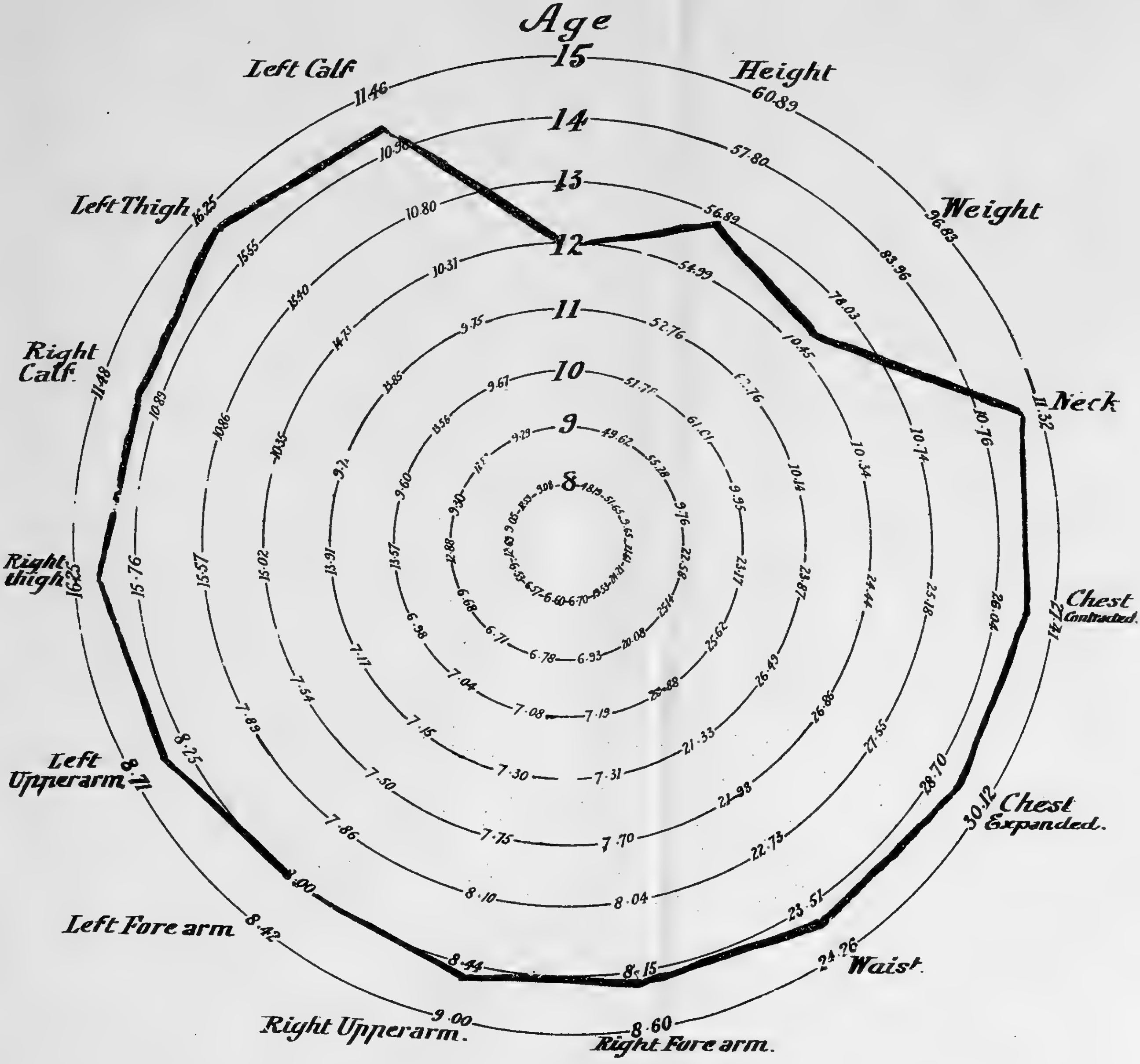
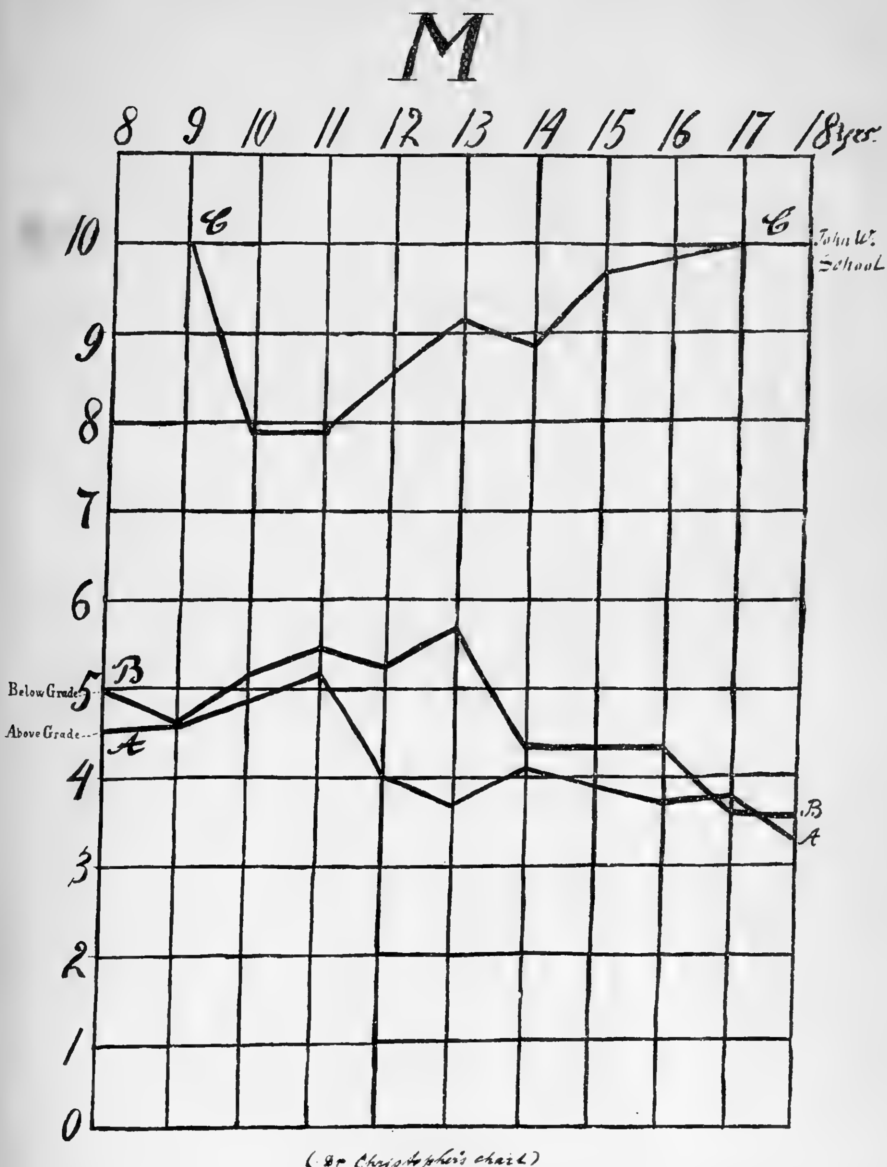


Table showing Median Weight of Boys aged 11 Distributed by School Grade K

Grades.	Numbers of Boys Weighed.	Median Weight Kilogrammes.
I	59	28·83
II	311	29·74
III	664	30·92
IV	546	31·43
V	123	32·41
VI	33	33·29

(Dr. Porter's Table – 1936 boys)

This shows that when you compare boys of the same age in sufficiently large numbers, you find that their mental ability is in direct proportion to their weight.



Dr. Christopher's chart, showing that the boy who has a normal physique is more likely to be of moral character

Sweden, draws special attention to this fact in his excellent report on the result of the inquiries into the physical condition of some 30,000 Swedish school children. The years of checked growth is the period when vitality seems lowest, and the power of resistance therefore smallest.

Diagram C.—Growth of Swedish Boys.—Prof. Keys table, showing how many boys suffer from ill-health at each year, shows us the maximum percentage for the tenth year, and we find this is the year of most retarded growth in his country.

Let us compare the height of our Hobart boys with the height of some other boys that have been measured.

Tasmanian and Boston Boys.—On Diagram D, line *A* represents the Tasmanians; the line *B* represents the height of boys from the Boston public schools, as measured by Dr. Bowditch, and have been taken irrespective of parentage. The boys have thus been taken from almost the same social grade. Notice how closely the lines run to each other till the fourteenth year, when the Hobart boys fall slightly to the rear.

Diagram E.—This chart compares Hobart Boys' height (line *A*) with that of English city boys (line *B*) of the labouring classes.—(Roberts.) You see this comparison is in favour of the Tasmanian. The third line (*C*) represents Boston boys of American parentage.—(Bowditch.)

Diagram F.—On this chart the height of German boys is indicated by line *B*. For the first five years you notice that the Tasmanians (line *A*) are the tallest. The third line (*C*) represents Belgian boys.—(Quetelet.)

Diagram H. On this diagram the lines indicate rate of growth of boys. Line *C* is the Tasmanian line. Lines *A* and *B* are taken from Dr. Seaver's book on Anthropometry. The top line *A* is taken from Gilbert's table; the middle line *B* represents the growth of New Haven boys. Observe how much lines *A* and *B* are like the line indicating the Tasmanian growth-rate. Each has two years of retarded growth about the same time.

Diagram I.—The top line represents Sydney boys (Coghlan's measurements); and you will notice that they are considerably taller than the Hobart boys, whose height is marked by the lower line.

Allow me to put a few comparisons of heights of boys before you in a different way. I purpose naming the sum of averages for each year between the ages 8 to 15, both inclusive. The unit will, in this instance, be centimetres.

1.	Sweden stands first with	1115
2.	New South Wales stands 2nd with	1111
3.	Boston	1109
4.	Germany	1100
5.	Denmark	1096
6.	England (Anthropological Soc.)	1088·7
7.	American (Report of Commissioners of Education)	1088·0
8.	Tasmania	1082
9.	Belgian	1075
10.	Italy...	1068

Large Chart J.—This is a graphic anthropometric chart to be used for plotting the measurements of Tasmanian boys. The chart can be used for any age between 8 and 15. It gives absolute records of averages, and these are arranged in concentric circles. I have plotted the average measurements of the American boy 14 years old according to table prepared by Scheuler Moon.

Weight.—The average weight varied from 51·65 lbs. to 96·83 lbs. during the period under observation. When we except the years of retarded growth, my tables show the same rate of annual increase as the standard works. Our average annual increase is 6·15 lbs. for the eight years observed. I have obtained tables showing average weight of boys in eight countries. Exact comparison can, however, not be made, as I have weighed our boys without clothes, while in other countries the weight of clothes is included. Some of the anthropometrists have given weight for clothing at different ages, but as small errors would be unavoidable, exact comparison is impossible.

Diagram D shows weight of American (line *D*) and Tasmanian (line *C*) boys. You see how closely they follow each other.

On the whole, I believe Tasmania compares very favourably with other countries in weight. It would certainly be amongst the first four.

