JOURNAL

AND

PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES,

1877.

VOL. XI.

EDITED BY

A. LIVERSIDGE,

Professor of Geology and Mineralogy in the University of Sydney.

THE AUTHORS OF PAPERS ARE ALONE RESPONSIBLE FOR THE STATEMENTS MADE AND THE OPINIONS EXPRESSED THEREIN.

AGENTS FOR THE SOCIETY:

Messrs. Trübner & Co., 57, Ludgate Hill, London, E.C.

SYDNEY: THOMAS RICHARDS, GOVERNMENT PRINTER.

1878.

NOTICE.

It is requested that all Communications respecting the Printing of the Journal of the Society, or List of Members, may be sent to Professor Liversidge (Editor), Union Club, Sydney.

All Donations presented to the Society are acknowledged by letter, and in the printed Proceedings of the Society.

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NOTICE.

THE ROYAL SOCIETY of New South Wales originated in 1821 as the "Philosophical Society of Australia"; after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; and finally, in May, 1866, by the sanction of Her Most Gracious Majesty the Queen, it assumed its present title.

CORRIGENDA.

Page.	*Line.*	
11	18	For "Göningen" *read* "Göttingen"
26	21	For "assume very definite limit" *read* "assumes very definite limits"
70	41	Before "Victorian" *insert* "2."
131	18	For "Warrnambool" *read* "Warnambool"
133	36	After "last" *delete* the period and *add* a comma
134	2	For "*Speroporina*" *read* "*Spiroporina*"
,,	32	After "it" *insert* "was"
139	9	For "M. FIDENS" *read* "M. BIDENS."
,,	21	*Delete* "MS."
,,	23	After "to" *add* "but described in 1861 in the *Quart. Jour. Microscopical Science*, N. Series, I, p. 79."
140	6	For "fig." *read* "w.-cut."
141	27	*Delete* the word "Genus"
,,	35	For "*Hasstiana*" *read* "*Haastiana.*"
142	7	For "*Melneina*" *read* "*Milneana.*"
143	8	For "*Melneina*" *read* "*Milneana.*"
,,	9	For "*Hoastiana*" *read* "*Haastiana.*"

CONTENTS.

VOLUME XI.

The Royal Society of New South Wales.

OFFICERS FOR 1877-8.

PRESIDENT:

HIS EXCELLENCY SIR HERCULES ROBINSON, G.C.M.G.,
&c., &c., &c.

VICE-PRESIDENTS:

REV. W. B. CLARKE, M.A., F.R.S., F.G.S.
CHRISTOPHER ROLLESTON.

HONORARY TREASURER:

REV. W. SCOTT, M.A.

HONORARY SECRETARIES:

PROFESSOR LIVERSIDGE. | DR. ADOLPH LEIBIUS.

COUNCIL:

FAIRFAX, JAMES R.
JONES, P. SYDNEY, M.D.
MOORE, CHARLES, F.L.S.
RUSSELL, H. C., B.A., F.R.A.S.
SMITH, HON. J., C.M.G., M.D.
WRIGHT, H. G. A., M.R.C.S.

ASSISTANT SECRETARY:

WEBB, W. H.

FUNDAMENTAL RULES.

Object of the Society.

1. The object of the Society is to receive at its stated meetings original papers on subjects of Science, Art, Literature, and Philosophy, and especially on such subjects as tend to develop the resources of Australia, and to illustrate its Natural History and Productions.

President.

2. The Governor of New South Wales shall be *ex officio* the President of the Society.

Other Officers.

3. The other Officers of the Society shall consist of two Vice-Presidents, a Treasurer, and two or more Secretaries, who, with six other Members, shall constitute a Council for the management of the affairs of the Society.

Election of Officers.

4. The Vice-Presidents, Treasurer, Secretaries, and the six other Members of Council, shall be elected annually at the General Meeting in the month of May.

Vacancies during the year.

5. Any vacancies occurring in the Council of Management during the year may be filled up by the Council.

Fees.

6. The entrance money paid by Members on their admission shall be One Guinea; and the annual subscription shall be One Guinea, payable in advance.

The sum of Ten Pounds may be paid at any time as a composition for the ordinary annual payment for life.

Honorary Members.

7. The Honorary Members of the Society shall be persons who have been eminent benefactors to this or some other of the Australian Colonies, or distinguished patrons and promoters of the objects of the Society. Every person proposed as an Honorary Member must be recommended by the Council and elected by the Society. Honorary Members shall be exempted from payment of fees and contributions; they may attend the meetings of the Society, and they shall be furnished with copies of Transactions and Proceedings published by the Society, but they shall have no right to hold office, to vote, or otherwise interfere in the business of the Society.

Confirmation of By-laws.

8. By-laws proposed by the Council of Management shall not be binding until ratified by a General Meeting.

Alteration of Fundamental Rules.

9. No alteration of or addition to the Fundamental Rules of the Society shall be made unless carried at two successive general meetings.

BY-LAWS

Passed at a General Meeting of the Society, held June 7th, 1876.

Ordinary General Meetings.

I. An Ordinary General Meeting of the Royal Society, to be convened by public advertisement, shall take place at 8 p.m., on the first Wednesday in every month, during the last eight months of the year; subject to alteration by the Council with due notice. These meetings will be open for the reading of papers, and the discussion of subjects of every kind if brought forward in conformity with the Fundamental Rules and By-laws of the Society.

Annual General Meeting.—Annual Reports.—Election of Officers.

II. A General Meeting of the Society shall be held annually in May, to receive a Report from the Council on the state of the Society, and to elect Officers for the ensuing year. The Treasurer shall also at this meeting present the annual financial statement.

Election of the Officers and Council.

III. The Officers and other members of the Council shall be elected annually *by ballot* at the Annual General Meeting to be held in May.

IV. It shall be the duty of the Council each year to prepare a list containing the names of members whom they recommend for election to the respective offices of Vice-Presidents and Hon. Secretaries and Hon. Treasurer, together with the names of six other members whom they recommend for election as ordinary members of Council. The names thus recommended shall be proposed at one meeting of the Council, and agreed to at a subsequent meeting.

V. Each member present at the General Annual Meeting shall have the power to alter the list of names recommended by the Council, by adding to it the names of any eligible members not already included in it and removing from it an equivalent number of names, and he shall use this list with or without such alterations as a balloting list at the election of Officers and Council.

Council Meetings.

VI. Meetings of the Council of Management shall take place on the last Wednesday in every month, and on such other days as the Council may determine.

Absence from Meetings of Council.—Quorum.

VII. Any member of the Council absenting himself from three consecutive meetings of the Council, without giving a satisfactory explanation in writing, shall be considered to have vacated his office, and the election of a member to fill his place shall be proceeded with at the next Council meeting in accordance with Fundamental Rule V. No business shall be transacted at any meeting of the Council unless three members are present.

Duties of Secretaries.

VIII. The Honorary Secretaries shall perform, or shall cause the Assistant Secretary to perform, the following duties :—

1. Conduct the correspondence of the Society and Council.
2. Attend the General Meetings of the Society and the meetings of the Council, to take minutes of the proceedings of such meetings, and at the commencement of such to read aloud the minutes of the preceding meeting.
3. At the Ordinary Meetings of the members, to announce the presents made to the Society since their last meeting ; to read the certificates of candidates for admission to the Society, and such original papers communicated to the Society as are not read by their respective authors, and the letters addressed to it.

4. To make abstracts of the papers read at the Ordinary General Meetings, to be inserted in the Minutes and printed in the Proceedings.

5. To edit the Transactions of the Society, and to superintend the making of an Index for the same.

6. To be responsible for the arrangement and safe custody of the books, maps, plans, specimens, and other property of the Society.

7. To make an entry of all books, maps, plans, pamphlets, &c., in the Library Catalogue, and of all presentations to the Society in the Donation Book.

8. To keep an account of the issue and return of books, &c., borrowed by members of the Society, and to see that the borrower, in every case, signs for the same in the Library Book.

9. To address to every person elected into the Society a printed copy of the Forms Nos. 2 and 3 (in the Appendix), together with a list of the members, a copy of the Fundamental Rules and By-laws, and a card of the dates of meeting; and to acknowledge all donations made to the Society, by Form No. 5.

10. To cause due notice to be given of all Meetings of the Society and Council.

11. To be in attendance at 4 p.m. on the afternoon of Wednesday in each week during the session.

12. To keep a list of the attendances of the members of the Council at the Council Meetings and at the Ordinary General Meetings of the members of the Society, in order that the same may be laid before the Society at the Annual General Meeting held in the month of May.

The Honorary Secretaries shall, by mutual agreement, divide the performance of the duties above enumerated.

The Honorary Secretaries shall, by virtue of their office, be members of all Committees appointed by the Council.

Candidates for admission.

IX. Every candidate for admission as an ordinary member of the Society shall be recommended according to a prescribed form, by not less than three members, to two of whom he must be personally known.

Election of new Members.

X. The names of such candidates, with the names of their supporters, shall be read by one of the Secretaries at an Ordinary General Meeting of the Society. The vote as to admission to take place by ballot at the next subsequent meeting. At the ballot the assent of at least four-fifths of the members voting shall be requisite for the admission of the candidate.

New Members to be informed of their election.

XI. Every new member shall receive due notification of his election, and be supplied with a copy of the obligation (No. 3 in Appendix), together with a copy of the Fundamental Rules and By-laws of the Society, a list of members, and a card of the dates of meeting.

Members whose subscriptions are unpaid to enjoy no privileges.

XII. An elected member shall not be entitled to attend the meetings nor to enjoy any privilege of the Society, nor shall his name be printed in the list of the Society, until he shall have paid his admission fee and first annual subscription, and have returned to the Secretaries the obligation signed by himself.

Members shall sign Rules—Formal admission.

XIII. Every member who has complied with the preceding By-laws shall at the first Ordinary General Meeting at which he shall be present, sign a duplicate of the aforesaid obligation in a book to be kept for that purpose, after which he shall be presented by some member to the Chairman, who, addressing him by name, shall say :—"By the authority and in the name of the Royal Society of New South Wales I admit you a member thereof."

Annual subscriptions, when due.

XIV. Annual subscriptions shall become due on the 1st of May for the year then commencing. The entrance fee and first year's subscription of a new member shall become due on the day of his election.

Subscriptions in arrears.

XV. Members who have not paid their subscriptions for the current year, on or before the 31st of May, shall be informed of the fact by the Hon. Treasurer.

And at the meeting held in July, and at all subsequent meetings for the year, a list of the names of all those members who are in arrears with their annual subscriptions shall be suspended in the Rooms of the Society. Members shall in such cases be informed that their names have been thus posted.

Resignation of Members.

XVI. No member shall be at liberty to withdraw from the Society without previously giving notice to one of the Secretaries of his desire to withdraw, and returning all books or other property belonging to the Society. Members will be considered liable for the payment of all subscriptions due from them up to the date at which they may give notice of their intention to withdraw from the Society.

Expulsion of Members.

XVII. A majority of members present at any ordinary meeting shall have power to expel an obnoxious member from the Society, provided that a resolution to that effect has been moved and seconded at the previous ordinary meeting, and that due notice of the same has been sent in writing to the member in question, within a week after the meeting at which such resolution has been brought forward.

Contributions to the Society.

XVIII. Contributions to the Society, of whatever character, must be sent to one of the Secretaries, to be laid before the

Council of Management. It will be the duty of the Council to arrange for promulgation and discussion at an Ordinary Meeting such communications as are suitable for that purpose, as well as to dispose of the whole in the manner best adapted to promote the objects of the Society.

Order of Business.

XIX. At the Ordinary General Meetings the business shall be transacted in the following order, unless the Chairman specially decide otherwise:—

1—Minutes of the preceding Meeting.
2—New Members to enrol their names and be introduced.
3—Ballot for the election of new Members.
4—Candidates for membership to be proposed.
5—Business arising out of Minutes.
6—Communications from the Council.
7—Communications from the Sections.
8—Donations to be laid on the Table and acknowledged.
9—Correspondence to be read.
10—Motions from last Meeting.
11—Notices of Motion for the next Meeting to be given in.
12—Papers to be read.
13—Discussion.
14—Notice of Papers for the next Meeting.

Admission of Visitors.

XX. Every ordinary member shall have the privilege of admitting two friends as visitors to an Ordinary General Meeting of the Society, on the following conditions:—

1. That the name and residence of the visitors, together with the name of the member introducing them, be entered in a book at the time.
2. That they shall not have attended two consecutive meetings of the Society in the current year.

The Council shall have power to introduce visitors, irrespective of the above restrictions.

Management of Funds.

XXI. The funds of the Society shall be lodged at a Bank named by the Council of Management. Claims against the Society, when approved by the Council, shall be paid by the Treasurer.

Money Grants.

XXII. Grants of money in aid of scientific purposes from the funds of the Society—to Sections or to members—shall expire on the 1st of November in each year. Such grants, if not expended, may be re-voted.

XXIII. Such grants of money to Committees and individual members shall not be used to defray any personal expenses which a member may incur.

Audit of Accounts.

XXIV. Two Auditors shall be appointed annually, at an Ordinary Meeting, to audit the Treasurer's Accounts. The accounts as audited to be laid before the Annual Meeting in May.

Property of the Society to be vested in the Vice-Presidents, &c.

XXV. All property whatever belonging to the Society shall be vested in the Vice-Presidents, Hon. Treasurer, and Hon. Secretaries for the time being, in trust for the use of the Society; but the Council shall have control over the disbursements of the funds and the management of the property of the Society.

Library.

XXVI. The Members of the Society shall have access to, and shall be entitled to borrow books from the Library, under such regulations as the Council may think necessary.

Museum.

XXVII. It shall be one of the objects of the Society to form a Museum.

Branch Societies.

XXVIII. The Society shall have power to form Branch Societies in other parts of the Colony.

Sections.

XXIX. To allow those members of the Society who devote attention to particular branches of science fuller opportunities and facilities of meeting and working together with fewer formal restrictions than are necessary at the general Monthly Meetings of the Society,—Sections or Committees may be established in the following branches of science:—

Section A.—Astronomy, Meteorology, Physics, Mathematics, and Mechanics.

Section B.—Chemistry and Mineralogy, and their application to the Arts and Agriculture.

Section C.—Geology and Palæontology.

Section D.—Biology, *i.e.*, Botany and Zoology, including Entomology.

Section E.—Microscopical Science.

Section F.—Geography and Ethnology.

Section G.—Literature and the Fine Arts, including Architecture.

Section H.—Medical.

Section I.—Sanitary and Social Science and Statistics.

Reports from Sections.

XXX. There shall be for each Section a Chairman to preside at the meetings, and a Secretary to keep minutes of the proceedings, who shall jointly prepare and forward to the Hon. Secretaries of the Society, on or before the 7th of November in each year, a report of the proceedings of the Section during that year, in order that the same may be transmitted to the Council.

Section Committees—Card of Meetings.

XXXI. The first meeting of each Section shall be appointed by the Council. At that meeting the members shall elect their own Chairman, Secretary, and a Committee of four; and arrange the days and hours of their future meetings. A card showing the dates of each meeting for the current year shall be printed for distribution amongst the members of the Society.

Money Grants to Sections.

XXXII. By application to the Council, grants of money may be made out of the General Funds of the Society to the Sections.

Membership of Sections.

XXXIII. No person who is not a member of the Society shall have the privilege of joining any of the Sections.

THE LIBRARY.

1. During the Session, the Library shall be open for consultation, and for the issue and return of books, between 4 and 6 p.m. on the afternoon of each Wednesday, and between 7 and 10 p.m. on the evenings of Monday, Wednesday, and Friday.

2. No book shall be issued without being signed for in the Library Book.

3. Members are not allowed to have more than three volumes at a time from the Library, without special permission from one of the Honorary Secretaries, nor to retain a book for a longer period than fourteen days; but when a book is returned by a member it may be borrowed by him again, provided it has not been bespoken by any other member. Books which have been bespoken shall circulate in rotation, according to priority of application.

4. Scientific Periodicals and Journals are not to be borrowed until the volumes are completed and bound.

5. Members retaining books longer than the time specified shall be subject to a fine of sixpence per week for each volume.

6. The books which have been issued shall be called in by the Secretaries twice a year; and in the event of any book not being returned on those occasions, the member to whom it was issued shall be answerable for it, and shall be required to defray the cost of replacing same.

Form No. 1.

ROYAL SOCIETY OF NEW SOUTH WALES.

Certificate of a Candidate for Election.

Name

Qualification or occupation

Address

being desirous of admission into the Royal Society of New South Wales, we, the undersigned members of the Society, propose and recommend him as a proper person to become a member thereof.

Dated this day of , 18 .

FROM PERSONAL KNOWLEDGE.	FROM GENERAL KNOWLEDGE.

Signature of candidate

Date received 18 .

Form No. 2.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's Rooms,

Sir, Sydney, 18 .

I have the honor to inform you that you have this day been elected a member of the Royal Society of New South Wales, and I beg to forward to you a copy of the Fundamental Rules and By-laws of the Society, a printed copy of an obligation, a list of members, and a card announcing the dates of meeting during the present session.

According to the Regulations of the Society (*vide* Rule No. 6), you are required to pay your admission fee of one guinea, and annual subscription of one guinea for the current year, before admission. You are also requested to sign and return the enclosed form of obligation at your earliest convenience.

I have the honor to be,

Sir,

Your most obedient servant,

To Hon. Secretary.

Form No. 3.

ROYAL SOCIETY OF NEW SOUTH WALES.

I, the undersigned, do hereby engage that I will endeavour to promote the interests and welfare of the Royal Society of New South Wales, and to observe its Rules and By-laws as long as I shall remain a member thereof.

Signed,

Address

Date

Form No. 4.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's Rooms,

Sir, Sydney, 18 .

I have the honor to inform you that your annual subscription of one guinea for the current year became due to the Royal Society on the 1st of May last.

It is requested that payment may be made by cheque or Post Office order drawn in favour of the Hon. Treasurer.

I have the honor to be,

Sir,

Your most obedient servant,

To Hon. Treasurer.

Form No. 5.

ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's Rooms,

Sir, Sydney, 18 .

I am desired by the Royal Society of New South Wales to forward to you a copy of its Journal for the year 18 , as a donation to the library of your Society.

I am further requested to mention that the Society will be thankful to receive such of the very valuable publications issued by your Society as it may feel disposed to send.

I have the honor to be,

Sir,

Your most obedient servant,

Hon. Secretary.

Form No. 6.

ROYAL SOCITEY OF NEW SOUTH WALES.

The Society's Rooms,

Sir, Sydney, 18 .

On behalf of the Royal Society of New South Wales, I beg to acknowledge the receipt of and I am directed to convey to you the best thanks of the Society for your most valuable donation.

I have the honor to be,

Sir,

Your most obedient servant,

Hon. Secretary.

Form No. 7.

Balloting List for the Election of the Officers and Council.

ROYAL SOCIETY OF NEW SOUTH WALES.

May, 18 .

BALLOTING LIST for the election of the Officers and Council.

Present Council.	Names proposed as Members of the new Council.	
	Vice-Presidents.	
	Hon. Treasurer.	
	Hon. Secretaries.	
	Members of Council.	

If you wish to substitute any other name in place of that proposed, erase the printed name in the second column, and write opposite to it, in the third, that which you wish to substitute.

LIST OF THE MEMBERS

OF THE

Royal Society of New South Wales.

P Members who have contributed papers which have been published in the Society's Transactions or Journal. The numerals indicate the number of such contributions.
† Members of the Council.
‡ Life Members.

Elected.		
1877		Abbott, Joseph Palmer, Murrurundi.
1877		Abbott, Thomas Kingsmill, P.M., Gunnedah.
1877		Abbott, W. E., Glengarry, Wingen.
1877		Adams, Francis A., A.J.S. Bank, Sydney.
1864		Adams, P. F., Surveyor General, Kirribilli Point, St. Leonards.
1874		Alger, John, Macquarie-street.
1870		Allen, The Hon. Sir George Wigram, M.P., Speaker of the Legislative Assembly, Elizabeth-street North.
1868		Allerding, F., Hunter-street.
1873		Allerding, H. R., Hunter-street.
1856		Allwood, Rev. Canon, B.A., *Cantab.*, Vice-Chancellor, University of Sydney, Woollahra.
1876		Alston, John Wilson, M.B. *Edin.*, Mast. Surg. *Edin.*, 435, Pitt-street.
1877		Anivitti, Julius, Artist, Academy of Art.
1877		Anderson, A. W., Union Club, Sydney.
1877		Anderson, H. C. L., M.A., Sydney Grammar School.
1876		Armstrong, W. D., Surveyor General's Office.
1876		Atchison, Cunningham Archibald, C.E., North Shore.
1873		Atherton, Ebenezer, M.R.C.S. *Eng.*, O'Connell-street.
1873		Austen, Henry, Hunter-street.
1876		Backhouse, Benjamin, Ithaca, Elizabeth Bay.
1877		Baker, The Hon. E. A., M.P., Minister for Mines, Sydney.
1876	P 4	Barkas, Wm. James, Lic. R. Col. Phys. *Lond.*, M.R.C.S. *Eng.*, Bombala.
1875		Bartels, W. C. W., Union Club.
1876		Bassett, W. F., M.R.C.S., *Eng.*, Bathurst.
1875		Bedford, W. J. G., M.R.C.S. *Eng.*, Staff Surgeon.
1875		Belgrave, Thomas B., M.D. *Edin.*, M.R.C.S. *Eng.*, Liverpool-street.
1877		Belfield, Algernon H., Eversleigh, Armidale.
1875		Belisario, John, M.D. Lyons' Terrace.
1876		Benbow, Clement A., 24, College-street.
1869	P 2	Bensusan, S. L., Exchange, Pitt-street.

NOTICE.

Members are particularly requested to communicate any change of address to the Hon. Secretaries, for which purpose this slip is inserted.

Corrected Address.

Name ....

Titles, &c. ....

Address ....

....

Date ....

To the

Hon. Secretaries,

Royal Society of N. S. W.,

Elizabeth-st., Sydney.

Elected.		
1877		Bennett, George, Toowoomba, Queensland.
1877		Bennett, John, Victoria Theatre, Sydney.
1876		Bennett, Samuel, Little Coogee.
1877		Bladen, Thomas, Pyrmont.
1869		Bode, Rev. G. C., St. Leonards, North Shore.
1872		Bolding, H. I., P.M., Newcastle and Union Club.
1869		Boyd, Sprott, M.D. *Edin.*, M.R.C.S. *Eng.*, Lyons' Terrace.
1874		Bowen, George M. C., Keston, Kirribilli Point, North Shore.
1858		Bradridge, Thomas H., Town Hall, George-street.
1876		Brady, Andrew John, Lic. K. & Q. Coll. Phys. *Irel.*, Lic. R. Coll. Sur. *Irel.*, Sydney Infirmary.
1871	P 1	Brazier, John, C.M.Z.S., 11, Windmill-street.
1868		Brereton, John Le Gay, M.D. *St. Andrew's*, L.R.C.S. *Edin.*, Macquarie-street.
1874		Brewster, John, George-street.
1876		Bristowe, E. H. C., 435, Crown-street, Sydney.
1876		Brodribb, W. A., F.R.G.S., Double Bay.
1876		Brown, Henry Joseph, Newcastle.
1876		Brown, Thomas, Eskbank, Bowenfels, and Australian Club.
1877		Bundock, W. C., 165, Victoria-street.
1876		Burn, James Henry, 69, Hunter-street.
1875		Busby, The Hon. William, M.L.C., Redleaf, South Head Road, Woollahra.
1875		Burton, Edmund, Land Titles Office, Elizabeth-street North.
1877		Burnell, Arthur, Survey Office.
1876		Cadell, Alfred, Vegetable Creek, New England.
1876		Cadell, Thomas, Wotonga, East St. Leonards.
1876		Campbell, Allan, L.R.C.P., *Glasgow*, Yass.
1876		Campbell, The Hon. Alexander, M.L.C., Woollahra.
1868		Campbell, The Hon. Charles, M.L.C., Pine Villa, Newtown.
1872		Campbell, The Hon. John, M.L.C., Campbell's Wharf, Lower George-street.
1870		Cane, Alfred, Stanley-street.
1876		Cape, Alfred J., Torfrida, Elizabeth Bay.
1876		Chandler, Alfred, 185 Pitt-street.
1876		Christie, Wm., L.S., Hawthorn Lodge, Glen Innes.
1850	P 18	†Clarke, Rev. W. B., M.A. *Cantab.*, F.R.S., F.G.S., C.M.Z.S., F.R.G.S., Mem. Geol. Soc. France, Corres. Imp. Roy. Geol. Inst. Austria, Hon. Mem. N.Z. Inst. Cor. Mem. Roy. Soc. Tasmania, Fellow of St. Paul's College, *Vice-President*, Branthwaite, St. Leonards, North Shore.
1877		Clarke, William, E. S. & A. C. Bank, Pitt-street.
1874		Clay, William French, M.A., *Cantab.*, M.D *Syd.*, M.R.C.S. *Eng.*, Fellow of St. Paul's Col., North Shore.
1876		Clune, Michael Joseph, M.A.,Lic. K & Q. Coll. Phys. *Irel.*, Lic. R. Coll. Sur. *Irel.*, 4, Hyde Park Terrace.
1876		Codrington, John Fredk., M.R.C.S., E. ; Lic. R C. Phys., L. ; Lic. R C. Phys., *Edin.*, Orange.
1876		Colyer, John Ussher Cox, A.S.N. Company, Sydney.
1856		Comrie, James, Northfield, Kurrajong Heights.
1876		Conder, Wm., Survey Office, Sydney.
1874		Coombes, Edward, Bathurst.
1859	P 1	Cox, James, M.D. *Edin.* C.M.Z.S., F.L.S., Hunter-street.

Elected.		
1865	P 2	Cracknell, E. C., Superintendent of Telegraphs, Telegraph Office, George-street.
1869		Creed, J. Mildred, M.R.C.S. *Eng.*, Scone.
1870		Croudace, Thomas, Lambton.
1877		Cunningham, Andrew, Lanyon, Queanbeyan.
1873		Daintrey, Edwin, Æolia, Randwick.
1876		Dalgarno, John V., Telegraph Office, George-street.
1876		Dansey, George Frederick, M.R.C.S., London, York and Margaret Streets, Wynyard Square.
1874		Dansey, John, M.R.C.S. *Eng.*, Wynyard Square.
1875		Dangar, Frederick H., Greenknowes, Darlinghurst.
1876		Darley, Cecil West, Newcastle.
1877		Darley, F. M., M.A., Union Club, Sydney.
1876		Davidson, L. Gordon, M.D., M.C., *Aberdeen*, Goulburn.
1877		Deck, John Feild, M.D., 251, Macquarie-street.
1856		Deffell, George H., Bayfield, Woolwich Road, Hunter's Hill.
1869		De Lissa, Alfred, Pitt-street.
1875		De Salis, The Hon. Leopold Fane, M.L.C., Cuppercumbalong, Lanyon.
1875		De Salis, L. W., junr., Strathmore, Bowen, Queensland.
1873		Dibbs, George R., M.P., 131, Pitt-street.
1876		Dight, Arthur, Richmond.
1876		Dixon Douglas, Australian Club.
1875	P 2	Dixon, W. A., F.C.S., Hunter-street.
1876		Docker, Ernest, M.A. *Sydn.*, 134, Burton-street.
1876		Douglas James, L.R.C.S. *Edin.*, Hope Terrace, Glebe Road.
1876		Drake, William Hedley, Commercial Bank, Inverell.
1873		Du Faur, Eccleston, F.R.G.S., Rialto Terrace.
1876		Eales, John, Duckenfield Park, Morpeth.
1876		Egan Myles, M.R.C.S., *Eng.*, 2, Hyde Park Terrace, Liverpool-street.
1874		Eichler, Charles F., M.D., *Heidelberg*, M.R.C.S., *Eng.*, Bridge-street.
1876		Eldred, W. H., 119, Castlereagh-street.
1876		Evans, George, Como, Darling Point.
1876		Evans, Owen Spencer, M.R.C.S., *Eng.*, Darling-street, Balmain.
1877		Fache, Charles James, Cleveland House, Redfern.
1877		Fairfax, Edward R., 177, Macquarie-street.
1868		†Fairfax, James R., *Herald* Office, Hunter-street.
1872		Farnell, J. Squire, M.P., Ryde.
1874		Fischer, Carl F., M.D., F.L.S., Soc. Zool. Bot. Vindob. Socius., 251, Macquarie-street.
1876		Fisher, Chas. Marshall, 132, Pitt-street.
1876		Fitzgerald, R. D., F.L.S., Surveyor General's Office.
1856		Flavelle, John, George-street.
1876		Forde, W., Carlton Terrace, Wynyard Square.
1863		Fortescue, G., M.B. *Lond.*, F.R.C.S., F.L.S., Lyons' Terrace.