Chest-girth.—The importance of this measurement is evident. We all know that a large chest increases the individual's vitality and reserve powers. At birth the chest-girth is 1-2 centimetres smaller than the girth of head. The chest-girth increases at a uniform rate till the age of 5 years, when it, according to Mr. Kohleman, should be about 20 inches. Mr. Kohleman is looked upon as an authority in this branch of the work, as he has made a special study of the development of the chest. He puts the normal annual increase in chest-girth between years 8 to 12 to be from 0·50 to 0·80 inches, while the years 13 to 15 should show accelerated development varying between 1·2 to 1·6 inches. I find the Tasmanians follow the rule fairly well, their measurement being, for the first period referred to, 0·47 to 0·95 inches, and 1·15 to 1·42 inches for the last two years. The chest-development thus follows the law of prepubertal acceleration.

The chest-expansion, by which I mean the difference between the girth of the expanded and that of the contracted chest, does not vary very much during the years observed, namely, 2·37 to 2·71 inches. I have here a few copies of the tables prepared by the men who have studied the subject in other countries. The comparison in every case is unfavourable to the Tasmanian boy. I referred before to Kohleman as a first authority—well, the Tasmanian boys are below his figures. Our boys are also below the American ones quoted in books on anthropometry. It would hardly be fair to compare with McLaren's tables, as his figures were most likely taken from boys who had had gymnastic training. Mr. Coghlan, the Sydney Statistician, who tabulated the result of the anthropometic measurements of 2000 children in Sydney, found on comparison that the Sydney boys were very much below measurements quoted in other tables. I regret to say our Tasmanian boys are not better than the Sydney ones.

Relation between Physical Development and Mental Ability (Diagram K.).—My investigation does not include an attempt of getting an idea of the mental ability of the boys, so allow me to quote Dr. Porter, who, with his assistants, measured 33,500 children in St. Louis public schools. He says—"I demonstrated that children who possessed more than the ordinary power of mental labour, as measured by the progress in their studies, are heavier, taller, and larger in their girth of chest and in width of head than their less-gifted companions of the same age." (Volume 6, No. 7, of the Transactions of the Academy of Science of St. Louis, March 21st, 1893.)

A more extended statement of those observations were presented to the Berliner Gesellschaft für Anthropologie, July 15, 1893, and appears in Virchow's Zeitschrift für

Ethnologie. In these papers the material was the total number of observations, irrespective of social conditions of parents. Let me take an example from Table 2 (*see* Chart K.). "The physical basis for precocity and dulness" will illustrate the result of the inquiry. Pupils aged 11 are found in grades 1, 2, 3, 4, 5, and 6 of the St. Louis public schools, as the following table shows. Of the total number, 59 were in the lowest grade, the first; 311 in the second, &c. The number opposite the grade indicates the number of boys found in that grade. May I now ask you to look at the figures in the third column—these show the average weight of the boys in each class. You will notice that the boys in the first grade weigh less than the boys in the second; and these, again, are lighter than the boys in the higher grades. This shows that when you compare boys of the same age in sufficiently large numbers, you find that their mental ability is in direct proportion to their weight.

Two years ago Dr. Christopher directed an examination of about 7000 children in Chicago. No expenditure of time, skill, and money was spared to make this the most thorough investigation of its kind ever made. He came to the same result as Dr. Porter, that average height and weight of school children decide their standing in school-work. (*See* Report of Board of Education of Chicago, 1899.)

Both these investigations show that the average dull child is shorter and lighter than the average bright child. They indicate that superior physical qualities are associated with superior mental ability.

Diagram M.—Let me show you a chart of Dr. Christopher. It shows the average number of physical abnormalities of children below grade (that is, dull pupils), in pupils above grade, and in pupils of the John Worthy School. The school just mentioned is associated with a penetentiary, and contains young criminals, and also some homeless children who have shown no criminal tendencies. You will notice that the bright pupil has fewest physical irregularities of growth (line *A*), the dull pupils score slightly higher (line *B*), while the criminal boys are leading by a long way (line *C*). These lines indicate that the normal boy is likely to be the best boy morally.

I have tried to show that normal growth is a very important factor in the developing of the young, affecting their mental as well as their physical standing.

Let me, however, remind you that great height is only desirable when there is increase of weight and chest-girth in proportion. More heat is lost by the abnormally tall than by those of average height. Greater height means increased work for the heart and skeletal muscles, and therefore more mechanical labour. Thus, the abnormally tall loses more energy; hence, to make health possible, the physical development must be so much above the average as the height is above it.

The lack of proportion between height and weight, chest-girth, &c., should be the cause of anxious inquiry. A tall child may have energy sufficient for the ordinary demands of a well-regulated life, while it may break down under the strain of unusual tasks.

BAD ENGLISH.

By E. C. Nowell.

EDUCATION.

By E. C. Nowell.

THE PSYCHOLOGY OF CHILD MIND AS APPLIED TO SCHOOL LIFE.

By A. Card.

PIONEER WORK IN TECHNICAL EDUCATION.

By W. J. Clunies Ross, B.Sc.

THE STATE, AND SECONDARY EDUCATION.

By J. W. Masters, M.A.

Appendix to Section B.—Chemistry.

THE METALLURGICAL LABORATORIES OF THE SCHOOL OF MINES, IN THE UNIVERSITY OF SYDNEY.

By A. Liversidge, LL.D., F.R.S., Professor of Chemistry, University of Sydney.

[Plates.]

An account of the then proposed Chemical Laboratories for the University of Sydney was given at the first meeting of this Association, Sydney, September, 1888. The laboratories were duly built in 1889, but since that date it has been necessary to add largely to them, to accommodate the greatly increased number of students in metallurgy and assaying.

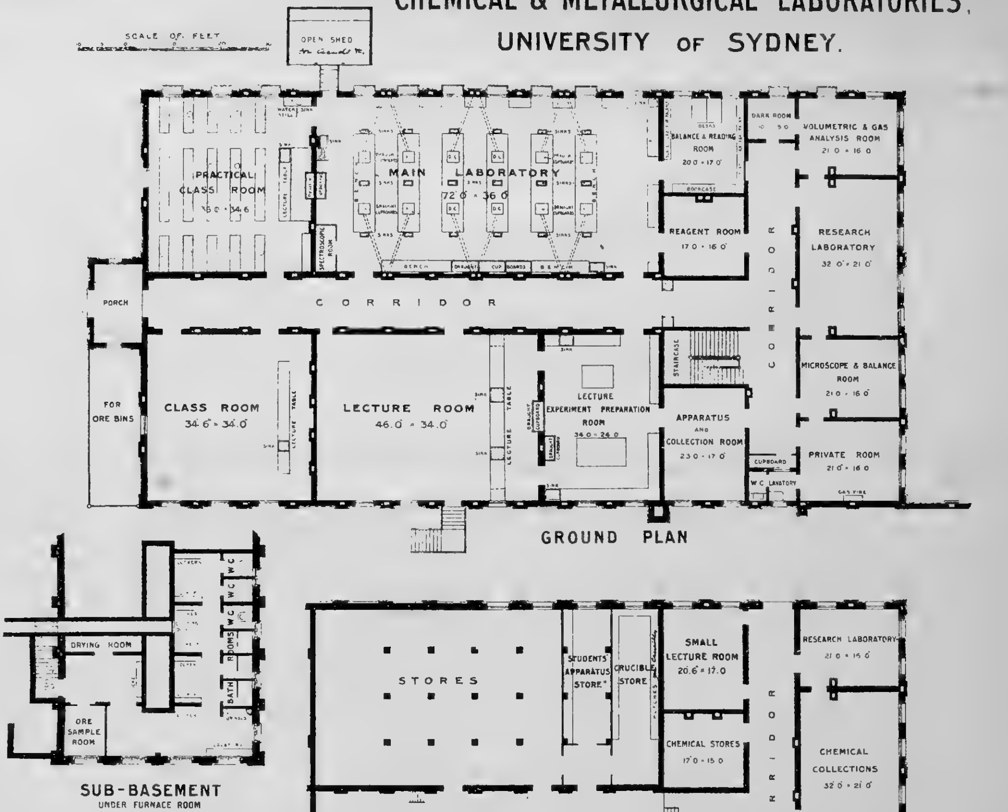
The accompanying plans and illustrations show the general arrangements and some of the fittings of the Chemical and Metallurgical Laboratories; an account, with illustrations, of the former will be found in the Report of this Association, Sydney, Session 1888, so that it is not necessary to go over the details of the chemical laboratories again; their positions, however, are shown in the plans (Plate 1), and photographic views of parts of them are reproduced in Plates 3 and 4, so as to give an idea of the general arrangements for teaching practical chemistry.

Most of the principal rooms are on the ground floor, the stores, workshops, &c., being in the basement, including lavatory accommodation. In addition to the ordinary wash-basins, there are three shower-baths for the use of the students—a very necessary provision in view of the dusty nature of some of their work; lockers are provided for their clothes, and recesses in which they can change to and from their working dungaree suits.

The chemical and metallurgical buildings cover an area of about 130 by 170 feet, and have been erected under the superintendence of the Government Architects' Department, New South Wales, from the writer's plans and designs.

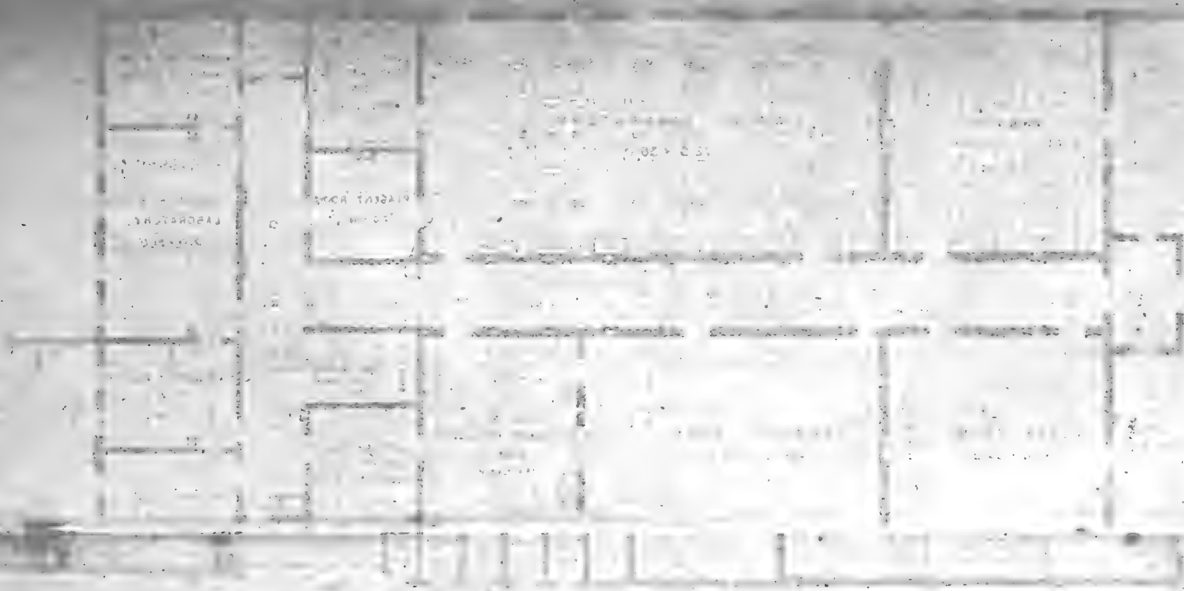
The whole of the benches and furnaces are fully occupied, and, in spite of the additions, more accommodation on the chemical side is urgently required. During the past year there were over 200 students working in the laboratories, *i.e.*, apart from others attending lectures only.