Elected.		
1877		Fraser, A. C., 235, Albion-street.
1875		Frazer, Hon. John, M.L.C., Quirang, Woollahra.
1876		Frean Richard, M.R.C.S. *Eng.*, Sydney Infirmary.
1876		Freehill, Bernard Austin, 130, Elizabeth-street.
1876		Firth, Rev. Frank, Wesleyan Parsonage, Waverley.
1877		Garnsey, Rev. C. F., St. James's Parsonage, Sydney.
1868	P 1	Garran, Andrew, LL.D. *Syd.*, *Herald* Office, Hunter-street.
1877		Garvan, J. P., 130, Elizabeth-street, Sydney,
1876		George, W. R. 172, Castlereagh-street.
1876		Gilchrist, W. O., Elizabeth Bay.
1875		Gilliat, Henry Alfred, Australian Club.
1876		Gillman, Thomas Henry, B.A., C.M., M.D., Queen's Univ. *Irel.*, Mast. Surg. Queen's Univ. *Irel.*, 20, College-street.
1876		Gipps, F. B., 134, Pitt-street.
1859		Goodlet, John H., George-street.
1876		Goode, George, M.B. Univ. *Dub.*, B.A., M.C.L., Eversfield House, Camden.
1876		Graham, Hon. Wm., M.L.C., Stratheam House, Waverley.
1873		Greaves, W. A. B., Armidale.
1877		Griffiths, Neville, The Domain, Sydney.
1875		Grundy, F. H., 183, Pitt-street.
1877		Gurney, T. T., M.A., Professor of Mathematics, University of Sydney.
1864		Hale, Thomas, Gresham-street.
1874		Hardy, J., Hunter-street.
1877		Hargrave, Lawrence, 94, Upper William-street.
1877		Harrison, L. M., Moira, Burwood.
1877		Hawkins, H. S., M.A., Balmain.
1874		Hay, The Hon. John, M.A., *Glasgow*, M.L.C., President of the Legislative Council, Rose Bay, Woollahra.
1876		Heaton, J. H., *Town and Country* Office, Pitt-street.
1875		Helsham, Douglass, York's Terrace, Glebe.
1877		Henry, James, 754, George-street.
1876		Heron, Henry, 4, Rialto Terrace, William-street South.
1859		‡ Hill, Edward S., C.M.Z.S., Rose Bay, Woollahra.
1877		Hindson, Lawrence, Careening Cove, North Shore.
1876	P 1	Hirst, Geo. D., 379, George-street.
1868		Holt, The Hon. Thomas, M.L.C., The Warren, near Sydney.
1876		Holroyd, Arther Todd, M.B. *Cantab.*, M.D. *Edin.*, F.L.S., F.Z.S., F.R.G.S., Master-in-Equity, Sherwood Scrubs, Parramatta.
1870	P 1	Horton, Rev. Thomas, Ina Terrace, Woollahra.
1877		Hume, J. K., Cooma Cottage, Yass.
1876		Icely, Thos. R., Carcoar.
1877		Innes, Sir J. George L., Knt., Darlinghurst.

Elected.		
1876		Jackson, Henry William, L.R.C.S. *Edin.*, Lic. R. Phys., *Edin.*, 130, Phillip-street.
1876		Jenkins, Richard Lewis, M.R.C.S., Nepean Towers, Douglass Park.
1874		Jennings, P. A., Edgecliffe Road, Woollahra.
1877		Jennings, W. E., B.A., Mining Department, Sydney.
1876		Jones, James Aberdeen, Lic. R.C. Phys,. *Edin.*, Booth-street, Balmain.
1876		Jones, Richard Theophilus, M.D. *Sydn.*, L.R.C.P. *Edin.*, Ashfield.
1867		†Jones, P. Sydney, M.D. *Lond.*, F.R.C.S. *Eng.*, College-street.
1877		Jones, Edward Lloyd, 345, George-street, Sydney.
1874		Jones, James, Bathurst-street.
1877		Jones, Griffith Evan Russell, B.A., *Syd.*, 382, Crown-street, Surry Hills.
1863		Josephson, Joshua Frey, F.G.S., District Court Judge, Enmore Road, Newtown.
1876		Josephson, J. P., 253, Macquarie-street North.
1873		Keele, Thos. Wm., Harbours and Rivers Department, Phillip-street.
1877		Keep, John, Broughton, Leichhardt.
1873		Kennedy, Hugh, B.A. *Oxon.* Registrar of the Sydney University.
1874		King, Philip G., William-street, Double Bay.
1877		Kinloch, John, M.A., Hyde Park, Sydney.
1877		Knox, Edward, jun., Fiona, Double Bay.
1874		Knox, George, M.A., *Cantab.*, King-street.
1875		Knox, Edward, 24, Bridge-street.
1877		Kopsch, G., 8 Bridge-street.
1867	P 3	Lang, Rev. John Dunmore, D.D., M.A. *Glasgow,* Jamison-street.
1876		Langley, W.E., *Herald* Office, Sydney.
1874	P 1	Latta, G. J., O'Connell-street.
1876		Laure, Louis Thos., M.D. Surg. Univ. *Paris*, 131, Castlereagh-street
1859	P 5	†Leibius, Adolph, Ph. D. *Heidelberg*, Senior Assayer to the Sydney Branch of the Royal Mint, *Hon. Secretary.*
1874		Lenehan, Henry Alfred, Computer,, Sydney Observatory.
1872	P 9	†Liversidge, Archibald, F.C.S.; F.G.S.; F.L.S.; F.R.G.S.; Assoc R. S. Mines, *Lond.*; Mem. Phy. Soc. London; Mem. Mineralogical Soc. Gt. Brit. and Irel.; Cor. Mem. Roy. Soc. Tas.; Cor. Mem. Senckenberg Institute, Frankfurt; Cor. Mem. Soc d'Acclimat. Mauritius; Hon. F. R. Hist. Soc. Lond; Professor of Geology and Mineralogy in the University of Sydney, *Hon. Secretary,* Union Club.
1875		Living, John, Marsaloo, North Shore.
1874		Lloyd, George Alfred, M.P., F.R.G.S., O'Connell-street.
1876		Lord, The Hon. Francis, M.L.C., North Shore.
1877		Lord, George Lee, Woolloomooloo.
1876		Lyons, W., M.R.C.S., *Eng.*, Wollongong.

Elected.		
1870		Macafee, Arthur H. C., York-street.
1876		M'Carthy, W. F., Deepdeen, Glenmore Road.
1876		M'Culloch, A H., jun., 165, Pitt-street.
1874		M'Cutcheon, John Warner, Assayer to the Sydney Branch of the Royal Mint.
1859		MacDonnell, William, George-street.
1868		MacDonnell, William J., F.R.A.S., George-street.
1877		MacDonnell, Samuel, 326, George-street, Sydney.
1876		M'Guire, W. H., Telegraph Office, George-street.
1872		Mackenzie, John, F.G.S., Examiner of Coal Fields, Newcastle.
1874		Mackenzie, W. F., M.R C.S., *Eng.*, Lyons' Terrace.
1876		Mackenzie, Rev. P. F., Paddington.
1876		Mackellar, Chas. Kinnard, M.B., C.M., *Glas.*, Lyons' Terrace.
1876		M'Kay, Dr., Church Hill.
1876		Maclaurin, Henry Norman, M.A., M.D. Univ., *Edin.*, Lic. R. Coll. Sur. *Edin.*, 187, Macquarie-street.
1873		Makin, G. E., Berrima.
1877		Mann, John, Neutral Bay.
1873	P 4	Manning, James, Milsom's Point, North Shore.
1876		Manning, Frederick Norton, M.D. Univ. *St. And.*, M.R.C.S., *Eng.*, Lic. Soc. Apoth. *Lond.*, Gladesville.
1869		Mansfield, G. A., Pitt-street.
1872		Marsden, The Right Rev. Dr., Bishop of Bathurst, Bathurst.
1876		Marsh, J. M., Edgecliff Road, Woollahra.
1876		Marshall, George, M.D. Univ. *Glas.*, Lic. R. Coll. S. *Edin.*, Lyons' Terrace.
1876		Martin, Rev. George, Victoria Terrace, Miller's Point.
1876		Martin, John, Addington, Ryde.
1875		Mathews, R. H., Mundooran.
1877		Merriman, James, Mayor of Sydney.
1868		Metcalfe, Michael, Bridge-street.
1873		Milford, F., M.D., *Heidelberg*, M.R.C.S. *Eng.*, College-street.
1876		Milford, S. F. F., Lands Office.
1876		Millard, Rev. Henry Shaw, Newcastle Grammar School.
1875		Moir, James, Margaret-street.
1875		Montefiore, E. L., Macleay-street.
1876		Montefiore, George B., F.G.S., 5, Gresham-street.
1856	P 2	†Moore, Charles, F.L.S., Director of the Botanic Gardens, Botanic Gardens.
		Morehead, R. A. A., 30, O'Connell-street.
1872		Morgan, Cosby William, M.D. *Brussels*, L.R.C.P. *Lond.*, 137, Castlereagh-street.
1876		Morgan, Allan Bradley, M.R.C.S. *Eng.*, Lic. Mid. Lic. R. Coll. Phys. *Edin.*, Ashenhurst, Burwood.
1876		Morgan, T. C., 137, Castlereagh-street.
1865	P 1	Morrell, G. A., C.E., Department of Works, Phillip-street.
1877		Morris, William, L.F.P. and S. *Glas.*, Wynyard Square, Sydney.
1877		‡Mullens, Josiah, F.R.G.S., 34, Hunter-street.
1865		Murnin, M. E., Exchange, Bridge-street.
1876		Murray, W. G., 52, Pitt-street.
1876		Myles, Chas. Henry, Wymela, Burwood.
1873		Neill, William, City Bank, Pitt-street.
1874		Neill, A. L. P., City Bank, Pitt-street.

Elected.		
1876		Neild, John Cash, M.D. & C.D., *Berlin*, M.R.C.S. *Eng.*, Lic. Soc. Apoth. *Lond.*, Elzabeth-street, Sydney.
1874		Nicol, D., Burwood.
1876		Nilson, Aroid, Department of Mines.
1873		Norton, James, Elizabeth-street.
1875		Nott, Thomas, M.D. *Aberdeen*, M.R.C.S. *Eng.*, Ocean-street, Woollahra.
1877		Olley, Rev. Jacob, Hunter's Hill.
1875		O'Reilly, W. W. J., M.D., M.C., Q. Univ. *Irel.*, M.R.C.S., *Eng.*, Liverpool-street.
1875		Owen, The Hon. Robert, M.L.C., 88, Elizabeth-street.
1875		Palmer, J. H., Legislative Assembly.
1876		Parbury, Chas., Union Club.
1876		Parrott, Thomas S., Ashfield.
1861		Paterson, Hugh, Macquarie-street.
1877		Paterson, James A., Union Bank, Pitt-street.
1877		Pedley, Percival R., 1 Carlton Terrace, Wynyard Square.
1872		Pendergast, Robert, Hay-street.
1877		Perkins, Henry A., Ocean-street, Woollahra.
1875		Phillip, H., Pacific Insurance Company.
1876		Pickburn Thomas, M.D., *Aberdeen*, Ch. M., M.R.C.S., *Eng.*, 40, College-street.
1877		Pile, George, 62, Margaret-street, Sydney.
1862		Prince, Henry, George-street.
1876		Quaife, Fredk. Harrison, M.D., Mast. Surg. Univ. *Glas.*, Piper-street, Woollahra.
1876		Quirk, Rev. Dr. J. A., O.S.B., LL.D., *Syd.*, Lyndhurst College.
1876		Quodling, W. H., Burwood.
1865	P 1	‡Ramsay, Edward, F.L.S., Curator of the Australian Museum, College-street.
1876		‡Ratte, F., Noumea, New Caledonia.
1874		Read, Reginald Bligh, M.R.C.S., *Eng.*, Randwick.
1877		Read, Richard, M.D., Singleton.
1868		Reading, E., Mem. Odont. Soc. *Lond.*, Castlereagh-street.
1876		Reece, J. D., Surveyor General's Office.
1870		Renwick, Arthur, M.D. *Edin.*, B.A., *Sydn.*, F.R.C.S.E., 295, Elizabeth-street.
1856		Roberts, J., George-street.
1868	P 3	Roberts, Alfred, M.R.C.S. *Eng.*, Hon. Mem. Zool. and Bot. Soc. Vienna, Bridge-street.
1876		Roberts, Rev. W. H., B.A., *Dublin*, St. Paul's College, Newtown.
1871		Robertson, Thomas, M.P., Pitt-street North.
1872		Robinson, His Excellency Sir Hercules, G.C.M.G., Governor of New South Wales, Government House.