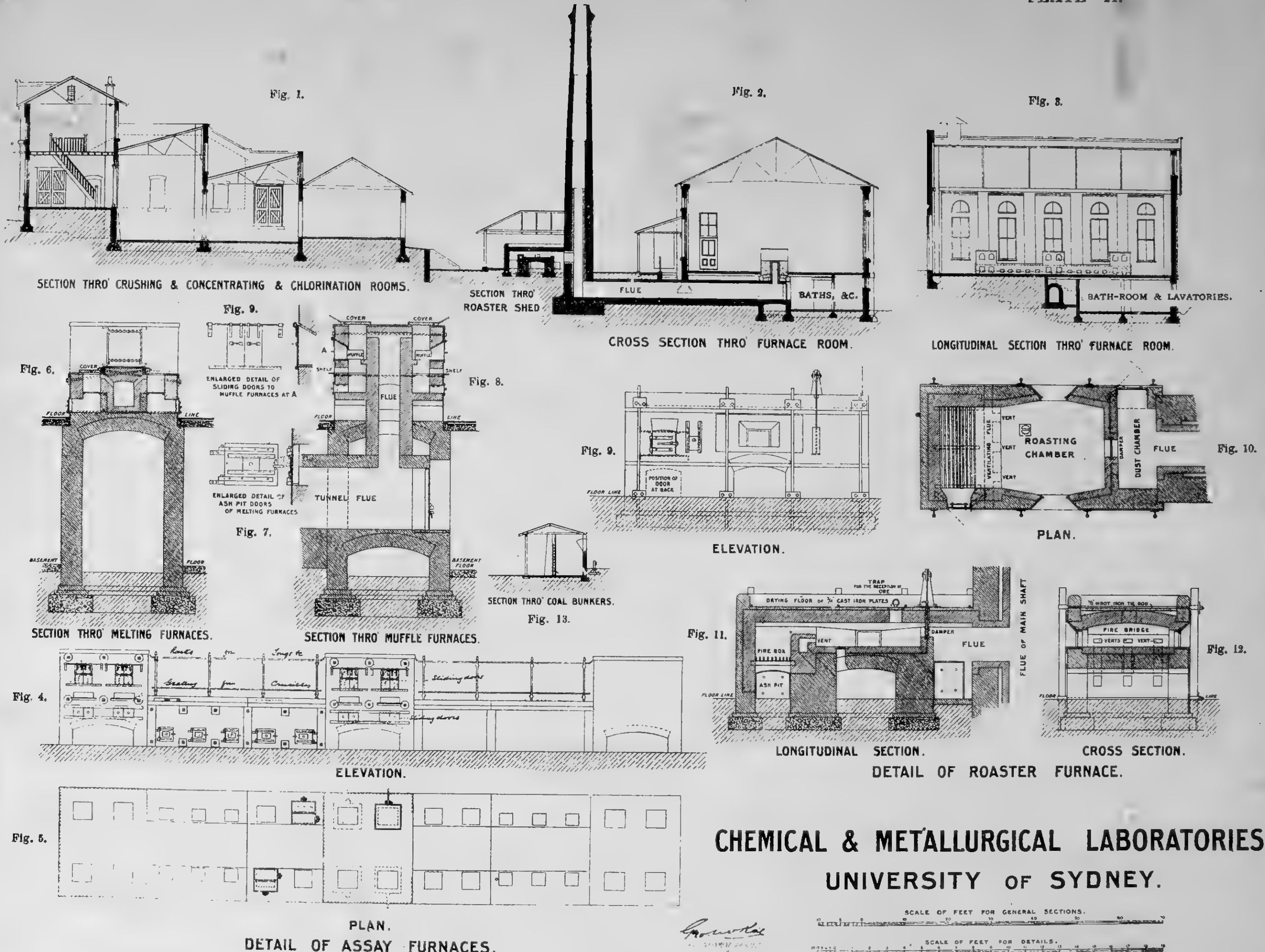
CHEMICAL & METALLURGICAL LABORATORIES, UNIVERSITY OF SYDNEY.



A. LIVERSIDGE.

Aust. Assoc. Adv. Science. Hobart. 1902





CHEMICAL & METALLURGICAL LABORATORIES,
UNIVERSITY OF SYDNEY.

A. LIVERSIDGE.

The Chemical Laboratories.

The chemical laboratories, built in 1889 (Report Aust. Assoc. A. Sci., 1888), are contained in a plain rectangular structure, about 170 feet long by 86 feet wide (Plate 1). There are two lecture rooms, two principal laboratories, and several other rooms for special purposes.

The large lecture room will seat 180, and the smaller one about 120 students. The junior laboratory (Plate 4) contains 40 benches, and the senior laboratory (Plate 3) has accommodation for 48 advanced students (Plate). There are also separate rooms for spectroscopic and gas analysis and photography. Two rooms have been specially provided and fitted up for research work; another room is set apart as a museum for chemical collections, and old forms of apparatus, &c., which are of historical interest.

The building is provided with the electric light throughout the upper floor, and the gas-engine for driving the dynamos is also attached to the shafting connected with the crushing, grinding, and concentrating machines, the apparatus for the liquefaction of gases, and other appliances. Leads are carried to convenient places in the laboratories, so that if necessary the full power of the dynamos may be used for experimental purposes.

Special efforts have been made to give the students the benefits of modern improvements and appliances, and particularly those which tend to save time. Draught cupboards, filter-pumps, exhaust-pumps, and similar conveniences are fitted to each bench. A number of large hoods and draught cupboards for combustions, sulphuretted hydrogen gas, water baths, and ovens are also provided. There are three balance rooms, each 21 feet x 16 feet, provided with balances for different purposes, which, to prevent vibration, rest on slate benches, supported upon stone brackets.

Metallurgical Laboratory.

Milling and Leaching Buildings.

The plant for the crushing, concentration, and other treatment of metalliferous ores is contained in the new building, and it includes a set of three small stamps by Krupp, presented by Messrs. Noyes Bros., Sydney; Gate's rock-breaker, Roger's crushing-rolls, trommels, samplers, amalgamating plates, a Frue vanner, plunger jigs, settling tanks, drilling and planing machines, &c.; also vats and the necessary appliances for the extraction of gold and silver ores by chlorine, cyanide, hyposulphite, and other similar leaching processes (see Plates). These have been constructed of such a size as to permit of their being worked by students. The milling and leaching room is about 35 by 100 feet; there are also verandahs and open yard space for outdoor operations.

The experimental roasting furnace, with a bed 6 feet x 4 feet, is placed out of doors, but under a tiled roof for coolness and protection from the weather (see Plate 2, fig. 2, 9, 10, 11, and 12), and the fuel bins are arranged alongside of it (Plate 2, fig. 13).

Assay Laboratory.

The new assay laboratory (Plates 1 and 2 and 8) is a lofty room, with 40 feet x 54 feet floor space; the walls are 22 feet high, and the roof 30 feet high. It is well ventilated. It contains 20 fusion and 12 muffle furnaces, arranged down the middle of the room. The flues are carried beneath the floor to a central stack (Plate 2, figs. 2 and 3). For cleanliness and strength the furnaces are completely enclosed in iron plates, and the muffles are closed by sliding double iron doors, in addition to the usual fireclay door. Iron racks are arranged over the fusion furnaces for drying crucibles, and for the reception of the tongs, pokers, &c., when not in use. (Plates 8 and 10 and Plate 2, figs. 3, 6, 7, 8, and 9, for sections and details.) In addition, there are 12 fusion and four muffle furnaces in the main building.

The working benches (Plates 8 and 9) are fitted with drawers, shelves, and draught cupboards with hot plates, and fixed bunsen burners. They are also provided with gas and water and exhaust pumps, in much the same way as those in the chemical laboratory. By using a staple and brass disk, which covers the angles of the three drawers, one padlock is made to securely close all three drawers. One disk also closes the two cupboards allotted to each student; the multiplicity of locks and the usual loss of keys are thereby avoided.

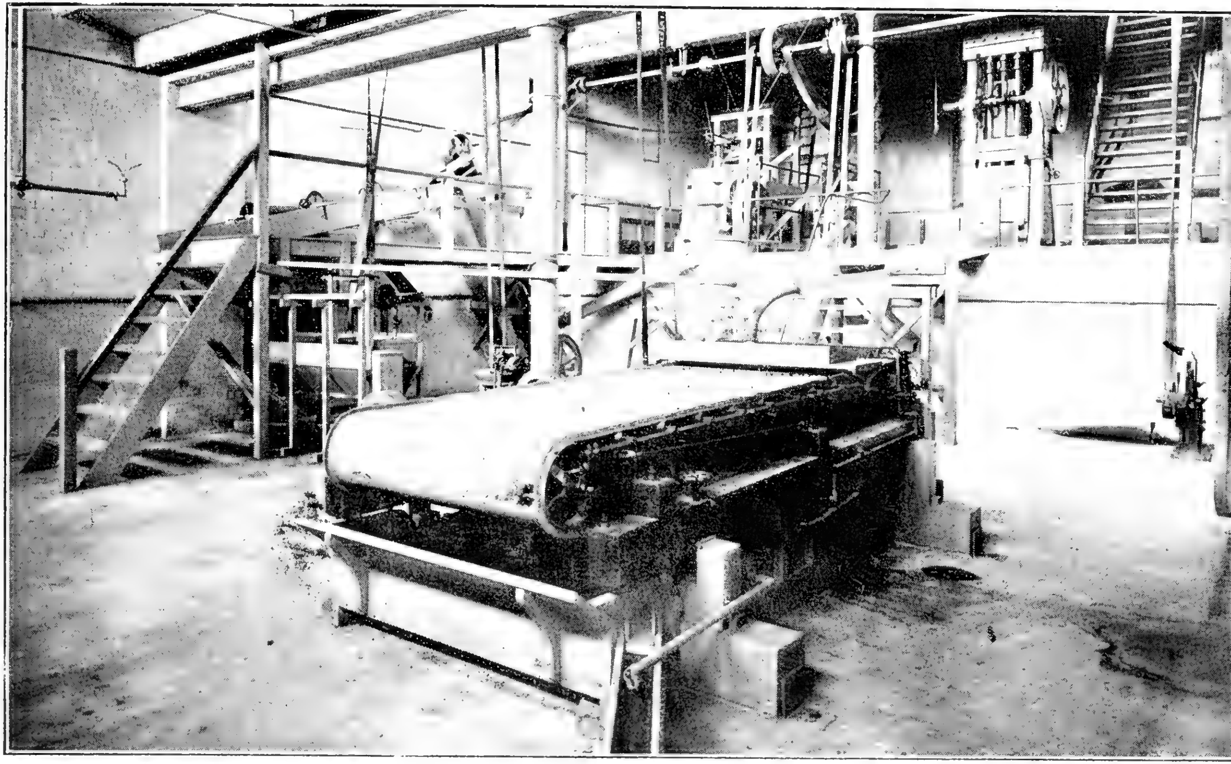
A feature in the assay laboratory, as well as in the chemical laboratory, is that all the water baths and water ovens are kept full by means of constant supply cisterns fitted with ball-taps, so that there is no danger of their running dry; neither is there the usual unnecessary waste of water, which is the fault of most systems. There is no limit to the number of water baths and ovens, which can be supplied by one cistern and ball-tap.

It is supplied with gas furnaces and gas muffles; also with leads and meters for electrolytical processes.

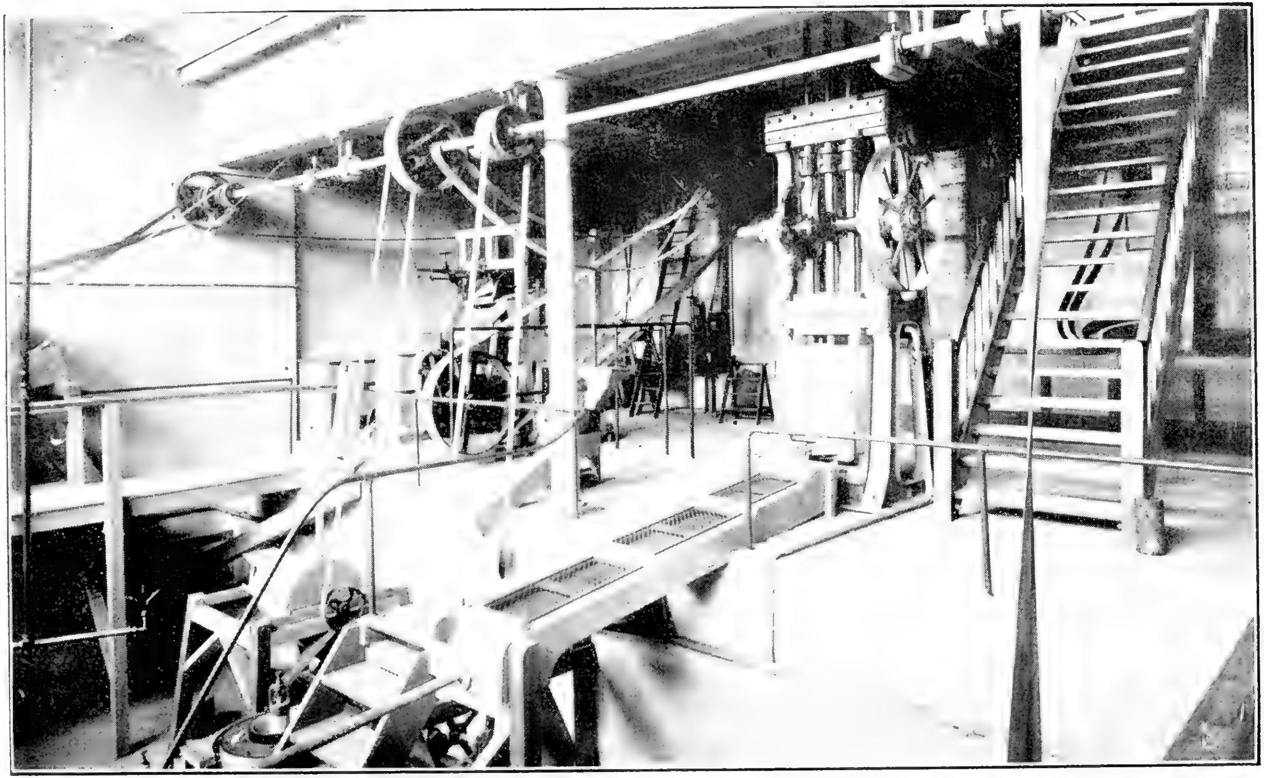
The Mining School at the University of Sydney has been opened to the public since 1892, and at present there are about 80 students working for the degree in Mining Engineering, or for certificates in some branch of that profession.

PART OF SENIOR CHEMICAL LABORATORY, UNIVERSITY OF SYDNEY, 70 x 37 feet.

PART OF THE JUNIOR CHEMICAL LABORATORY, UNIVERSITY OF SYDNEY, to accommodate 40 students, 40 x 37 feet. Each bench has draught-hood and water-pumps.



Part of Milling Building, School of Mines, University of Sydney, showing Stamps, Cornish Rolls, Frue Vanner, Trommels, &c.

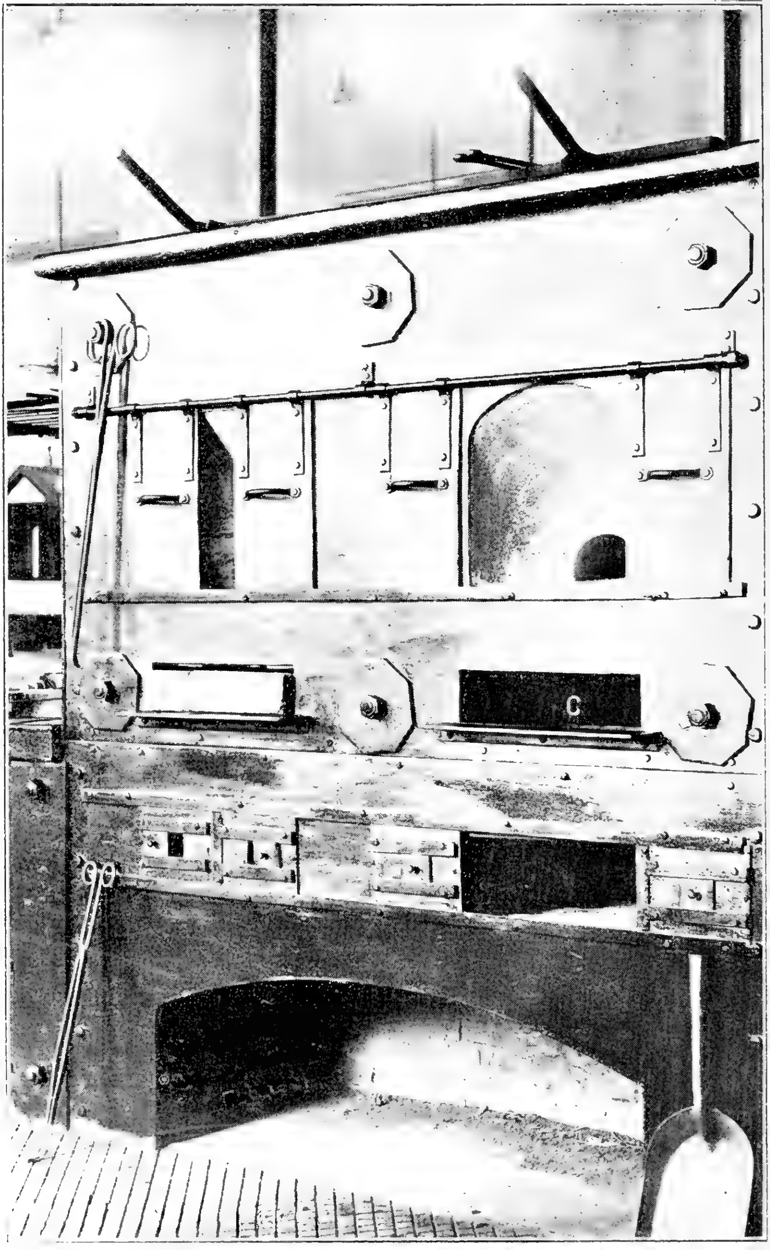


PART OF MILLING ROOM, UNIVERSITY OF SYDNEY, showing set of stamps, &c., steps to sampling room, &c.

PART OF THE METALLURGICAL LABORATORY, UNIVERSITY OF SYDNEY, showing small Chilian mill, jigs, leaching vats, &c.

PART OF THE LARGE ASSAY LABORATORY, UNIVERSITY OF SYDNEY. 12 muffle and 20 melting furnaces. 40 x 54 feet and 26 feet high.

ASSAY LABORATORY, UNIVERSITY OF SYDNEY. Bench for four students, with draught-hood (containing hot plate), water-pump, &c.



A PAIR OF MUFFLE FURNACES, THE METALLURGICAL LABORATORY, UNIVERSITY OF SYDNEY.

These are entirely cased in iron, with sliding iron doors (A) and (B). The firebar opening (C) is closed by a sheet-iron plate.

INDEX TO AUTHORS.

INDEX TO SUBJECTS.

LIST OF MEMBERS.

Hobart, 1902 Session.

Abbot, F.—Botanical Gardens, Hobart.
Adams, C. W.—Chief Surveyor, Blenheim, N.Z.
Adams, C. W.—Blenheim, N.Z.
Ahern, Miss—Tinamba, V.
Allen, J. B., M.A.—Technical School, Perth, W.A.
Allen, Miss L.—Thomas-street, Unley, Adelaide.
Allen, J. B.—Technical School, Perth, W.A.
Alston, Miss Rose—" Montalta," Middle Park, S. Melbourne.
Anderson, J. T. Noble—49 Elizabeth-street, Melbourne.
Ansell, M. M.—Hobart.
Atkins, C. J.—Collins-street, Hobart.
Avery, Mrs. D.; M.A.—Belmont Avenue, Kew.
Avery, D., M.Sc., F.C.S.—Working Men's College, Melbourne.

Bage, R.—" Cranford," Fulton-street, E. St. Kilda.
Bage, Miss E.—" Cranford," Fulton-street, E. St. Kilda.
Bage, Mrs.—" Cranford," Fulton-street, E. St. Kilda.
Bage, Miss—" Cranford," Fulton-street, E. St. Kilda.
Bailey, F. M.—Colonial Botanist Depôt of Agriculture, Brisbane.
Bailey, Mrs. J. F.—Toowong, near Brisbane.
Bailey, Mrs. J. F.—Department of Agriculture, Brisbane.
Baines, A. C.—Christchurch, N.Z.
Baines, A. C.—Upper Riccarton, Christchurch.
Baker, R. T., F.L.S.—Sydney.
Baker, W. H.—Parkside, Adelaide.
Barclay, C. J.—Hobart, Tas.
Barnard, R. J. A., M.A.—Queen's College, Carlton, Melbourne.
Barnard, Miss A.—40 Dalgety-street, St. Kilda.
Barnard, C. E., M.D.—Hobart, Tas.
Barrachi, P.—The Observatory, Melbourne.
Barnett, Dr. L. E.—Stafford-street, Dunedin.
Barton, Miss—Royal Mint, Melbourne.
Barton, Mrs. R.—Royal Mint, Melbourne.
Barton, R.—The Royal Mint, Melbourne.
Baskerville, Miss—Hobart, Tas.
Beale, T. B.—The Square, Palmerston N.
Beddome, H.—Kingston, Tas.
Bell, C. Napier—Dunedin.
Benham, Prof., D.Sc.—Dunedin, N.Z.
Benham, W. Blaxland, D.Sc.—Prof. of Biology, Otago University, Dunedin.
Benham, Mrs.—St. David's-street, Dunedin.
Benjafield, Dr.—Hobart, Tas.
Bennison, Thos.—" Lenna," Hobart, Tas.
Bevan, Mrs. F.—Dequetteville Terrace, Kent Town, Adelaide.
Bevan, F.—Dequetteville Terrace, Kent Town, Adelaide.
Blackett, Mrs.—c|o C. R. Blackett, Esq., Government Analyst, Melbourne.
Blackett, C. R., F.C.S.—Government Analyst, Swanston-street, Melbourne.