Elected.		
1873		Rogers, Rev. Edward, Rural Dean, Fort-street.
1856	P 5	†Rolleston, Christopher, Auditor General, Castlereagh-street.
1865		Ross, J. Grafton, 24, Bridge-street.
1876		Rowling, Dr., Mudgee.
1864	P 12	†Russell, Henry C., B.A., *Syd.*, F.R.A.S., F.M.S., Hon. Mem. S. Aust. Inst., Government Astronomer, Sydney Observatory, *Vice-President.*
1875		Sahl, Charles L., German Consul, Consulate of the German Empire, Wynyard Square.
1876		Saliniere, Rev. E. M., Glebe.
1876		Samuel, The Hon. Saul, C.M.G., M.L.C., Gresham-street.
1876		Schuette, Rudolf, M.D., Univ. *Göttingen*, Lic. Soc. Apoth. *Lond.*, 10, College-street.
1856	P 1	†‡Scott, Rev. William, M.A. *Cantab.*, Hon. Mem. Roy. Soc. Vic., Warden of St. Paul's College, *Hon. Treasurer*, St. Paul's College, Newtown.
1876		Scott, A.W., M.A. *Cantab.*, Ferndale, South Head Road.
1876		Sedgwick, Wm. Gillett, M.R.C.S., *Eng.*, Newtown.
1877		Selfe, Norman, C.E., Rockleigh, Balmain.
1876		Sharp, James Burleigh, J.P., Clifton Wood, Yass.
1876		Sharp, Henry, Green Hills, Adelong.
1875		Sheppard, Rev. G., Elizabeth-street.
1876		Shields, John, M.R.C.S., *Ed.*, Bega.
1875		Slade, G.P., Wheatley, North Shore.
1877		Slattery, Thomas, Manly Beach.
1872		Sleep, John S., 139, Pitt-street.
1877		Sloper, Fredk. Evans, 360, Liverpool-street.
1852	P4	†Smith, John, The Hon., C.M.G., M.D., LL.D., *Aberdeen*, M.L.C., F.C.S., Hon. Mem. Roy. Soc. Vic., Professor of Physics and Chemistry in the University of Sydney, 193, Macquarie-street.
1875		Smith, Robt., B.A., *Syd.*, Solicitor, Bridge-street.
1874		Smith, John M'Garvie, 404, George-street.
1876		Smith, R. S., Surveyor General's Office.
1876		Southey, H. E., Oaklands, Mittagong.
1876		Stackhouse, Thos., Commander R.N., Australian Club.
1872	P 1	Stephen, George Milner, B.A., F.G.S., Mem. Geol. Soc. of Germany; Cor. Mem. Nat. Hist. Soc., Dresden; F.R.G.S. of Cornwall; Five Dock.
1857		Stephens, William John, M.A. *Oxon.*, 233, Darlinghurst Road.
1876		Stopps, Arthur J., Surveyor General's Office.
1876		Strong, Wm. Edmund, M.D., *Aberdeen*, M.R.C.S., *Eng.*, Liverpool.
1874		Stuart, The Hon. Alexander, M.P., Colonial Treasurer, Clunes, Cambridge-street, South Kingston, Petersham.
1876		Stuart, Clarendon, Upper William Street South.
1876		Suttor, Wm. Henry, J.P., Cangoura, Bathurst.
1874		Taylor, Chas., M.D. *Syd.*, M.R.C.S., *Eng.*, Parramatta.
1876		Tayler, William George, F.R.C.S., *Lond.*, 219, Pitt-street.

Elected.		
1862	P 5	Tebbutt, John, F.R.A.S., Observatory, Windsor.
1870	P 1	Thompson, H. A., O'Connell-street.
1875		Thompson, Joseph, Potts' Point.
1877		Thompson, Thos. James, Pitt-street, Sydney.
1876		Thomas, H. Arding, Narellan.
1876		Thomas, Wm. Smith, M.R.C.S., *Eng.*, Wollongong.
1876		Tibbits, Walter Hugh, Dubbo.
1876		Toohey, J. T., Melrose Cottage, Cleveland-street.
1873		Trebeck, Prosper N., George-street.
1876		Trouton, F. H., A.S.N. Company's Offices, Sydney.
1877		Tucker, G. A., Superintendent, Bay View Asylum, Cook's River.
1868		Tucker, William, Clifton, North Shore.
1875		Tulloh, W. H., Margaret-street.
1875		Turner, G., 3 Fitzroy Terrace, Pitt-street, Redfern.
1874		Vessey, Leonard A., Survey Office.
1876		Voss, Houlton H., Union Club.
1867		Walker, Philip B., Telegraph Office, George-street.
1870		Wallis, William, Moncur Lodge, Potts' Point.
1867		Ward, R. D., M.R.C.S. *Eng.*, North Shore.
1877		Warren, William Edward, M.D., M.R.C.S., 26, College-street, Sydney.
1876		Waterhouse, J. M.A. *Syd.*, Newington College, Parramatta.
1876		Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, Randwick.
1876		Watson, C. Russell, M.R.C.S., *Eng.*, Camden Terrace, Newtown.
1877		Watt, Alfred Joseph, Ashfield, Parramatta Road.
1859		Watt, Charles, New Pitt-street.
1874		Watt, John B., The Hon., M.L.C., 104, Macleay-street.
1876		Waugh, Isaac, M.B., M.C., *T.C.D.*, Parramatta.
1876		Webster, A. S., Union Club.
1867		Weigall, Albert Bythesea, B.A. *Oxon.*, M.A. *Syd.*, Head Master of the Sydney Grammar School, College-street.
1877		Weston, W. J., Union Club.
1874		White, Rev. James S., M.A., LL.D., *Syd.*, Gowrie, Singleton.
1875		White, Hon. James, M.L.C., Cranbrook, Double Bay.
1877		White, Rev. W. Moore, LL.D., Arthursleigh Terrace, Elizabeth-street.
1876		Wilson, F. H., Newtown.
1876		Windeyer, Hon. W. C., M.A., *Syd.*, M.L.A., King-street.
1876		Wise, George Foster, Immigration Office, Hyde Park.
1874		Wilkinson, C. S., Government Geologist, Department of Mines.
1876		Wilkinson, Henry Toller, Department of Mines.
1862		Williams, J. P., New Pitt-street.
1876		Williams, Percy, Treasury.
1873		Wood, Harrie, Under Secretary for Mines, Department of Mines.
1874		Woolgate, E., Parramatta.
1877		Woods, T. A. Tenison-, Phillip-street, Sydney.
1876		Woolrych, F. B. W., 138, Castlereagh-street.
1872		Wright, Horatio, G. A., M.R.C.S., *Eng.*, Wynyard Square.

Honorary Members.

Elected, August, 1875.

Agnew, Dr., Hon. Secretary, Royal Society of Tasmania, Hobart Town.

Barlee, The Hon. F., late Colonial Secretary of Western Australia.

Bernays, Lewis A., F.L.S., Vice-President of the Queensland Acclimatization Society, Brisbane.

Ellery, Robert F., F.R.S., F.R.A.S., Government Astronomer of Victoria, Melbourne.

Gregory, Augustus Charles, F.R.G.S., Surveyor General of Queensland, Brisbane.

Haast, Dr. Julius von, Ph. D., F.R.S., F.G.S., Government Geologist and Director of the Canterbury Museum, New Zealand.

Hector, James, C.M.G., M.D., F.R.S., Director of the Colonial Museum and Geological Survey of New Zealand, Wellington.

M'Coy, Frederick, F.G.S., Hon. F.C.P.S., C.M.Z.S., Professor of Natural Science in the Melbourne University, Government Palæontologist, and Director of the National Museum, Melbourne.

Müller, Baron Ferdinand von, C.M.G., M.D., Ph. D., F.R.S., F.L.S., Government Botanist, Melbourne.

Schomburgh, Dr., Director of the Botanic Gardens, Adelaide, South Australia.

Waterhouse, F. G., F.G.S., C.M.Z.S., Curator of the Museum, Adelaide, South Australia.

Woods, Rev. Julian E. Tenison, F.G.S., F.R.G.S., Hon. Mem. Roy. Soc., Vic., Hobart Town, Tasmania.

Elected, 6 December, 1876.

Cockle, His Honor Sir James, Chief Justice, M.A., F.R.S., Brisbane, Queensland.

De Koninck, Prof., M.D., Liège, Belgium.

Obituary, 1877.

Elected.

1870. Allen, The Hon. George, M.L.C., Toxteth Park, Glebe.

1868. Fairfax, The Hon. John, M.L.C., *Herald* Office, Hunter-street.

1874. Pedley, Frederick, Wynyard-square.

ANNIVERSARY ADDRESS.

By H. C. Russell, B.A., F.R.A.S., &c., Vice-President.

[*Delivered before the Royal Society of N.S.W., 2 May, 1877.*]

Gentlemen,

At the commencement of last session it was your pleasure to elect me one of your Vice-presidents, and in so doing to lay upon me the duty of giving the opening address this session. I wish your choice had fallen on some one with more leisure than myself, or that we might, as in years past, have had the pleasure of listening to our honored and senior Vice-president, whose unceasing labours on behalf of our Society have earned for him such a high place in our esteem.

Fifty-six years have passed since a few (ten) earnest workers met together in Sydney, and formed the first Scientific Society in Australia. We are proud that we can trace the origin of our Society to that early effort made to plant science on a new soil; and although there have been periods of depression—"droughts" in our scientific world during which no progress was made—yet the Report you have just heard contains ample proof that the young Society was planted on congenial soil.

You have heard, then, what we have done during the past year, and I need not dwell upon it, except on one or two points, for which I ask your forbearance.

First, however, allow me to congratulate you upon our flourishing condition.

With 132 members added to our number during the year, with seven working sections formed, with 1,000 books added to our library, besides furniture and instruments purchased for our use, with a volume showing our year's work larger than any which has preceded it, with friendly exchange relations established with no less than 107 kindred Societies scattered over all parts of the world, with a growing spirit of work amongst our members, and with a fair prospect that a liberal Government will help us to carry out our purposes, we certainly have good reason to congratulate ourselves on the year's progress.

The following list of papers read does not include those read to the Sections; but the number (15) bears favourable comparison with the number (10) read the previous year :—

1. Anniversary Address. By the Rev. W. B. Clarke, M.A., F.R.S.
2. Notes on some remarkable Errors shown by Thermometers. By H. C. Russell, B.A., F.R.A.S.
3. On the Origin and Migration of the Polynesian Nations. By Rev. Dr. Lang.
4. On the Deep Oceanic Depression off Moreton Bay. By Rev. W. B. Clarke, M.A., F.R.S.
5. Some Notes on Jupiter during his Opposition of 1876. By Mr. G. D. Hirst.
6. On the Genus Ctenodus. By Mr. W. J. Barkas, M.R.C.S.E.
7. Part 2 of above paper, being Microscopic Structure of Mandibular and Palatal Teeth of Ctenodus.
8. Part 3 of above, Vomerine Teeth of Ctenodus.
9. Part 4 of above, on the Dentary Articular and Pterygo-palatine Bones of Ctenodus.
10. On the formation of Moss Gold and Silver. By Archibald Liversidge, Professor of Geology and Mineralogy in the University of Sydney.
11. Recent Copper-extracting Processes. By Mr. S. L. Bensusan.
12. Meteorological Periodicity. By H. C. Russell, B.A., F.R.A.S.
13. Effects of Forest Vegetation on Climate. By Rev. W. B. Clarke, M.A., F.R.S.
14. Fossiliferous Siliceous Deposit from Richmond River, New South Wales. By Archibald Liversidge, Professor of Geology and Mineralogy in the University of Sydney.
15. On a remarkable example of Contorted Slate. By Archibald Liversidge, Professor of Geology and Mineralogy in the University of Sydney.

In addition to the above, four papers were read in the Astronomical Section, three in the Section for Chemistry and Mineralogy, five in the Microscopical Section, one to Fine Arts Section, several read to the Medical Section (number not given in Report), two to the Sanitary Section; besides which, a great deal of useful work was done in the Sections, and several of them formed a basis on which they will be able to increase their usefulness during this session.

The work done by our Sections was therefore considerable, and will appear still more so, if it is borne in mind that, owing to the time lost in preliminary arrangements, they could not begin until July.

When it was announced at our last Annual Meeting that Sections would be formed, some of the most sanguine amongst us thought that not more than three or four could be formed on a working basis; and I confess that I was not a little surprised when seven out of the nine proposed were formed. Surely no better proof could be desired, that the wish to be at work was increasing amongst us. And the progress made last session justifies the hope that, during the one on which we are entering, much more will be accomplished. There are amongst us, no doubt, many workers who have not the leisure required to prepare such a formal paper as the Royal Society requires, who will find in the Sections ample opportunity for bringing their work forward. And, if I may venture to make a suggestion on this subject, it is that they should devote themselves specially to such facts and phenomena as are peculiar to Australia, for by so doing our Journal will become of very great value in the estimation of those to whom we send it in exchange for the valuable works which they publish.

The Report has justly reminded you of the obligation we are under owing to the liberality of our Government in printing our Journal; but I cannot let the allusion pass without calling your attention to the difficulty there is in getting much of the technical matter we publish through the Press, and the obligation we owe both to Mr. T. Richards, Government Printer, and to Mr. C. Potter, Acting Government Printer, for their uniform courtesy and attention to our wants while getting the Journal through the Press.