Blondel, H. S.—c/o Resident Engineer, Adelaide Railway Station.
Boas, L. H., B.Sc.—Gover-street, North Adelaide.
Bonython, Sir J. L.—Carcew, Adelaide.
Botherwick, Thos.—18 North Terrace, Adelaide.
Booth, Chas., A.M.P.—Perth, W.A.
Bourne, Miss C. E.—Girls' Grammar School, Maryborough, Q.
Boydell, H. C.
Bragg, Prof., M.A.—University, Adelaide.
Brett, Percy G.—Colonial Bank, Terang.
Brown, Hon. N. J.—Hobart, Tas.
Brown, Rev. Dr. Geo. Gordon—North Sydney.
Brown, Mrs. Douglas—"The Bungalo," E. Melbourne.
Brown, H. Y. L., Government Geologist—Adelaide.
Browne, F. Styant—Launceston, Tas.
Buckley, T. H. W.—Hobart, Tas.
Bucknell, Rev. S.—Hobart, Tas.
Buntine, Rev.—Chalmers Church, Hobart.
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Burgess, Miss May, B.Sc.—"Mevindee," South Malvern, Adelaide.
Burgess, J. O.—New South Wales.
Burgess, Miss May, B.Sc.—Adelaide.
Burt, Miss F.—Alma Road, St. Kilda, Melbourne.
Butler, W. F. Dennis, B.Sc.—Hobart.

Cane, Miss Carabell—7 Kensington Road, South Yarra.
Camion, Miss—Kew, Victoria.
Card, Arthur—Church of England Grammar School, Melbourne.
Card, Geo. W.—Mines Department, Sydney.
Carolin, J. P.—191 Collins-street, Melbourne.
Catlett, W. H., F.L.S.—Sydney.
Cato, W. C.—Augusta Road, Hobart.
Chambers, John.
Chambers, Miss F. H.—"Faireleight," Alma Road, E. St. Kilda, Victoria.
Chapman, R. W., M.A.—University, Adelaide.
Chilton, Chas., D.Sc., M.B., C.M., F.L.S.—Canterbury College, Christchurch.
Chomley, His Honor Judge—"Woodlands," Tennyson-street, St. Kilda.
Chomley, Miss A.—"Woodlands," Tennyson-street, St. Kilda.
Chomley, Miss M.—"Woodlands," Tennyson-street, St. Kilda.
Clark, Miss Anon.—Knightsbridge, Adelaide.
Clark, Miss Caroline, M.A.—Knightsbridge, Adelaide.
Clark, M. Lymonds—Knightsbridge, Adelaide.
Clarke, A. H., Dr.—Macquarie-street, Hobart.
Clarke, Mrs. A. H.—Macquarie-street, Hobart.
Clarke, Rev. Geo.—Summerhome, Moonah, Tasmania.
Clarke, Mrs.—Westella, Hobart.
Cleland, Dr. W. L.—Lunatic Asylum, Parkside, Adelaide.
Cleland, W. L., jun.—Lunatic Asylum, Parkside, Adelaide.
Clemes, S.—Hobart.
Coghlan, T. A.—Sydney, N.S.W.
Colbourn, H. J.—Agricultural Department, Hobart.
Colley, D. J.—Royal Mint, Sydney.
Collins, J. T., M.A., LL.M.—Selborne Chambers, Chancery Lane, Melbourne.
Collins, Mrs. J. T.—Packington-street, Kew.
Collins, A.—"Glen Ayr," South Terrace, Adelaide.
Collison, Miss Edith, B.Sc.—Jeffcott street, N. Adelaide.

Conder, H.—83 St. John's Grove, Launceston.
Conlon, A.—Agricultural Department, Hobart.
Cook, W. E., M.E.
Cookson, Miss A. M.—Girls' Grammar School, Brisbane.
Cox, J. D.
Cox, Miss—c/o Mrs. Umphelby, *Esplanade Hotel*, St. Kilda.
Craig, A. W., M.A.—"Naringook," Waterloo-street, Camberwell.
Cribb, Hon. T. B., M.L.A.—The Treasury, Brisbane.
Crisp, Mrs. A.—Hobart, Tas.
Crocker, Miss—"Doan," Fulton-street, E. St. Kilda.
Crocker, Miss E.—"Doan," Fulton-street, E. St. Kilda.
Crocker, Mrs. D. S.—"Doon," Fulton-street, E. St. Kilda.
Crouch, E. J., Dr.—Macquarie-street, Hobart.
Crowther, E. L., M.D.—Hobart.

Dalby, J., B.A.—Dutton Terrace, Medindie, Adelaide.
Daniells, H. J.—Sandy Bay, Hobart.
Danks, J.—Albert Park, Melbourne.
Davenport, J.—Burnside, Adelaide.
Davidson, W. H.—Public Department, Sydney.
Dawbarn, G. J.—School of Mines, Ballarat.
Dawes, A. G.—Elsternwick, Victoria.
Dawson, E.—Papanui Road, Christchurch, N.Z.
Delaney, Right Rev. Dr.—Hobart, Tas.
Dickenson, Mrs. F. M.—320 Collins-street, Melbourne.
Dickenson, F. M.—320 Collins-street, Melbourne.
Dickson, Miss May—Hobart, Tas.
Ditty, Mrs.—Ballarat.
Dixon, Samuel—New Glenelg, South Australia.
Deane, Henry, M.A., M.I.C.E.
Dobbie, E. D.—Hobart, Tas.
Dobbie, A. W.—Gawler Place, Adelaide.
Dobson, E.—"Leura," Papanui, Christchurch, N.Z.
Docker, His Honour, M.A.
Douglas, W.
Downs, Miss H. E.—Girls' Grammar School, Rockhampton, Q.
Downes, Miss J. M.—"Violetta," Strickland Road, Bendigo.
Drake, Dr.—Hobart, Tas.
Duce, Miss—Jeffcott-street, North Adelaide.
Dudley, Mrs.—Auburn, South Australia.
Dudley, E. M.—Auburn, South Australia.

Easterfield, Professor—Victoria College, Wellington.
Eberhard, Carl—Hobart.
Edquist, A. S.—Richard-street, South Australia.
Edwards, G. H.—Public Works, Hobart.
Elkington, Professor J. S., M.A., LL.B.—University, Melbourne.
Elkington, Miss Agnes M.—University, Melbourne.
Ellery, R. L. J., C.M.G., F.R.S.—Observatory, Melbourne.
Ellesin, A. C., Miss—Malvern, Victoria.
Elliot, Miss A. N.—High-street, Hobart.
Ellis, Dr. H. D.—Eaglehawk, Tasmania.
Elliss, J. S. E., F.R.I.B.A.—108 Pitt-street, Sydney.
Elliston, A. C.—East Malvern, Victoria.
Eltridge, W. W.—Railway Department, Hobart.
Engelhardt, B. G.—Germanton, New South Wales.
Enys, J. D., F.G.S. (Life Member)—Eyns Castle, Penryn, Cornwall, England.

Evans, T. M.—Murray-street, Hobart.
Evans, L. A.—Agricultural Department, Hobart.

Farrer, W. J., B.A.—Queanbeyan, New South Wales.
Farrer, A.—Town Hall, Ballarat.
Fennelly, R., A.M.I.C.E.—Kilmore.
Fenton, Miss E.—11 Harrison's Crescent, Fairmont Park, Hawthorn.
Fenton, J. J., F.S.S.—Government Statist, Melbourne.
Fenton, Mrs.—11 Harrison's Crescent, Fairimont Park, Hawthorn.
Finlay, W. A.—Murray-street, Hobart.
Finlayson, Miss—Carrington-street, Adelaide.
Finnis, Rev. H. R.—Hobart.
Fishbourne, Miss—"St. Aidan's," Moonee Ponds.
Fishbourne, Dr.—"St. Aidan's," Moonee Ponds.
Fitzgerald, Hon. G. P.—Collins-street, Hobart.
Fitzgerald, Sir Thos.—Melbourne.
Fitzroy, Colonel—Davey-street, Hobart.
Fison, Rev. Lorimer, D.D.—Nai-Kele-Kele, Essendon, Victoria.
Fleming, David—24 Buxton-street, N. Adelaide.
Fletcher, J. J., M.A., B.Sc.—Linnean Society of N.S.W., Sydney.
Forrest, Mrs.—"Hawksleigh," Balaclava Road, E. St. Kilda.
Forrest, J. K.—"Hawksleigh," Balaclava Road, E. St. Kilda.
Fowler, T. W., M.C.E.—University, Melbourne.
Freeman, W.—Land Board Office, Bourke, New South Wales.

Gardner, Miss—6 Canterbury Road, Toorak.
Garret, A. W.—Bay Road, New Town, Hobart, Tas.
George, Miss Marian—Advanced School for Girls, Adelaide.
Georgs, Miss—Advanced School for Girls, Adelaide.
Giblin, Dr. W.—Macquarie-street, Hobart.
Gilfillan, A.—Stock Exchange Building, Collins-street, Melbourne.
Godfrey, Miss F. M.—"Graylings," E. St. Kilda.
Godfrey, Mrs. F. R.—"Graylings," E. St. Kilda.
Godfrey, J. R., B.A.—c/o F. R. Godfrey, Esq., "Graylings," E. St. Kilda.
Godfrey, F. R.—"Graylings," Alma Road, E. St. Kilda.
Gordon, G.—"Ellerslie," Toorak.
Gordon, Mrs. G.—"Ellerslie," Toorak.
Gough, Mrs.—Hobart.
Gould, H. T.—The Pharmacy, Hobart.
Gower, E. I., B.A., Hobart.
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Penzance...	Royal Geological Society of Cornwall.
Windsor	The Queen's Library.
York	Yorkshire Philosophical Society.

Africa.

Cape Town	*South African Philosophical Society.
	*Geological Commission.
Pietermaritzburg ...	*Surveyor-General (Government Geologist's Department).

Ceylon.

Colombo	Royal Asiatic Society (Ceylon Branch).

Canada.

Halifax (Nova Scotia)	*Nova Scotian Institute of Science.
Montreal	*Natural History Society of Montreal.
,, ...	McGill University.
,, ...	Royal Society of Canada.
Ottawa	Geological and Natural History Survey of Canada.
Quebec	Literary and Historical Society.
Toronto	*Canadian Institute.
,, ...	University.
Winnipeg...	Manitoba Historical and Scientific Society.