Another matter which should not be passed over with so short a notice as is given to it in our Council's Report, is the establishment of exchange relations with no less than 107 other and kindred Societies scattered over the world. By this means we have, in return for 579 volumes sent out (our own and others given us for distribution), secured at least 1,000 new works for our library, very many of them valuable ones, which could only have been obtained for use in the Colony in exchange for works of a kindred Society like ours. This alone is no small matter to record for the past year, and it reminds me of something I wished to say. You all know how our Rules set forth that the "object of this Society is to receive original papers on scientific subjects, art, literature, and philosophy; and especially such subjects as tend to develop the resources of Australia, and illustrate its natural history and productions"; and you also know how, in a humble way, we have steadily kept to our purpose, but by adding to it this year the distribution of our own and other publications of a like character, partly for the return we knew we should get, and partly with the object of spreading knowledge, we have, so far as our means permitted, taken in this Colony the position held by the Smithsonian Institution in America. That institution had, as you are aware, an origin very different from ours, it is a monument to the love of knowledge and munificence of an Englishman named "Smithson," who, on condition that the money was spent for the "Increase and diffusion of knowledge among men," devoted his fortune (about £100,000) to found it. Right nobly the work is carried on by the Regents or Council of the institution, in publishing new works, and in sending them, together with all the scientific books they can get, the world over. Sustained by ample funds from the endowment, they can act as their love of science dictates, while we who have only our subscriptions to work upon, are following their example as far as we can. It is a laudable position for us to aspire to; and I hope that as our "Smithson" has not yet appeared, our Government will help us to do this work, which is for the public good, until he does.

The Report also alludes to two other matters which I should like to bring more particularly under your notice. One is that we have devoted a considerable sum of money to the purchase of scientific periodicals for our library, and although it has helped materially to reduce our Treasurer's balance, it is a good investment.

The other is the number of valuable donations that have been received from our members. Their names as donors have already been laid before you at the monthly meetings, and will be found recorded in our annual Journal, now on the table. I would like to read them over, but the list is too long. I cannot, however, refrain from calling your attention to one fact, that the spirit amongst us which these donations evince is a most satisfactory one to recognize. It is the source from which kindred Societies in England and elsewhere derive so many valuable books and instruments. And I have no doubt that when it becomes known that the donors' names are permanently recorded as benefactors of the Society, and that such gifts in the hands of the Librarian become extremely valuable to the members, we shall have many more to record. From the three sources I have named, we are collecting a library, which as many of you are aware, is rapidly filling our small council room.

I hope that I have not been tedious in making these remarks. I have done so because I think we have arrived at a most important period of our history, and much of our future progress will depend upon the course we now adopt. For we have grown to be a large Scientific Society; we have divided ourselves into Sections, and find many willing to work—more even than we expected, and we have no elbow-room in which to accommodate them. If this continues, it will be found one of the most effective things in checking the usefulness of the members, who at least expect a comfortable place to work in. Indeed, the Society has always wanted house-room, and it may be said, perhaps to its credit, that it has heretofore thought more of its work than its home. And I hope it will continue to do so. But I am sure I am only speaking the conviction of the majority of our members when I say that the time has arrived when we *ought* to have, when we *must have*, a home of our own. Every kindred Society that I know of is provided with a home at Government expense, both here and in other places. In England, the Royal and other Societies are provided with splendid rooms in Burlington House, which must have cost the Government upwards of £100,000. They receive also annual grants from the Government, and this year the Royal Society's share is £5,000, a clear proof of the value of such an institution in the community. Coming nearer home, the Royal Society in Victoria received from the Government a piece of land in Melbourne, and £2,000 towards their building, together with an annual grant of £200. In Tasmania the Royal Society is provided by the Government with fine rooms, and has an annual grant of money, and so in other places; while the Royal Society of Sydney has never received any assistance from Government except the printing of our Journal since 1873. This is not a fair position for us to be in; and I am convinced that if we rightly represent the matter, we shall obtain the assistance we need to enable us to extend our usefulness. I will not here discuss the question of how this should be done; but I think it is a proper object to place in the hands of a committee of the members.

With one remark bearing upon the subject I will leave it. The question may be asked, does it pay to foster science? We have not far to look in the experience of other countries for an answer, and their experience points unmistakeably to the fact that science is the mainspring of advancement in arts and manufactures. Let science keep in the back-ground, and art at once becomes a machine, reproducing the same thing age after age, with a gradual deterioration proportionate to the wear and tear, as we see in Eastern countries; but let science take its legitimate place, let instruction and means be given to the thoughtful workers in its fields, and it is soon found to be but an easy step from pure science to pure art.

It is not many years since England was the workshop of the world; and Germany, like some other nations, looked on, wishing to share the profits, but unable to do so. Her rulers wisely thought that the reason was a want of education in the physical sciences, and they made her schools of chemistry the best in Europe. Students flocked there—even from other countries—and they came away full of the spirit of research, and ennobled by daily contact with her renowned professors. What is the result? Forty years since, industry in the arts could scarcely be said to exist in Germany. Now England has lost one of her best customers and found a rival instead; and not to mention other articles, in the newest European industry, that of the manufacture of dyes. Germany, last year, made more than all the rest of Europe, England and France included.

So much for the culture of science, and it affords a lesson which England has not been slow to profit by, for she is now devoting money freely to science culture. And if we are to keep pace with the world we must do likewise. As one of the leading men of the day has recently said—"There can be no doubt that, whether science be looked upon as a means of culture or as a means of commercial progress, it is both our duty and our interest to promote it."

Turning now to the scientific progress made during the year, I feel that it is hopeless to try to condense within the limits of this address what would fill a goodly volume; and the field is so large that I fear even to enter it lest I should not get out before your patience was exhausted, especially as we have another important paper to read to-night. I will therefore try and select only a few facts from the great multitude.

In spectrum analysis no *great* discovery has been made, but much has been done in its various branches. Messrs. Roscoe and Schuster's valuable investigations into the absorption of bands of potassium and sodium, together with Lockyer's work on the varying absorptive powers of metallic and metalloidal vapours under different temperatures, and especially with regard to calcium, which gives two distinct spectra—are most valuable contributions to science.

Mr. Christie, using the large spectroscope of the Greenwich Observatory, has confirmed Dr. Huggins's marvellous discovery of the proper motion of stars, but he has not been able, any more than Dr. Huggins, to find proofs of motion in the nebulæ. No doubt this is owing to the inherent difficulty of getting exact measures of the bright lines of faint spectra. Dr. Huggins has this year made another advance in the examination of star spectra, and has succeeded in so improving his apparatus that a star can be kept on the slit of the spectroscope until a photograph is taken; and he has secured the finest photographs of star spectra yet obtained. The advance thus made is most important, for the spectra can now be measured and compared at leisure, free from all the difficulties which beset the direct analysis of the star-light.

In the magnificent physical observatory which has just been constructed at Potsdam, near Berlin, no expense has been spared to provide it with the best optical instruments. Dr. Vogel, the director, says that the spectroscope made by Hugo Schroder, of Hamburg, is a splendid instrument, and its twenty-one single prisms, combined into a system on Rutherford's plan, will enable him to measure one-hundredth part of the space between the D lines, and shows in the same space nine fine lines. When I saw this statement recently published, it recalled the information I had given you in November, 1875, viz., that nine fine lines had been seen at Berlin between D 1 and D 2 with the spectroscope then in use; that some years previously (1868) Dr. Huggins, using the great spectroscope at Oxford, saw twelve lines in the same space; and that Colonel Campbell, with a spectroscope made by Hilger, had in London seen nineteen lines between the two Ds; and comparing these statements with my own experience here, using a much finer spectroscope (also by Hilger, of London) which shows me seven lines between the two Ds, I was led to think that these differences must be due to atmosphere, and not to the quality of the spectroscope. If so, it is a most important question to determine; and I have therefore carefully examined these lines with our large spectroscope, which has a dispersion equal to eighteen, 64° prisms, while Colonel Campbell's was only equivalent to eight. The measuring apparatus of mine also admits of measuring one three-hundredth part of the space between the D lines. In order to identify the lines I have numbered them 1 to 7, beginning at D1, and their positions as determined by a number of readings with the micrometer are as follows :—

D1	1	2	3	4	5	6	7	D2	D3
000	41	67	124	151	173	213	232	291	299

4 is the nickel line always seen ; 7 is the position or very near it of the zinc line ; 1, 2, 3, 5, and 6 are evidently atmospheric lines, as they increased in distinctness very fast as the sun neared the horizon ; 4 also seems to enlarge as if there were an atmospheric line coincident with it, and 6 increased faster than any other; when the sun was near the horizon it was as thick again as D1 ; 7 did not increase at all, and almost disappeared when the sun was near setting.

The line D3 has not, I think, been described before. It is a difficult line to see, and only to be made out with high powers. I have not reduced my measures to wave lengths, because the results obtained by Dr. Huggins and Colonel Campbell are only recorded in drawings, without measures. I have had prepared enlarged drawings of those obtained in Oxford and London, with a careful plot from my own measures, which I now show you.

There are not many of the lines which agree ; but as Dr. Huggins used bisulphide of carbon prisms, and Colonel Campbell only eight prisms, some of the differences might disappear if all could be reduced to wave lengths. On closely comparing the drawings, it will be seen that five lines were recorded in London between my 7 and D 2, two others between D 1 and No. 1, and three between Nos. 2 and 3. These spaces appear in Sydney, even under the most favourable conditions, entirely free from lines, or any sign of them. It would appear, therefore, that there must be some gases in the atmosphere of Europe, and especially of London, which are not present in Australia. Whatever these may be, they have eluded chemical analysis, and they may prove to be of importance in judging of the purity of an atmosphere. If it should prove so, it will be rather curious that we are obliged, after all, to use our eyes to see what we breathe. Whether these lines indicate substances which make the difference between health and disease, cannot yet be decided; but there is no doubt that the air at times contains the cause of disease in such a subtle form as to elude all the ordinary modes of investigation.

Astronomers have this year to chronicle another temporary star, showing spectroscopic evidence of a sudden and extraordinary increase in its temperature. The new star, which was discovered on the 24th of November last by Professor Schmidt, of Athens, was of the third magnitude, and not far from Rho Cygni. On the 2nd December it was spectroscopically examined by M. Cornu, of Paris, and found to give a spectrum of bright lines, the positions of which were fortunately determined, although the star was then only of the fourth or fifth magnitude. Eight lines were measured, and five of these were found to be almost exactly coincident with C, D, E, F, and G of the Frauenhofer lines. So that the principal lines in the star spectrum coincide with the brightest lines of the sun's chromosphere seen in total eclipses, which seems to prove that the materials of the star were in a state of incandescence. It will be remembered that a still more remarkable star, giving a bright line spectrum, appeared in 1866—T. Coronæ Borealis—and in ten days faded beyond the limits of unaided vision.

Mr. Crookes seems disposed to give up the theory that the radiometer motions, or any part of them, are due to light only, for he says:—"I have recently succeeded in producing such a complete exhaustion in the radiometer that I have not only reached the point of maximum effect, but gone so far beyond it that repulsion nearly ceases, and the results I have thus obtained seem to show conclusively that the true explanation of the action of the radiometer is that given by Mr. Johnstone Stoney, according to which the repulsion seen in the radiometer is due to internal movements of the molecules of the residual gas."

On the other hand, a French *savant* (M. Ledieu), in a paper read before the French Academy, remarks, that the theory which explains the action of the radiometer by saying that light falling on black discs becomes heat, and so establishes a difference in temperature between the discs and the gas in the case, which produces the motion, expressly requires that there shall never be an equilibrium of temperature between the discs and the gas in the case of the radiometer; but this cannot be admitted, for the arms keep revolving at a uniform speed so long as the light is present. He had tried many experiments, and in one of them the instrument was heated nearly to redness, and the discs began to move, but the speed was sensibly accelerated by the momentary presence of a single flame, which joined its action to that of the radiant heat; and he had obtained perfect rotation in an instrument in which both sides of the disc were equally polished.

It will be remembered that in 1872 Herr Groneman, of Gönin-gen, propounded a new theory of the origin of the aurora. His hypothesis is that there are in space streams of minute particles of iron, revolving about the sun in the same way that meteors do, and that these, when passing the earth, become attracted to its poles, and from them stretch out as long filaments into space; but as they meet the earth's atmosphere with planetary velocity, they become ignited, and thus form the luminous aurora, giving with the spectroscope a green iron line. He has recently returned to this theory, and brought forward much additional matter in its favour. In connection with this subject the researches of Professor Nordenskiold are very interesting. He has been examining the purity of snow, both at Stockholm and near the North Pole. To north-west of Spitzbergen he found the snow contaminated with minute black particles, which proved on examination to be exactly the same as those found at Stockholm, and consisted of particles of metallic iron, phosphorus, cobalt, and fragments of Diatomaceæ.

From observations made in June last on two bright spots seen on Jupiter, Mr. John Brett infers that such spots have a proper motion on the surface of the planet, and that they are globular bodies almost as large as the earth; and he further infers, from their gradual disappearance as they approach the limb, that they are wholly immersed in the semi-transparent material of the planet. The rate of proper motion assigned to them is 165 miles per hour.

A most interesting inquiry is opened up by this observation—viz., whether there are such bodies revolving about Jupiter. The white and black spots so frequently seen, though better defined in outline, would seem to belong to some such system. Analogy of course would teach us to expect such forms as the results of cyclones in the atmosphere of a planet, in consequence of its rotation. But the rate of motion—165 miles in a hour—is certainly a difficulty, as the motion of storm centres on the earth is only 4 to 6 miles per hour; but it must not be forgotten that there are some barometer waves transmitted through our atmosphere at the rate of 50 miles an hour.

Professor Hall, of Washington Observatory, using the great 26-inch refractor, recently detected a small well-defined white spot on the planet Saturn. It was reported to six other American observatories and carefully watched; the mean of the observations gives a rotation period to the planet of 10 hours 15 minutes, which agrees very well with Sir. W. Herschel's determination, made in 1793–4, of 10 hours 16 minutes 0·4 seconds.

Professor Langley, of Allegheny Observatory, has just published some results of his solar observations, and gives it as his opinion that the solar atmosphere is proved to be a thin stratum, which cuts off one-half of the heat that would otherwise reach the earth. This, he considers, is proved by its action in producing the dark lines in the spectrum, or, in other words, stopping the light and heat of the sun; and he calculates that should this envelope be increased 25 per cent. in thickness, the mean temperature of our globe would be reduced 100° Fahrenheit, and possibly some such phenomenon took place in the glacial period.