India.

Aligarh	Anglo-Oriental College.
Bombay	Royal Asiatic Society (Bombay Branch).
Calcutta...	Asiatic Society of Bengal.
Madras	Central Museum.

Ireland.

Dublin...	National Library of Ireland.
,, ...	Royal Dublin Society.
,, ...	Royal Irish Academy.
,, ...	Trinity College.

Jamaica.

Kingston...	Institute of Jamaica.

Malta.

Malta	Public Library.

Mauritius.

Port Louis	Royal Society of Arts and Sciences.

New Brunswick.

St. John	Natural History Society of New Brunswick.

New South Wales.

Sydney	*Australian Museum.
,, ...	Botanic Gardens.
,, ...	Department of Mines and Agriculture.
,, ...	Department of Public Instruction.
,, ...	*Government Statistician.
,, ...	Linnean Society of N.S.W.
,, ...	N.S.W. Board of International Exchanges.
,, ...	Parliamentary Library.
,, ...	Public Library.
,, ...	Royal Geographical Society of Australasia (N.S.W. Branch).
,, ...	Royal Society of N.S.W.
,, ...	School of Arts.
,, ...	Technological Museum.
,, ...	University.

New Zealand.

Auckland...	Auckland Institute.
Christchurch	Public Library.
Dunedin	Otago Institute.
Wellington	*New Zealand Institute.
,, ...	*Polynesian Society.
,, ...	*Registrar-General's Office.

Queensland.

Brisbane	Parliamentary Library.
,, ...	*Royal Geographical Society of Australasia (Queensland Branch).
,, ...	*Royal Society of Queensland.

Scotland.

Aberdeen	University.
Edinburgh	Edinburgh Geological Society.
,, ...	Royal Society.
,, ...	University.
Glasgow	*Philosophical Society.
,, ...	University.
St. Andrew's	University.

South Australia.

Adelaide	Public Library, Museum, and Art Gallery of S.A.
,, ...	*Royal Geographical Society of Australasia (South Australian Branch).
,, ...	*Royal Society of South Australia.
,, ...	University.

Straits Settlements.

Singapore	Royal Asiatic Society (Straits Branch).

Tasmania.

Hobart	Parliamentary Library.
,, ...	Royal Society of Tasmania.
Launceston	Geological Survey of Tasmania.

Victoria.

Ballarat	School of Mines and Industries.
Melbourne	*Australasian Institute of Mining Engineers.
,, ...	Field Naturalists' Club of Victoria.
,, ...	Government Statist.
,, ...	*Mining Department.
,, ...	Observatory.
,, ...	Parliamentary Library.
,, ...	Public Library.
,, ...	Registrar-General.
,, ...	*Royal Geographical Society of Australasia (Victorian Branch).
,, ...	Royal Society of Victoria.
,, ...	University.
,, ...	Victorian Institute of Engineers.
,, ...	*Victorian Institute of Surveyors.
,, ...	Working Men's College.

Western Australia.

Perth	Parliamentary Library.
,, ...	Victoria Public Library.

Greece.

Athens...	University.

Italy.

Bologna	*R. Accademia delle Scienze dell' Instituto.
,, ...	University.
Catania	*Accademia Gioenia di Scienze Naturali.
Milan	R. Instituto Lombardo di Scienze, Lettere, ed Arti.
Modena	R. Accademia di Scienze, Lettere, ed Arti.
Pisa	*Società Toscana di Scienze Naturali.
Rome	*R. Accademia dei Lincei.
,, ...	R. Comitato Geologico d'Italia.
Sassari	*University.

Japan.

Tokyo	*Asiatic Society of Japan.
,, ...	Imperial University.

Java.

Batavia	*K. Natuurkundige Vereeniging in Nederlandsch-Indië.

Mexico.

Mexico...	*Sociedad Cientifica "Antonio Alzate."

Netherlands.

Amsterdam	Académie Royale des Sciences.
Harlem	*Bibliothéque du Musée Teyler.
,, ...	Colonial Museum.
Leyden	University.

Norway.

Christiana	Köngelige Norske Fredericks Universitet.

Portugal.

Coimbra	*Universidade.
Lisbon	Academia Royale das Sciencias.

Russia.

Helsingfors	*Societas Scientiarum, Fennica.
Moscow	Société Impériale des Naturalistes.
St. Petersburg... ...	Académie Impériale des Sciences.
,, ...	*Institut des Mines.

Spain.

Barcelona	*Real Academia de Ciencias.
Madrid	Universidad.

Sweden.

Stockholm ... ... *K. Svenska Vetenskaps-Akademie.
Upsala ... ... K. Vetenskaps Societeten.
,, ... *Université Royale d'Upsala.

Switzerland.

Basel ... ... *Naturforschende Gesellschaft.
Geneva ... ... Schweizerische Naturforschende Gesellschaft.
Lausanne... ... ... Société Vaudoise des Sciences Naturelles.
Zurich ... ... Naturforschende Gesellschaft.

United States of America.

Albany ... ... *New York State Library, Albany.
Baltimore... ... ... *John Hopkins University.
Berkeley ... ... University of California.
Boston... ... ... American Academy of Arts and Sciences.
Cambridge ... ... *Harvard University.
Chicago ... ... Academy of Sciences.
,, ... *The John Crerar Library.
Cincinnati ... ... American Association for the Advancement of Science.
Denver ... ... Colorado Scientific Society.
Hoboken (N.J.) ... Stevens' Institute of Technology.
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Madison (Wis.)... ... *Wisconsin Academy of Sciences, Arts, and Letters.
Minneapolis ... ... *Minnesota Academy of Natural Sciences.
Missoula ... ... *University of Montana (Department of Biology).
Montana ... ... State School of Mines.
Newhaven (Conn.) . *Connecticut Academy of Arts and Sciences.
,, . Yale University.
New York ... ... Columbia University Library.
,, ... *New York Academy of Sciences.
,, ... School of Mines, Columbia College.
Palo Alto ... ... Leland Stanford, Jun., University of California.
Philadelphia ... ... Academy of Natural Sciences.
,, ... American Philosophical Society.
,, ... Commercial Museum.
,, ... Franklin Institute.
Rochester (N.Y.) ... *Rochester Academy of Sciences.
Salem (Mass.) ... ... Essex Institute.
St. Louis ... ... Academy of Science.
San Francisco ... ... *California Academy of Sciences.
Stanford ... ... University of California.
Washington... ... ... Bureau of Education (Department of the Interior).
,, ... *Bureau of American Ethnology.
,, ... National Academy of Sciences.
,, ... *Philosophical Society.
,, ... Secretary (Department of the Interior).
,, ... *Smithsonian Institution.
,, ... *U.S. Geological Survey.
,, ... U.S. National Museum (Department of the Interior).

Uruguay.

Monte Video ... ... National Library and Museum.

ADDITIONS TO THE LIBRARY

OF THE

AUSTRALASIAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

(From July 1st, 1898, to Dec. 31st, 1902.)

Adelaide, S.A. ... ... Department of Mines :
  Handbook of Mining, with maps.
  Record of the Mines of S.A., Targoola, &c.
 Proceedings of the Royal Society, 1898-1901.
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Baltimore, U.S.A. ... John Hopkins University : Circulars Nos. 137 to 159.

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[*Chemistry* and *Mineralogy*]: Professor E. H. Rennie, M.A., D.Sc. (President's Address); W. M. Doherty; J. B. Kirkland; E. W. Knox; Professor A. Liversidge, LL.D., F.R.S.; J. H. Maiden, F.L.S. SECTION C [*Geology* and *Palæontology*]: Professor F. W. Hutton, F.R.S.; John Dennant, F.G.S., F.C.S.; E. J. Dunn, F.G.S.; A. W. Howitt, F.G.S.; Professor A. Liversidge, LL.D., F.R.S.; James Park, F.G.S.; W. J. Clunies Ross, B.Sc.; S. H. Wintle, F.L.S. SECTION D [*Biology*]: Professor A. P. Thomas, M.A., F.L.S. (President's Address): A. J. Campbell, F.L.S.; T. F. Cheeseman, F.L.S.; Professor W. A. Haswell, D.Sc., F.R.S.; W. Saville Kent, F.L.S.; W. H. D. Le Souef; F. A. Skuse; D. Sullivan, F.L.S.; J. Bracebridge Wilson, M.A. SECTION E [*Geography*]: W. H. Misken, F.E.S. (President's Address); Rev. S. Ella. SECTION F [*Economic and Social Science and Statistics*]: R. M. Johnston, F.L.S. (President's Address); H. H. Hayter, C.M.G.; Fred. Turner, F.R.H.S. SECTION G [*Anthropology*]: Hon. John Forrest, C.M.G., M.L.C. (President's Address); James Barnard; Rev. R. H. Codrington; Bolton S. Corney; Rev. W. W. Gill, LL.D.; A. W. Howitt; Rev. Geo. Pratt; Rev. A. J. Webb. SECTION H [*Sanitary Science and Hygiene*]: J. Ashburton Thompson (President's Address); J. Jamieson, M.D.; F. A. Nyulasy, M.B., Ch.B.; J. W. Smail, M.Inst.C.E.; W. L. de Roberts, C.E. SECTION I [*Literature and Fine Arts*]: J. W. Agnew, M.D. (President's Address). SECTION J [*Architecture and Engineering*]: Professor W. H. Warren, M.Inst.C.E. (President's Address); Professor Kernot, M.A., C.E.; John Sulman, F.R.I.B.A.

Reports of Research Committees.—(1) Mineral Census of Australasia; (2) The State and Progress of Chemical Science in Australasia, with special reference to Gold and Silver Appliances used in the colonies and elsewhere; (3) Bibliography of the Australasian, Papuan, and Polynesian Races; (4) Australasian Biological Station; (5) Construction and Hygienic Requirements of Places of Amusement in Sydney; (6) Australasian Geological Record; (7) Town Sanitation.

Volume III.—Contents.

CHRISTCHURCH SESSION—13 JAN., 1891. (595 pages.)

PRESIDENTIAL Address by Sir James Hector, K.C.M.G., M.D., F.R.S. SECTION A [*Astronomy, Mathematics, Physics,* and *Mechanics*]: Papers by the following:—Professor Lyle, M.A. (President's Address); Professor A. W. Bickerton; Professor W. H. Bragg, M.A.; A. C. Gifford; Geo. Hogben, M.A.; John T. Meeson, B.A. SECTION B [*Chemistry* and *Mineralogy*]: Professor Orme Masson, M.A., D.Sc. (President's Address); Professor Bickerton; N. T. M. Wilsmore, B.Sc. SECTION C [*Geology* and *Palæontology*]: Reginald A. F. Murray, F.G.S. (President's Address); J. H. Baker; H. Hill, F.G.S.; James Park, F.G.S.; Professor Geo. H. F. Ulrich, F.G.S. SECTION D [*Biology*]: Professor W. A. Haswell, D.Sc., F.R.S. (President's Address); Professor A. Bickerton; J. T. Kirk, F.L.S.; Professor T. J. Parker, D.Sc., F.R.S.; Geo. M. Thomson, F.L.S. SECTION E [*Geography*]: G. S. Griffiths, F.G.S. (President's Address); F. R. Chapman; Captain Crutchley, R.N., F.R.G.S.; Dr. T. M. Hocken; J. T. Meeson, B.A.; C. W. Parnell; S. Percy Smith, F.R.G.S. SECTION F [*Economic* and *Social Science*]: Hon. G. W. Cotton, M.L.C. (President's Address). SECTION G [*Anthropology*]: A. W. Howitt (President's Address); Rev. W. W. Gill, LL.D.; R. Coupland Harding; Rev. Jas. W. Stack; E. Tregear, F.R.G.S.; John White. SECTION H

[*Sanitary Science* and *Hygiene*] : Hon. Allan Campbell, M.D., M.L.C. (President's Address); Benj. Backhouse, H.A.R.I.B.A.; W. E. Cook, M.C.E.; Courtney Nedwill, M.D., and Edwin Cuthbert, M.Inst.C.E.; I. de Zouche, M.D. SECTION I [*Literature* and *Fine Arts*] : R. H. Roe, M.A. (President's Address). SECTION J [*Architecture* and *Engineering*] : John Sulman, F.R.I.B.A. (President's Address); C. W. Adams; C. Napier Bell; R. W. Chapman, M.A., B.C.E.; E. Dobson, M.Inst.C.E.; J. P. Maxwell, M.Inst.C.E.; W. H. Warren, M.Inst.C.E.; Robt. Wilson, F.R.S.E.

Reports of Research Committees.—(1) The Committee to investigate and report upon the Seismological Phenomena of Australasia; (2) The Tides of South Australia; (3) The Unification of Colours and Signs of Geological Maps; (4) The Improvement of Museums as a Means of Popular Education; (5) The Fertilisation of the Fig in the Australasian Colonies; (6) The Location and Laying out of Towns; (7) The Question of Antarctic Exploration; (8) Rust in Wheat.

Volume IV. Contents.

HOBART SESSION—7 JAN., 1892. (985 pages.)

PRESIDENTIAL Address by His Excellency Sir Robert G. C. Hamilton, K.C.B., LL.D. Papers by the following :—SECTION A [*Astronomy, Mathematics, Physics,* and *Mechanics*] : Professor W. H. Bragg, M.A. (President's Address); Sir Robert Ball; A. McAulay, M.A. SECTION B [*Chemistry* and *Mineralogy*] : W. M. Hamlet, F.C.S. (President's Address); Donald Clark, B.C.E.; A. W. Craig, M.A., and N. T. Wilsmore, B.Sc.; W. M. Doherty; A. Henrick Jackson, B.Sc.; J. B. Kirkland, F.C.S.; Professor A. Liversidge, LL.D., F.R.S.; J. H. Maiden, F.L.S.; J. C. H. Mingaye, F.C.S.; A. J. Sach, F.C.S.; N. T. M. Wilsmore, B.Sc. SECTION C [*Geology* and *Palæontology*] : Professor T. W. E. David, B.A., F.G.S. (President's Address); J. H. Harvey; H. W. F. Kayser, M.E.; A. Montgomery, M.A., and W. F. Ward, A.R.S.M.; F. Danvers Power, F.G.S.; J. Provis; W. J. Clunies Ross, B.Sc., F.G.S.; A. J. Sach, F.C.S. SECTION D [*Biology*] : Professor W. Baldwin Spencer, M.A. (President's Address); F. M. Bailey, F.L.S.; A. Dendy, M.Sc., F.L.S.; Professor W. A. Haswell, M.A., D.Sc., F.L.S.; Professor F. W. Hutton, F.R.S.; W. Saville Kent, F.L.S.; Colonel Legge, R.A.; Professor T. J. Parker. SECTION E [*Geography*] : Commander Pascoe, R.N. (President's Address); J. Fraser, LL.D.; J. McClymont, M.A.; Captain N. Moore, R.N.; A. Mault; Rev. J. B. Woollnough, M.A.; J. P. Thomson, F.R.G.S. SECTION F [*Economic* and *Social Science* and *Statistics*] : R. Teece, F.I.A. (President's Address); Hon. N. J. Brown; J. J. Fenton, F.S.S.; Robert Giffen, C.B., LL.D.; H. H. Hayter; Alfred de Lissa; Mrs. A. Morton; E. Paris Nesbit; A. J. Ogilvy, W. E. Stopford; A. Sutherland, M.A. SECTION G [*Anthropology*] : Rev. Lorimer Fison, M.A. (President's Address); Rev. S. M. Creagh; Rev. B. Danks; Rev. S. Ella; Rev. W. W. Gill, LL.D.; Rev. W. Gray; Rev. J. Lawrie; Rev. J. W. Leggatt; Rev. D. Macdonald. SECTION H [*Sanitary Science* and *Hygiene*] : Professor W. H. Warren, M.Inst.C.E. (President's Address); C. E. Barnard, M.D.; E. O. Giblin, M.D.; E. Hirschfield, M.D.; T. James, M.D.; A. Mault; Miss V. Mackenzie; A. Park, M.R.C.V.S. SECTION I [*Literature* and *Fine Arts*] : Professor E. E. Morris, M.A. (President's Address); J. R. Ashton; T. A. Browne; R. V. Elliott, M.A.; Miss E. Mills; W. C. Piguenit; P. A. Robin; J. Rule; A. Sutherland, M.A. SECTION J [*Architecture* and *Engineering*] : C. Napier Bell, C.E. (President's Address); E. Dobson, M.Inst.C.E.; W. W. Eldridge; C. Wordsworth James, C.E.; D. M. Maitland; A. North; A. O. Sachse, C.E.; Allen Stewart, Alan C. Walker, A.R.I.B.A.

Reports of Research Committees.—(1) Seismological Phenomena in Australasia; (2) The Tides of the Coast of South Australia; (3) The Fig in the Australasian Colonies; (4) The Antarctic Committee; (5) Supplementary Bibliography for Australia, Malaysia, Melanesia, and Polynesia.

Volume V.—Contents.

ADELAIDE SESSION—25 SEPT., 1893. (665 pages.)

PRESIDENTIAL Address by Professor Ralph Tate, F.G.S., F.L.S. Papers by the following:—SECTION A [*Astronomy, Mathematics,* and *Physics*]: H. C. Russell, C.M.G., B.A., F.R.S. (President's Address); R. W. Chapman and Captain Inglis; C. C. Farr, B.Sc.; G. Fleuri; G. Hogben, M.A.; W. H. Steele, M.A.; Sir Charles Todd, K.C.M.G., M.A.; Captain Weir. SECTION B [*Chemistry*]: C. N. Hake, F.C.S. (Presidents' Address); D. Avery, B.Sc.; Donald Clark; T. C. Cloud, F.C.S., and G. J. Rogers, A.R.S.M.; D. H. Jackson, B.Sc.; G. W. MacDonald, B.Sc.; Professor Rennie, M.A., D.Sc., and E. F. Turner; W. Percy Wilkinson. SECTION C [*Geology* and *Mineralogy*]: Professor T. W. E. David, B.A., F.G.S.; J. Dennant, F.G.S., F.C.S.; G. B. Pritchard and T. S. Hall, M.A.; W. Howchin, F.G.S.; Professor A. Liversidge, LL.D., F.R.S.; Geo. Sweet, F.G.S., and C. C. Brittlebank. SECTION D [*Biology*]: C. W. de Vis, M.A. (President's Address); Rev. Thomas Blackburn, B.A.; A. J. Campbell, F.L.S.; Prof. A. Dendy, D.Sc.; C. Hedley, F.L.S.; M. Holtz, F.L.S.; Col. Legge, F.L.S.; D. McAlpine; John Shirley, B.Sc. SECTION E [*Geography*]: A. C. Macdonald, F.R.G.S. (President's Address); Charles Hedley, F.L.S.; Charles Hope Harris; J. Stirling, F.G.S. SECTION F [*Ethnology* and *Anthropology*]: Rev. S. Ella (President's Address); A. F. Cudmore; A. T. Magarey; S. E. Peal, F.R.G.S.; Francis H. Wells. SECTION G [*Economic Science* and *Agriculture*]: H. C. L. Anderson, M.A. (President's Address); His Honor Mr. Justice Bundey; W. Gill; A. Molineux; D. Murray. SECTION H [*Engineering* and *Architecture*]: R. J. Scott, A.M.I.C.E. (President's Address); J. T. Noble Anderson, C.E.; Chas. Hope Harris; Prof. Kernot, M.A., C.E.; Geo. Knibbs; J. C. B. Moncrieff, M.I.C.E.; J. H. Packard; S. Smeaton, B.A., C.E.; S. A. Institute of Surveyors. SECTION I [*Sanitary Science* and *Hygiene*]: A. Mault (President's Address); Dr. Barnard, and A. Park, M.R.C.V.S.; G. A. Goyder, junr., F.C.S.; C. E. Owen Smyth; John Sulman, F.R.I.B.A. SECTION J [*Mental Science* and *Education*]: Professor Laurie, LL.D. (President's Address); E. F. J. Love, M.A.; Rev. Canon Poole, M.A.; P. Ansell Robin, M.A.; John Shirley, B.Sc.

Reports of Research Committees.—(1) Seismological Phenomena in Australasia; (2) The Systematic Conduct by the various Governments of Australia of the Photographic work of the different Geological Surveys; (3) Progress Reports upon the Evidences of Glacial Action in Australasia during the Tertiary and Post-Tertiary Eras; (4) The Protection of Native Fauna.

Volume VI.—Contents.

BRISBANE SESSION—11TH AUGUST, 1898. (858 pages.)