The pendulum experiments which have been carried on in India in connection with the Trigonometrical Survey since 1865 have been reduced at Kew, and, it is said, offer incontestable evidence in confirmation of the hypothesis of a diminution of density in the strata of the earth's crust which lie under continents and mountains, and an increase of density in the strata under the sea.

The progress of meteorology during the past year has not been so rapid as many persons desire and think possible, but there can be no doubt that the widespread interchange of ideas and observations is tending to place meteorology in the position of a true science, from which we may expect a complete account of the motions of the earth's atmosphere and ocean, as well as of the various other elements which form climate; as well as the relations which subsist between them; and the cosmical phenomena which, without doubt, have much to do with the changes we see. Each step in advance seems to bring fresh proof of the intimate relations which subsist between the earth's atmosphere and the sun's surroundings, and of the necessity for combining the study of these branches of science.

How far the former is a result of the latter no one is at present prepared to say; but the many efforts which have been made to show the dependence of meteorological changes on sun spots, and the amount of evidence brought forward to prove it, show how commonly the belief is entertained by those who reason on the subject.

Meantime meteorology is rapidly extending its practical side, and the great success of weather maps and storm warnings in England, France, and America, especially the latter country, has led to their adoption by other European States; and there seems little doubt that Europe will soon be covered by an international system which will afford as much information to the seaman and the farmer as the weather-map of America does. In Australia we may congratulate ourselves on having made a beginning; and the weather-map that has been published daily in Sydney since the 3rd February, 1877, is only the first of a series which will be published daily in each Colony; by which means the information which is now being freely exchanged by the four Colonies, South Australia, Victoria, Queensland, and New South Wales, will be placed before the public. As the method of producing the weather-map here is novel and different to that adopted in England and America, perhaps a few words of explanation may be devoted to it. In England, after the telegrams are received, a map is prepared by hand for lithographic printing, and 500 copies are printed by 3 p.m. each day, and distributed to subscribers, who pay a moderate sum for the information. Several of the daily newspapers reproduce portions of this map by engraving it on a block, and taking a cast from it, which is again stereotyped ; such at least was the method when I last heard. In America a stock of outline maps of the States is kept ready to receive the weather information. Such parts of it as can be given in type are set up and printed on the outline map. The isobars are then put on a lithograph stone and printed on the map, which is then transferred to the stone containing isotherms, and there receives its fourth and last printing, and is ready for distribution early in the afternoon ; but it is not, so far as I am aware, reproduced by the newspapers. About 2,000 copies are distributed daily by post, and must of course take days in reaching some places.

In Sydney the map is prepared in this way :—A block of metal of the size of the map, and one-eighth of an inch less in thickness than the height of ordinary type, has fixed upon it an electro outline of the coast and mountains of the eastern half of Australia ; the electro is just of the thickness required to make it type high. At the position which each station occupies a hole is cut in the block, of the right size to receive the wind symbol, and the type necessary to express the force of wind, height of barometer, letter for rising or falling barometer and the temperatures. Spaces are also cut out to receive the list of temperature and rainfall, also for the explanatory matter. The rest of the block is flat, and, as I have stated, ⅛-inch lower than the type. When the telegrams have been reduced and corrected, they are given on a convenient form to a compositor, who in a short time makes all the changes that are necessary to convert the figures of yesterday into those of to-day.

The compositor has also a set of sea symbols, wind arrows, words, &c., to express any information that is to be given on the map; these are simply glued on to the block wherever they may be required, and as they are only $\frac{1}{8}$-inch high, they just come to the height of the type. If any curves are required on the map, they are bent by hand from strips of soft metal rolled $\frac{1}{8}$-inch high, and are glued on to the surface in the same way as the other symbols. As soon as this is done it is ready to print from in an ordinary press, and a few copies are printed off for distribution. The map is then sent to the *Herald* Office, and there stereotyped for the morning's paper, after which it is returned to the Observatory for next day's map. In this way it is thought that the information reaches the public sooner than it could by any other method. There is, however, nothing to stop the issue of copies each day soon after noon if thought desirable; for it is evident that the time required to prepare this map is less than others referred to, and printing from type can be done much quicker than from a lithograph stone.

Turning now to other matters: it will be remembered that experiments on the amount of sunshine were made in London, by placing a globe of clear glass in a hemispherical cup of wood, and estimating the amount from the wood carbonized. The method was, it is true, exceedingly rough, but it yielded an interesting result; unfortunately it turned out that no satisfactory estimate of the amount of energy could be obtained. Dr. Roscoe invented a small machine to get over the difficulty, by exposing, at regular intervals during the day, small pieces of sensitive paper, with the object of calculating the sun's heating power from the amount of silver decomposed, but it has not been found to give the information required, that is, a continuous record of the sunshine. Mr. Scott, Director of the Meteorological Office, London, has now designed a modification of the original instrument. Instead of wood to be burnt he uses slips of cardboard ruled into hours; these are placed daily at the back of the glass bulb, and each day therefore has its own record. This is a great improvement, but we are not told how the effect is now to be measured; and there is some difficulty in the way, since the weight of the cardboard would vary with the state of the weather, and this would be a serious difficulty if the sun's effect is to be ascertained by weighing.

In connection with this subject, it will be remembered that about seven years since a French inventor, M. Mouchot, exhibited before the Emperor a steam-engine worked by direct sun heat. He has been working at the machine ever since, and some of his recent results are so good that it seems probable that direct sun heat may in warm, fine countries become an economic source of power.

The machine is thus constructed:—A mirror in the form of a truncated cone, 74 inches in diameter, has its axis converted into a boiler 11 inches in diameter and 31 inches high. With this the mirror makes an angle of 45°, so that all the rays falling on it are reflected into the boiler. To prevent loss of heat by radiation, the boiler is covered with an air-tight glass case. This apparatus is placed on an axis parallel to that of the earth (a polar axis) and then turned so that the axis of the cone points to the sun. Clock-work is then connected to the polar axis, and keeps the mirror turned to the sun. The results obtained in ordinary weather are as follows:—4 gallons of water introduced at a temperature of 68° Faht. at half-past 8 a.m. were turned into steam of 30 lbs. pressure per square inch in forty minutes. The pressure was then allowed to rise to 75 lbs. on the inch, which it did in a few minutes, but the boiler was not strong enough to carry the test to a greater pressure. The steam was used to drive an engine and a pump. At another trial the machine distilled a gallon of wine in fifteen minutes.

These are surprising results to be obtained in the climate of France, and seem to make the experiment worth trying on our sunny plains.

Another use, however, might be made of it. Such an instrument, properly constructed, might be kept at work always, and made to deliver the water distilled into measures placed at fixed intervals (hours or minutes) during the day, and the water so collected would form an exact measure of the sunshine.

Mr. Glashier, in a paper on the mean temperature of every day at Greenwich, from observations taken there from 1813 to 1873, has made a valuable contribution to science. The results have been plotted into a curve, representing amongst other things the variation of the temperature throughout the year. From this it appears that in January the curve is normal, but in February there is always a considerable rise between the 5th and the 10th of the month, and a fall between that and the 15th. The curve is rather unsteady during March and April, and in May it shows a remarkable depression between the 10th and the 15th, which Mr. Glashier thinks is probably due to some astronomical cause. The curve also shows rather sudden depressions about the 30th June and 8th July, and is then normal until the 5th or 6th of November, when a remarkable depression sets in and lasts about three weeks. (During this time the earth passes through the November meteor shower.) During December the curve is normal again. Considering the length of the series from which these results are obtained, it would seem probable that all the irregularities in the curve are due to some external cause; or, in other words, to the intervention of something between the earth and the sun, which for the time adds to or absorbs the sun heat.

Turning from these interesting *mean* results, we find that during the year extremes have been reached both *in* the earth and near the pole. A remarkable series of observations on underground temperatures have been taken in a boring made at Sperenberg, near Berlin. The bore was carried to the extraordinary depth of 4,172 English feet. The first 283 feet of it were made in gypsum, with some anhydrite, and the remainder entirely in rock-salt. The greatest depth at which the temperature was obtained was 3,491 feet, as the upper part of the bore was lined with iron pipes, and could not therefore be plugged to prevent convection of heat. The first temperature was taken at 721 feet from the surface. Two plans were adopted for securing the actual temperature of any part of the bore. First, in sinking it, when the temperature was to be taken, a smaller bore was driven in advance for several feet; into this the thermometer was lowered, and a wooden plug driven into the top of the small bore, so as to prevent convection affecting the temperature. After the thermometer had remained in from twenty to thirty hours, it was withdrawn and read. The other method was, to cut off by means of two plugs sections of the well, in which a thermometer was kept about the same number of hours. I give the results of these measures:—

Depth in feet English.	Difference.	Temperature corrected for pressure, Faht. scale.	Difference.	Increase per 100 feet.
		*48·2		
721	206	70·9	......	......
927	206	74·3	3·4	1·7
1,133	206	79·6	5·3	2·7
1,339	206	80·4	0·8	0·4
1,545	206	84·4	4·0	2·0
1,751	206	87·6	3·2	1·6
1,957	206	91·6	4·0	2·0
2,163	206	96·5	4·9	2·5
3,491	1,328	115·8	19·3	1·5

* Mean temperature of air at the well.

This gives an average of 1° Faht. for every 51·5 English feet, and the increase for the last 1,300 feet was not so rapid as in the higher levels.

Turning now to the other extreme, we learn from Captain Marham's letter to Commodore Hoskins, *re* Polar Expedition, that:—

"The cold up to the end of February, 1876, was not felt severely, although the temperature was ranging from – 30° to – 60°; but during the last few days of that month and beginning of March the cold was intense, the temperature falling as low as – 74°. This, I believe, is the lowest that has ever been recorded. In this temperature glycerine became perfectly solid and quite transparent, rectified spirits of wine became of the consistency of hair-oil (for want of a better simile), whisky froze hard, and we were able to break off pieces and eat it. Concentrated rum, 30 o.p., also froze hard in a shallow saucer, and in a bottle resembled frozen honey or molasses in regard to thickness. On chloroform, however, no apparent effect was produced. The lowest mean temperature for twenty-four consecutive hours was − 70·3 ; for thirty-six consecutive hours it was − 69·93, and for six days the mean was − 60° or 92° below freezing point. Latitude of station, 83° 20′ 26″. May 12, 1876."

It will be remembered that the lowest temperature ever recorded in balloon experiments was 44° below freezing point − 12°, at six miles high (32,000 feet), on September 5, 1862.

I have already detained you too long, and with just an allusion to an interesting question raised by Mr. J. A. Brown, of London. I will close. Mr. Brown, in a paper on simultaneous variations of the barometer, shows, from observations made in Europe, Asia. Africa, America, and Australia, that during the week, March 31 to April 5, 1845, all the barometer curves exhibit a maximum near the beginning, and another near the end of the week, with a minimum near the middle ; and he asked whether there may not be other causes of varying atmospheric pressure than a change of the mass of the air ; in other words, whether the attraction of gravitation is the only force concerned in barometric oscillations. Admiral Fitzroy strongly objected to the theory that the curve of the barometer indicated the height of atmosphere over it, or that it represented atmospheric waves ; and he thought these effects were due to the action of the polar and equatorial currents on each other, and showed that these waves of pressure travel to north-east and south-west, and are quite distinct from the local changes in pressure due to storms, &c. Their rate of motion also is quite different from that of storms, which make from 4 to 6 miles per hour only ; while these waves of pressure travel here over south-eastern Australia at the rate of 20 miles, and in some cases 50 miles an hour. They are a very marked and interesting feature in our meteorology, and their uniform progression over the whole of south-east of Australia at the rate mentioned seems to me at variance with Fitzroy's theory that they are caused by air-currents. A glance at the curves, plotted for a year over the whole Colony, shows that these waves uniformly travel from west to east, and in most cases so rapidly that the crest appears all over the Colony on the same day. Such a rapid translation seems to me to point to some external cause; and on comparing Sydney barometer curves for 1873 with those of Greenwich for the same year, I was struck with the number of coincidences in the character of the curves. In many cases the points of elevation and depression occur on the same day at both places, and in several instances the curves follow the same form for more than a month. There are great temporary differences, due no doubt to local causes, but the similarity is very striking.

It is somewhat difficult to see what could make a simultaneous loss of atmospheric pressure in the two hemispheres, unless it be the heat of the sun acting more intensely on the equator, and so making a great demand on the trade winds which are supplied from temperate latitudes, and would, in that case, draw off the pressure. The fact that such a loss of pressure causes an in-rush of polar wind seems to confirm this view. That there are such sudden changes in the sun's heating power has been shown in many ways, and notably by Mr. Glashier, in the paper I have alluded to to-night.

The Forest Vegetation of Central and Northern New England, in connection with Geological Influences.

By W. Christie.

[*Read before the Royal Society of N.S.W., 4 November,* 1876.]

In venturing to consider the subject of forest vegetation in connection with its geological influences, I purpose limiting my remarks to that portion of the Colony with which my ordinary avocation has, by bringing me into daily contact with it for the past few years, made me the more familiar, viz., Central and Northern New England.

Various important reasons have led me to thus limit the territory under consideration. The first is—That by confining myself to one district, with which I am intimately acquainted, my remarks will be more accurate and reliable than would be possible were I to extend them to those portions of the Colony over which my observations have been more limited and casual. Secondly—That the region in question presents a sufficiently varied geological character to illustrate many of the effects of geological influence on the indigenous forest vegetation. Thirdly—That, inasmuch as the climate of this region is nearly uniform over its whole extent, the question may be considered more directly within itself than it could be were the complications arising from climatic changes to be entered upon in connection with it. And fourthly—That as the general rules which may be strictly applicable in this and other districts having a similar climate may and in fact in many cases do not apply in those districts which, from geographical position or other causes, are subjected to different climatic influences, it is probable that the interests of the subject under inquiry may be better served by first considering the rules obtaining in separate and limited areas; and then, by considering their differences in connection with the known effects of climate on vegetation, we may arrive at a knowledge of those laws which appear to govern the forest growth in connection with its geology. It is with the view only of offering my contribution to the first of these aspects, that I have ventured to compile my notes on the subject, feeling that the question in its entirety involves so many and varied considerations, which are intimately blended one with the other, as to render it almost impossible to even touch upon them all in a brief paper like this.

Having been disappointed in arrangements which I had made for the illustration of my remarks by photographs of portions of the characteristic forests of this district, I have adopted what I conceive to be the next best course, viz., that of accompanying them with specimens of the principal timbers and soil. The specimens number about sixty, and I trust will give a tolerably clear idea of the various combinations of soils and timbers which I purpose to consider. Of the genus *Eucalyptus*, which occupies by far the most prominent place in the forests of New England, I have collected twenty species. The total number inhabiting this district probably amounts to thirty or more; but while a large number of the varieties of this genus which prevail on the eastern slopes below the steep escarpments which so well define the boundary of the plateau to the east does not ascend to the elevated and colder regions of New England, and many varieties which are common in the region to the west of the table-land do not encroach upon its naturally defined limits, there are yet some which, I believe, are peculiar to it. Those are, at any rate, not found on or below either of the slopes, nor have I seen them in any other part of the Colony north or west of Murrurundi.

As an instance of this change of species, which occupy apparently the same relative positions in different localities, and as showing the difficulty of defining any general conclusions from observations in any one district, I will mention the river gum of of the interior (*E. rostrata*). This tree, according to Dr. Woolls, does not occur at all to the east of the Dividing Range. It is, however, common on the western rivers. I have observed it on all the waters from the Mooki and Namoi Rivers north to the Dumaresq. It lines the banks of those rivers to within a few miles of the plateau, when it generally yields its place to the river oak, one of the *Casuarinæ*. On the plateau, however, the gum-tree which occupies the place of *E. rostrata* under exactly the same conditions, so far as soil and geological formation are concerned, is known by the local name of "Sally" (described No. 8). The name is probably a corruption of *E. saligna*. (I do not think, however, that this is the species which frequents the low grounds about Parramatta, as mentioned by Dr. Woolls in his "Flora of Australia," p. 231.) But on the eastern waters a species distinct from either of those mentioned frequents the river banks. It is known as the flooded or blue gum (*E. Eugenioides*).

The fact of those three species inhabiting the same kind of soils and localities in their respective districts, while neither of them appears to encroach on the territory of the others, seems to show that they are not only influenced and kept within their own proper limits by climatic influences, but that the impregnation of the atmosphere by the salts of the ocean has some share in the division of the forest vegetation. What that share is, or what influence the climatic effects exert, is beyond the object of this communication; but they may be incidentally refered to, where a comparison between the occurrences on the plateau and those in its vicinity may tend to eliminate any point in the inquiry.

The greater portion of Central New England is composed of granitic formations. These occupy very large tracts, and in the stanniferous regions the country is generally characterized by rough, almost inaccessible, ridges, covered with huge blocks, alternating with swampy valleys of a soft, rotten nature, over which in wet weather it is almost impossible to travel. The granite for the most part is similar to specimens marked Q, and the soil formed from its detritus retains a very large amount of moisture; so that if the wheels of a vehicle break through the outer crust, the argillaceous matter from below spirts up and is soon worked into a bog, out of which it is almost impossible to be extracted. Numerous tracts of such country as this occur about Guy Fawkes and Oban; and the Dividing Range, between the Severn and Mole Rivers, is composed almost exclusively of such formation. Those localities are all characterized by the same description of forest vegetation. Stringy-bark (specimen 19), *Eucalyptus amygdalina*, attains here large dimensions, more particularly in the rough and elevated ranges, where it is the prevailing timber, and is usually accompanied by undergrowths of saplings, *Acacia*, and frequently *Banksia integrifolia*. There the sward is generally composed of blady grass and rushes. Tracts of undergrowth of scrub oak generally occupy the summits; but as we descend into the valleys, the peppermint (specimen No. 13), *Eucalyptus hemiphloia*, mixes in the forest with occasional red gum (specimens 2 and 2A), *Eucalyptus resinifera*, and blue gum (specimens 3 and 3A), *Eucalyptus tereticornus* (?) As we leave the more rugged tracts, the peppermint becomes more and more the predominant timber; and frequently the low ridges forming the valleys of the larger streams are clothed with a fine open forest in which no other timber mixes. This timber is almost invariably found on granitic soils, and generally where it occurs the undergrowths are less dense, and the grass richer and better than in other growths on those soils. On the banks of the streams in such localities the sally occurs, and occasionally enters into combination with the peppermint for some little distance back. The small-leafed shrubby tea-tree, *Leptospermum parvifolium*, grows in the bed of the streams, but is never found beyond the limits of the bank. In those tracts in which the granite contains a larger proportion of quartz than that described, various species of the group *Leiophloiæ*, smooth-barked trees, of the genus

Eucalyptus, mix in the forests. The most common of these are the white gum (specimen No. 9), *Eucalyptus hæmastoma*, the grey gum (No. 7), *Eucalyptus sp.*, red gum (Nos. 2 and 2A), *Eucalyptus resinifera*, and a species of spotted gum (Nos. 1 and 1A), *Eucalyptus sp.* There are, I think, only four members of the group *Hemiphloiæ* found in this district, two species of yellow box, the white box (*E. hemiphloia*), and a timber sometimes called black-but, and sometimes messmate, *Eucalyptus obliqua* (Nos. 10, 20, 11, 12). The white box, so far as I have seen, never occurs on granitic soils. A species of yellow box (No. 20), however, appears to be peculiar to granitic, elvanite, and sandstone formations, and is so very like the white box that it is frequently taken for it. This tree, however, has a small leaf, and the shape of the seed-vessel is quite different from that of the latter; it is also very much more fully barked, and, on examination, I have found that in various localities in which box was said to exist on granitic or elvanite soils that this tree had been mistaken for it. The other three members of this group, however, are in some localities numerous among the combination mentioned, and it appears that the more sandy the detritus from the granite is, owing to the larger amount of quartz contained therein, the greater the diversity of this genus, and the greater the liability to the intrusion of trees of other characters. The *Banksia integrifolia* (No. 38), *Acacia*, and various undergrowths, generally occur more plentifully in those soils. It may be worthy of remark that, in all the localities of this district in which I have seen the *Banksia* growing, molybdenite has been or may be obtained in the rock. This, however, is probably accidental.

The soils of granitic formation are generally considered unsuitable for sheepwalks. It is certain that on those soils sheep are very susceptible of "foot-rot" and "bottle," unless they are under very careful management; but that they *can* be profitably kept on them is proved by the fact that during the past few years numerous farming selectors have settled on this formation, and, having given their attention to sheep-breeding, are becoming quite prosperous on portions of country which were said to be unfit for anything but cattle. At Wellington Vale, which is of almost exclusively granitic formation, under the able superintendence of my friend Mr. A. E. Gaden, I recently saw an offer of £2 per head refused for 100 out of a small flock of 300 ewes which had been bred on that run. These facts are more eloquent than language, in pointing out what may be done by careful attention on the generally despised granitic sheep runs.

With reference to the "bottle" disease,—a selector about two years ago pointed out to me a small plant which he called the bottle weed, and he assured me that sheep contracted the disease by eating it. The plant grows to a height of from four to six inches, bearing a small pink flower; and having had my attention thus directed to it, I watched it carefully on every opportunity that offered, and find that it is carnivorous, preying upon gnats, mosquitoes, and such small winged insects; it is botanically known as *Drosera peltata*.

The weed, however, grows on swampy or damp granitic or elvanite flats, and it is in those localities that the bottle disease is generally contracted. Whether the plant really has anything to do with it, I cannot of course say; but I think it more likely that the disease arises from the animals inhaling some miasmatic atmosphere obtaining in those localities to which the plant is peculiar.

The apple tree (*Angophera subvelutina*) occurs in some localities on granitic soils; but there appears to be a difference in the leaf between this and the apple tree of black basaltic alluvia. In the latter tree I believe the leaves are invariably opposite, with a very short petiole; but in the former, numerous branches may be obtained on which the leaves are alternate, and having a petiole of from half to three-quarters of an inch in length, giving the tree the appearence of having been influenced by hybridization. In other respects I have been unable to trace any differences between them.

In those tracts covered by elvanite formation, which are numerous and extensive on the north-western slopes of New England, as well as in many other localities scattered throughout its area, and which occupy a large proportion of the rough and broken country lying between Strathbogie and the Dumaresq River, the vegetation is characterized by plants which seldom, if ever, occur in granitic soils. The yellow ironbark (No. 17), *Eucalyptus leucoxylon*, and the common ironbark (No. 18), *Eucalyptus siderophloia*, occupy the most conspicuous place in the forest, and are frequently accompanied by a stunted red gum (a smooth-barked tree, attaining a height of fifteen to twenty feet, with a diameter seldom exceeding twelve inches), and occasionally by stringy-bark. In the warmer portions, such as at or near the base of the mountains forming the southern side of the valley of the Dumaresq River, and where the character of the rock merges more into that of sandstone, pines occur to a limited extent. On those soils (the characters of which are exhibited by specimens marked A, H, IH, and M, from various portions of the district) the dogwood (*Jacksonia scoparia*) and grass-tree (*Xanthorrhœa media*) are invariably found as undergrowths, accompanied by a stunted species of acacia. Most of the undergrowths of this soil are exhibited by specimens Nos. 21 and 29.

The timbers generally on this class of soil are hollow, and do not attain that luxuriant growth which marks most of the vegetation occurring on granite. This is frequently more marked in those localities contiguous to soils of a more fertile kind, such as where basaltic formations overlie the elvans, and the timbers generally appear to dwindle and lose a great portion of the limited vigour which they attain at a greater distance from the better class of soil.

In localities where the prevailing rocks are micaceous quartzose granite, with numerous outcrops of quartz and dykes of slate (as specimens R, S, and T), such as on the Dividing Range between Dundee and Glen Elgin, scrub oak, and two or three species of acacia, among which is that known as *Lignum vitæ*, combine in forming dense undergrowths in a forest composed for the most part of stringy-bark and red gum. Forest oak is of frequent occurrence on the adjacent flats in this and the preceding formation; but this timber appears to be more common about their edges, where the detritus from the adjoining formations mix. Under such circumstances there is always a marked difference in the forest vegetation, as the different species which abound on the separate formations in their pure state become combined in the same groups, and frequently trees which are not to be found in either take up their positions here. The spotted gum (Nos. 1, 1A) *Eucalyptus species*, in many cases assume very defined limit under those circumstances, when it is not found growing in either of the surrounding soils.

New England owes much of its prosperity to the influence of its extensive tracts of soil of basaltic origin, which extend over a very large portion of its western slopes, and form those rich alluvial flats which offer so great an attraction to the agriculturist, and the good sound ridges, so excellent as sheepwalks.

On those soils the effects of climatic change on the forest vegetation appear to be more visible and marked than on any others in New England; and although they vary considerably in different localities, and generally the variations are distinguished by a corresponding change in the vegetation, yet in most cases the changes, owing to climatic effects, are so well marked that no reasonable doubt can exist as to their cause. For instance, the white gum (No. 9), *Eucalyptus hæmastoma*, in the colder portions, such as about Ben Lomond and Glen Innes, forms open forests, for the most part of large timber, with a slight intermixture of peppermint. On rich black basaltic soils it is almost wholly replaced as we approach those warmer regions below the falls to the west by the white box (*E. hemiphloia*). The peppermint disappears altogether on exactly the same class of soil on which it flourishes in the lower temperatures, while the number of species of the genus *Eucalyptus* which enter into combination appears to be increased.

On the soils of the colder regions the prevailing timbers are this species of white gum, with apple-tree; the vegetation in the warmer is usually composed of white box and apple-tree, intermixed more or less with yellow box (sp. No. 10), *E. bicolor* (?), two species of white gum (Nos. 5 and 9), *Eucalyptus Stuartiana* (?) and *Eucalyptus hæmastoma* and a little acacia and native cherry (*Exocarpus cupressiformis*). These latter, however, are common in both the climates as an occasional undergrowth to the forests named; but while they are frequently found in this class of soils, they are by no means peculiar to it, being found largely in argillaceous rock formations, granite, &c.

The rich red friable basaltic soils, such as specimen marked G, appear to be always characterized by a forest growth, consisting for the most part of stringy-bark (36), with one or two specimens of half-barked trees, such as messmate or blackbut, with a dense undergrowth of wattle, acacia, and wild hop (*Daviesia latifolia*). A very large tract of this class of soil occurs to the west of Vegetable Creek, and another of similar nature, but smaller, at the back of Glendon estate. Those localities differ some 1,500 feet in elevation, but the vegetation is very similar throughout. There is a similar tract of country some 20 or 30 miles north-easterly from Tenterfield, and another 10 miles north of Wellington Vale. Although those localities differ considerably in elevation above the sea level, and their climates vary quite sufficiently to show their effect on the forest vegetation, so far as other timbers are concerned, they are all characterized by the same kind of vegetation: and I have never observed any timbers on one of them that are not found on the others.

The white box appears to grow chiefly on stiff red or black trappean soils, and while it occupies the largest portion of the ridges and elevated ground, the apple-tree (*Angophera subvelutina*) predominates on the flats. A white gum (specimen No. 9), however, occasionally grows in those situations—in fact, so far as the particular region in question is concerned, this species appears to be common to more classes of soil than any other; but on the colder portions the parasite *Loranthus aurantiacus*, a species of mistletoe, is common on it, while in the warmer regions it is of more frequent occurrence on the red gum (specimens 2 and 2A), *E. resinifera*, which for the most part grows on poor soils.