PRESIDENTIAL Address by the Hon. A. C. Gregory, C.M.G., F.R.G.S., M.L.C. Papers by the following:—SECTION A [*Astronomy, Mathematics,* and *Physics*]: Alex. McAulay, M.A. (President's Address);

Sir Robt. Ball, LL.D., F.R.S.; P. Baracchi, F.R.A.S.; Professor Bragg, M.A.; Ralph Copeland, Ph.D., F.R.A.S., F.R.S.E.; G. Fleuri; H. C. Russell, B.A., C.M.G., F.R.S.; J. P. Thomson. SECTION B [*Chemistry*]: J. H. Maiden, F.L.S. (President's Address); W. M. Doherty, F.C.S.; F. B. Guthrie, F.C.S.; W. A. Hargreaves, M.A. B.C.E.; Dr. Jos. Lauterer, Pract. Arzt., M.R.S.; Prof. A. Liversidge, LL.D., F.R.S.; J. H. Maiden and H. J. Smith; J. C. H. Mingaye, F.C.S.; E. H. Rennie, D.Sc., and E. F. Turner; F. W. Simmonds; E. A. Weinberg, M.E. SECTION C [*Geology*]: Professor T. W. E. David, B.A., F.G.S. (Presidents' Address); Wm. Fryar; E. G. Hogg, M.A.; R. L. Jack, F.G.S.; Prof. A. Liversidge, LL.D., F.R.S.; John Munday; Graham Officer, B.Sc., and Lewis Balfour, B.A.; E. F. Pittman, A.R.S.M.; G. B. Pritchard. SECTION D [*Biology*]: Professor Arthur Dendy, D.Sc., F.L.S. (President's Address); F. M. Bailey, F.L.S.; Dr. M. C. Cooke, M.A.; A. J. Campbell; A. G. Hamilton; Joseph Lauterer, M.D.; Col. W. O. Legge, F.L.S.; Dr. J. Muller; D. Le Souef. SECTION E [*Geography*]: Baron Ferdinand Von Mueller, K.C.M.G., Ph.D., F.R.S. (President's Address); Rev. W. Allen; M. M. Astrie; Rev. Geo. K. Baskerville; J. P. Brooke; Mr. Christopher Gardner, C.M.G., F.R.G.S.; His Excellency Sir H. W. Norman, G.C.B., G.C.M.G., C.I.E; Hon. A. W. Paul, C.I.E.; H. Warrington Smith. SECTION F [*Ethnology* and *Anthropology*]: Thos. Worshop (President's Address); Rev. S. Ella; W. J. Enright, and R. H. Mathews; Prof. R. O. Garner; Jos. Lauterer, M.D.; A. T. Magarey; Rev. J. E. Newell; T. A. Parkhouse; Rev. J. B. Starr. SECTION G [*Economic Science*]: Prof. W. Scott, M.A. (President's Address); R. R. Garran, B.A.; Hon. Andrew Garran, M.A., LL.D.; Sir S. W. Griffith; J. B. Gregory, B.A.; W. McMillan; Grace Neill; Rev. R. Stephen, M.A. [*Agriculture*]: A. H. Benson; P. R. Gordon; Angus Mackay, F.C.S.; C. C. Mair; E. M. Shelton, M.Sc. SECTION H [*Architecture* and *Engineering*]: Jas. Incham, M.Inst.C.E. (President's Address); P. F. Hockings, A.F.R.I.B.A.; Prof. W. C. Kernot, M.A., C.E., F.R.G.S.; Prof. A. Liversidge, LL.D., F.R.S.; Thos. Parker, C.E.; John Rogers, A.M.I.C.E.; Thos. Turnbull. SECTION I [*Sanitary Science* and *Hygiene*]: J. W. Springthorpe, M.A., M.D., M.R.C.S. (President's Address); Joseph Ahearne, L.R.C.P.; S. S. Cameron, M.R.C.P.S.; E. Hirschfield, M.D.; J. Sydney Hunt, M.R.C.S.; Wilton Love, M.B.; K. I. O'Doherty, F.R.C.S.; J. Ashburton Thompson, M.D.; F. H. V. Voss, F.R.C.S. SECTION J [*Mental Science* and *Education*]: H. Belcher, M.A., LL.D.

Reports of Research Committees:—(1) Seismological Committee; (2) Glacial Evidence Committee; (3) Psychical Research Committee.

Volume VII.—Contents.

SYDNEY SESSION—6TH JANUARY, 1898. (1161 pages.)

PRESIDENTIAL Address by P. Baracchi, F.R.A.S. Papers by the following:—SECTION A [*Astronomy*, *Mathematics*, and *Physics*]: C. Coleridge Farr, B.Sc.; Miss F. Martin, and Professor R. Threlfall, M.A.; T. F. Furber, F.R.A.S., L.S.; Captain A. Inglis; R. W. Chapman, M.A., B.C.E., and Captain A. Inglis; Major-General Schaw, C.B.; Professor R. Threlfall, M.A., and J. Bernard Allen, B.Sc.; H. C. Kiddle, F.R.M.S.; P. Baracchi, F.R.A.S.; G. H. Knibbs, F.R.A.S., L.S.; H. C. Russell, C.M.G., F.R.S., F.R.A.S., &c.; D. M. Maitland, L.S.. SECTION B [*Chemistry*, 7th Jan., 1898]: M. Blunno, Esq.; W. M. Hamlet, F.I.C., F.C.S.; E. H. Gurney, F.C.S.; G. H. Blakemore, Esq.; Edgar Hall, and E. S. Simpson, B.E.; J. C. H. Mingaye, F.C.S.; W. J. Clunies Ross, B.Sc.; T. Steel, F.C.S., F.L.S.; W. M. Doherty, F.C.S.; F. B. Guthrie, F.C.S.; A. N. Pearson, Esq. Section C [*Geology* and *Mineralogy*, 8th Jan., 1898]: F. W. Hutton, F.R.S., F.G.S., &c. (Presidential Address); Evelyn G. Hogg, M.A.; C. C. Brittlebank, G. Sweet, F.G.S., and Professor T. W. E. David, B.A., F.G.S.; E. F. Pittman, A.R.S.M.; S. B. J. Skertchly, B.Sc.; Rev. J. Milne Curran, F.G.S.; R. L. Jack, F.G.S., F.R.G.S.; E. J. Statham, Esq.; A. E. Kitson, F.G.S., and W. Thorn, Esq.; A. W. Howitt, F.G.S.; G. H. Knibbs, F.R.A.S., L.S.; J. W. Grimshaw, M.Inst.C.E., and Rev. J. Milne Curran, F.G.S.; W. J. Clunies Ross, B.Sc.; W. S. Dun, Esq.; H. G. Stokes, Esq.; T. S. Hall, M.A.; A. C. Andrews, B.A. Section D [*Biology*, 7th Jan., 1898]: Acting-Professor C. J. Martin, D.Sc., M.B., &c. (Presidential Address); F. M. Bailey, F.L.S.; J. F. Bailey, Esq.; St. Eloy D'Alton; W. J. Clunies Ross, B.Sc.; D. McAlpine, Esq.; L. Rodway, Esq.; H. T. Tisdall, F.L.S.; A. W. Howitt, F.G.S.; J. C. Luekmann, F.L.S.; J. H. Maiden, F.L.S.; Professor Ralph Tate, F.G.S., F.L.S.; A. G. Hamilton, Esq.; N. Holtze, Esq.; John Shirley, B.Sc.; Wm. Soutter, Esq.; W. W. Froggatt, Esq.; G. M. Thomson, Esq.; A. J. Campbell, F.L.S.; W. J. Rainbow, Esq.; T. F. Macdonald, M.B., Ch.M.; J. Flashman, M.D., Ch.M.; A. H. S. Lucas, M.A., B.Sc.; J. Douglas Ogilby, Esq.; A. J. North, C.M.Z.S.; C. Fuller, Esq.; Gregg Wilson, M.A., D.Sc., Ph.D.; R. T. Baker, F.L.S.; T. Steel, F.C.S., F.L.S. Section E [*Geography*, 7th Jan., 1898]: Sir James Hector, K.C.M.G., M.D., F.R.S. (President's Address); A. C. Macdonald, F.R.G.S., F.R., Hist.S., F.I.I., &c.; W. H. Fietkens, Esq.; Thos. Walker Fowler, M.C.E., F.R.G.S., F.G.S., &c.; Hon. P. G. King, M.L.C., F.R.G.S.; J. R. McClymont, M.A. Section F [*Ethnology* and *Anthropology*, 8th Jan., 1898]: A. W. Howitt, F.G.S., &c. (President's Address); Monsieur D. Marceron; Rev. Dr. Macdonald; Elsdon Best, Esq.; R. H. Mathews, L.S.; Rev. S. Ella; Rev. Dr. Geo. Brown; H. H. Thiele, Esq.; the late Rev. Dr. W. W. Gill, B.A.; Miss Feuira Henry; John Fraser, B.A., LL.D.; S. Percy Smith, F.R.G.S.; Rev. W. W. Gray; A. Hamilton, Esq.; Rev. J. B. Stair; Rev. John Campbell, B.A., LL.D.; W. J. Enright, Esq.; John J. Cary, Esq. Section G [*Economic Science* and *Agriculture*, 7th Jan., 1898]: R. M. Johnson, F.L.S., F.S.S., &c. (President's Address); W. Jethro Brown, M.A., LL.D.; Alfred De Lissa; W. Jethro Brown, M.A., LL.D.; A. B. Piddington, B.A., M.L.A.; Rev. J. C. Corlette, D.D.; Hon. Sir Samuel Griffith, G.C.M.G., M.A.; Sir R. C. Baker, K.C.M.G.; J. T. Walker, Esq.; H. L. E. Ruthning, Esq.; W. Walker, Esq.; Wm. Farrer, M.A.; M. A. O'Callaghan, Esq.; A. H. Benson, M.R.A.C.; F. Turner, F.L.S., F.R.H.S.; C. Faller, Esq.; W. W. Froggatt, Esq.; R. T. Baker, F.L.S.; H. W. Potts, F.C.S.; F. B. Kyngdon, M.R.A.C.; Albert Gale, Esq.; D. McAlpine, Esq.; T. Steel, F.C.S., F.L.S.; A. N. Pearson, Esq.; T. U. Walton, B.Sc., F.I.C., F.C.S.; J. P. Dowling, Esq.; Henry Lord, G.T.C.A.C.; W. S. Campbell, F.L.S.; R. Helms, Esq. Section H [*Engineering and Architecture*, 7th Jan., 1898]: A. B. Moncrieff, M.Inst.C.E., M.Am. Soc. C.E., &c. (President's Address); H. Deane, M.A., M.Inst.C.E.; C. O. Burge, M.Inst.C.E.; W. Shellshear, M.Inst.C.E.; F. Back, A.I.C.E., F.S.S., &c.; F. Marchant, M.Inst.C.E.; C. E. Owen Smith, Esq.; J. B. Barlow, Esq.; James Nangle, Esq.; John Sulman, F.R.I.B.A.; G. Allan Mansfield, Esq.; Howard Joseland, Esq.; J. H. Ronaldson, Esq. Section I [*Sanitary Science* and *Hygiene*, 8th Jan., 1898]: Hon. Allan Campbell, M.L.C., L.R.C.P., L.F.P.S., &c. (President's Address); J. Ashburton Thompson, M.D.; Sydney Jamieson, M.B. (Edin.), M.R.C.S.

(Eng.); George Lane Mullings, M.A., M.D.; Frank Tidswell, M.B., Ch.M. (Syd.), D.P.H. (Camp.). SECTION J [*Mental Science and Education*, 7th Jan., 1898]: John Shirley, B.Sc. (President's Address); Rev. Thos. Roseby, M.A., LL.D., F.R.A.S.; Rev. Geo. Littlemore; Rev. Jas. Hill, M.A.; Rev. A. J. Griffith, M.A.; Rev. N. J. Cocks, M.A.; Miss L. Macdonald, M.A.; Rev. J. Prescott, M.A.; F. V. Pratt, M.A.; C. J. Brennan, M.A.; P. F. Rowland, B.A.; P. Ansell Robin, M.A.; W. L. Atkins, B.A.; Miss E. A. Badham; Mrs. W. L. Atkins, B.A.; Miss M. Hodge; Miss H. C. Newcomb; Dr. S. T. Knaggs; Dr. T. F. Macdonald; Professor D. C. Selman.

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