On those soils the Darling pea (*Swansonia galegifolia*) appears to flourish luxuriantly. This pest is gradually but surely making its way up to the table-land from the warmer and richer regions to the west, and is a source of great trouble and annoyance to flockmasters. Two years ago this plant was comparatively rare on the Rocky Creek Run, which is situated to the east of Ashford, and just within the confines of New England; but I was informed the other day by Mr. Gordon, proprietor, that at the present time this noxious weed had spread to such an extent as to curtail the carrying capacity of the run by nearly one-half. I have not yet observed this plant on the table-land, and I trust that many years will elapse before it makes its appearance there.

The Bathurst burr (*Xanthium spinosum*) and two species of thistle have, however, not only made their appearance on New England, but are already making considerable havoc on many of our best tracts of agricultural land. Those well-known plants appear to be little affected by the influence of either soil or climate; wherever the seed may chance to be dropped they spring up most vigorously, soon choking all the other vegetation which existed on the spots overrun by them.

The degree of decomposition which the highly ferruginous basaltic soils have undergone appears to have a considerable effect on the indigenous vegetation. On those rich friable soils, such as specimen marked G, which is from a continuous range which I have traced for more than 30 miles, and is almost all of the same character, with occasional pisolitic nodules scattered over the surface, the vegetation is throughout stringy-bark, acacia, wild hop (*Daviesia latifolia*).

This soil is to all appearance composed of exactly the same material as that exhibited in specimen B, but has undergone a greater amount of decomposition, to which, I think, it owes its much higher state of friability. On this latter, however, which for the most part in this district occurs in patches, the vegetation is in all cases totally different to what it is on the former, being a white gum—specimen No. 5—(*E. Stuartiana ?*) and apple-tree (*Angophera*), with occasional accacia. The line of division between those two soils is usually very easily defined; and although the patches of the latter, which consist almost entirely of pisolitic nodules, with very little real soil, may be entirely surrounded by other vegetations, they are seldom if ever encroached upon by them.

In reviewing the various facts which I have endeavoured, with, I fear, but inadequate success, to lay before the Society, with reference to the connection between the indigenous forest vegetation and the principal geological formations of Central and Northern New England, it will be observed that, while many of the timbers are common to various soils, and some are common to them all, there are others which frequent only one class. Thus, the common wattle (*Acacia decurrens*) is found in almost every formation; so also is the stringy-bark in some of its varieties, and many other trees of the genus *Eucalyptus*; but the timber known as peppermint (*E. amygdalina ?*) is almost exclusively found on granitic country, as also the "Sally" (*E. saligna*) and the grey gum (*E. coracea ?*). On this soil those timbers are generally found in the drier localities, while the stringy-bark frequents moister regions. Varieties of iron-bark—the dog-wood (*Jacksonia scoparia*) and grass-tree—frequent elvanite and porphyritic regions, and are seldom found on any other; while the white gum (specimen 5), *E. Stuartiana? Daviesia*, the wild hop, appear to be peculiar, or nearly so, to basaltic soils, and stringy-bark to those soils in its driest and most friable portions.

There appears to be an amount of regularity in the various combinations of timber trees in the forest vegetation in connection with its geological alliances which can hardly be accounted for, except by the supposition that there is some general law which governs them. Although the observations made in one limited district will probably not afford sufficient information on which to determine what that law is, still I venture to think that a comparison between its effects in a few districts where, the climates being known, their effects may be considered in conjunction, will so far illustrate its general principles as to render an acquaintance with them of great practical utility.

Nor do many of the effects of this law differ to so great an extent in various localities and climates as may perhaps be supposed. Many of them have for several years had their recognized significance in pastoral and agricultural matters. Such phrases as "Box Forest," "Iron-bark Ranges," "Apple-tree Flats," "Stringy-bark Ridges," "Myall Plains," &c., have all had their own respective associations in the minds of those interested in the pastoral or agricultural capabilities of land, ever since the Colony began to assume a prominent position in these pursuits; and, what is more, those associations are the same throughout all parts of this Colony and Queensland, showing that those timbers, being more widely spread than most other species, obey the same general law throughout. But the associations resulting from those observations were thus early arrived at because, involving as they did a large amount of pecuniary interest, the observers were much more numerous than they otherwise would have been; and while those results which immediately affect individual prosperity are well known, all the surrounding circumstances appear to point to the same geological influences over the other forest vegetation as control the few examples named, which, although subject to certain local variations arising from climatic or other considerations, are regular when the value of those causes of variation is considered and allowed for.

APPENDIX.

The following are descriptions of twenty-one species of the genus *Eucalyptus* found in Central and Northern New England. Specimens were exhibited at the meeting when this paper was read:—

SPOTTED GUM.—Group *Leiophloiæ* (specimens No. 1 and 1A.)—The bark of this tree is smooth, but more of a lead colour than most of the ordinary species, and is mottled with light and dark patches, caused by the falling off of the outer skin. *Leaf:* The leaves are lanceolate, from five to six or seven inches long, and alternate, supported on petiole 1 inch in length. The midrib is slightly above the plane of the leaf, and the marginal nerve is indistinct; a distinct nerve runs round the outer edge of the leaf. *Seed-vessel:* The umbels contain generally seven florets, six of which are set on the peduncle at right angles to it, and the seventh stands upright in the centre. The operculum is three times as long as the capsule, and is conical, the pedicle about a quarter of an inch long, and peduncle about the same length. *Wood:* The wood is hard and tough, and is said to be durable as fencing material. *Habits, &c.:* This timber grows generally about the junction of rich soil with that of a poorer class; in localities where the wash from a rich basaltic ridge mixed with that from granite or sandstone, this tree would be found growing. In some localities this is very much defined. At the Nine-mile Creek, where one ridge is basaltic and the other granitic, a tin miner informed me that he worked as far as the line of gums, and that the stanniferous washdirt never encroached on the ground occupied by them. The gums there are of this species, and I have observed that it always in this district grows under those conditions mentioned.

RED GUM.—Group *Leiophloiæ* (specimens Nos. 2 and 2A).—The bark of this timber is of a greyish-brown colour, and the wood is red, and very hard and brittle. It is a durable timber for fencing material. *Seed-vessels:* The umbels contain from seven to ten florets. The operculum, which is conical, is two and a-half times as long as the capsule. The capsule is four-celled, and the valves protrude. Its margin is not well-defined on the fully developed seed-vessels. A red streak runs round the junction of the operculum with the capsule. It sometimes has a smeared appearance, as if the streak had been drawn with red ink and partly wiped off again. *Leaf:* Alternate, and from six to eight inches long. When held to the light it appears mottled. It is of a dark bluish-green colour, not glaucous, and the midrib is prominent on under side. The marginal nerve is well-defined. *Habits, &c.:* This tree is found generally on patches of poor elvanite outcrops, among basaltic soils, in company with box and apple; but where the soil is granitic with elvans, its combination is stringy-bark and iron-bark, with various undergrowths. The parasite *Loranthus aurantiacus* (mistletoe) frequently grows on this tree in the latter kind of soils.

Blue Gum.—Group *Leiophloiæ* (specimen No. 3).—This tree is very similar in general appearance to the spotted gum and red gum of this district. It is difficult to distinguish between the barks of those three timbers. The wood is hard and brittle, of a deep red colour, and has a high specific gravity. The leaf is ovate on this species, whereas on the other two named above it is lanceolate. It is of a bluish-green colour, slightly glaucous; the midrib is prominent on both sides of the leaf, and the veins are very distinct. Generally alternate, but sometimes opposite, the leaf is from 4 to 5 inches long and 1 wide, supported on petiole of ¾ of an inch in length. *Seed-vessel:* The seed-vessel differs considerably from all the other species on New England. The umbels are not regular in either the number of florets or their systematic arrangement on peduncle. Many of the florets appear as if they had been stuck on at random. The operculum is two and a half times as long as the capsule, and is of about the same dimensions throughout, having a blunt, rounded extremity. The capsule is thicker than the operculum, and forms a defined step at the junction, looking as if the operculum had been stuck *into* the capsule. The peduncle is three times as long as the pedicel, and twice as long as the capsule. The vessel, after parting with the operculum, has a well-defined lip round the orifice, through which the valves, which are very pointed, protrude. It is sometimes three and sometimes four celled. *Habits, &c.:* Grows chiefly on poor soils, partly granitic and partly elvanite; accompanies iron-bark, stringy-bark, and some other gums. In the swampy portions of such soils a plant known as *Drosera peltata*, or *bottle-weed*, which is a flesh-eater, grows.

Blue Gum.—Group *Leiophloiæ* (specimen No. 3a).—This tree, in the arrangements of the florets in the umbels, is somewhat similar to the previously described blue gum, and the barks are very similar; but the wood of this species is not so red, nor does it appear to be so hard. The leaf is more lanceolate than that of the tree named. The midrib is prominent on both sides of the leaf, and the marginal nerve and veins are coarse and well-defined. The leaves are alternate. The petiole is three-fourths of an inch long. *Seed-vessel:* The operculum is two and a half times as long as the calyx, and before it is cast off the vessel has a blooming red mottled colour, similar to that on ripening peaches. The peduncle is about as long as the operculum and calyx together. The umbels generally start from junction of leaf stem, but not always; this appears in some way to depend upon the age of the tree. *Habits, &c.:* Grows on similar soils and in similar situations to that previously described.

BROWN-BARKED GUM.—Group *Leiophloiæ* (specimen No. 4).—Bark reddish brown, smooth and slightly mottled. The wood is red and hard. The leaf is from 3 to 4 inches long, and 1 wide, supported on petiole ¾ of an inch in length, alternate, midrib well defined, marginal nerve rather indistinct, veins very numerous, light bluish-green in colour, and very glaucous. *Seed-vessel:* The umbel generally contains seven florets, six of which radiate, and the remainder stand in the centre. On the young vessels the pedicel is short and thick, but as the calyx becomes more developed the pedicel becomes thinner. The peduncle is three-tenths of an inch long. The capsule is about one-third *shorter* than the operculum. The glaucous appearance is very observable on the young seed-vessels. The calyx is generally three but sometimes four celled, and the valves protrude. The flower is of a yellowish-white colour. *Habits, &c.:* Grows generally on patches of poor soil, on otherwise good country; such, for instance, as about porphyritic or elvanite dykes, or outcrops in basaltic formations. In such situations it generally has an undergrowth of dogwood (*Jacksonia scoparia*) and a little grass-tree.

WHITE GUM.—Group *Leiophloiæ* (specimen No. 5.)—Bark smooth and clean, slightly mottled, and at the present time (November) the outer skin hangs in long strips from upper branches. The leaves are generally opposite, many are stem-clasping; the petiole seldom exceeds a quarter of an inch in length. The midrib is well defined and prominent; the marginal nerve and veins are delicate. *Wood:* Light-coloured; heavy but soft; it is not considered durable where exposed to the action of the weather. *Seed-vessels:* The seed-vessels are in umbels of three florets; the operculum is slightly longer than the capsule; the pedicel is one-third as long as the peduncle; some capsules are three and some four-celled, and the valves protrude slightly. *Habits, &c.:* This timber generally grows in rich red basaltic soils which are stony—pisolitic—in company with apple.

PINKED-BARKED GUM.—Group *Leiophloiæ* (specimen No. 6.)—This tree attains a height of from fifty to sixty feet, and diameter from fifteen to twenty inches. The bark is smooth on trunk and branches, and is of a pink colour, and slightly mottled. The wood is hard. *Seed-vessels:* Arranged in umbels of three florets, on short thick pedicel and peduncle one-fourth of an inch long. The operculum is equal in length to the capsule. The calyx is as frequently three as four celled, and the valves protrude. *Leaf:* The leaf is long, and rather thick, and the midrib well defined; the marginal nerve is delicate, and close to edge of leaf. It is frequently covered with small carbuncles about the size of fly-dirt, which gives the leaf a dirty and rough appearance. The midrib is particularly prominent on under side.

Habits, &c.: Frequents basaltic soils, generally, in the warmer parts of New England, in conjunction with box and apple, with occasional native cherry (*Exocarpus cupressiformis*). The tree is of a rather drooping habit, and is not common in New England.

GREY GUM.—Group *Leiophloiæ* (specimen No. 7).—*Bark:* Smooth, blotched dark and light lead colour; very slightly fibrous. Rough for about six feet up trunk. *Wood:* Light-coloured, soft and heavy; fairly durable as fencing material. *Leaf:* Five to six or seven inches long; some alternate and some opposite on same branchlet; petiole half an inch long; midrib prominent and well defined. The marginal nerve is narrow, and two or three well-defined longitudinal veins run parallel to the midrib on either side; the transverse veins form with these a lattice. *Seed-vessels:* Are arranged in umbels of three, four, five, or six florets, standing generally in junction of petiole and twig, on peduncle about one-third of an inch long. Some capsules are tri-valved and some quadri-valved; the valves protrude. The operculum is equal in length to the calyx. *Habits, &c.:* This gum is generally indicative of poor soil; it enters into combination with all the timbers found on granitic formations.

SALLY.—Group *Leiophloiæ* (specimen No. 8.)—*Bark:* Rough at butt, but after a height of a few feet, it is smooth and of a dark green colour; it is thinner than the generality of the barks of the genus. *Wood:* The wood is almost useless, except as fuel; it is usually very much eaten by lepidopterous larvæ, and the aborigines frequently cut up small trees for the purpose of obtaining those grubs. *Leaf:* The leaf is alternate. On small shoots from the root it is almost circular and large, but in older trees it is from three to four inches long and about one inch wide, and is lanceolate. It is ribbed very much like the leaf of the *E. coriacea*. *Seed-vessel:* The seed-vessels are about one-tenth of an inch in diameter, and are arranged in umbels of twelve florets, on short pedicels; the peduncle is not more than one-eighth of an inch long, and about one-sixteenth thick. The capsule is three-celled, and the valves sunk, and operculum short. *Habits, &c.:* This tree usually does not exceed a diameter of from eight to twelve inches, but there are numerous specimens which assume a diameter of thirty inches or more. The latter are of rather a drooping habit, and are pretty trees; but the smaller ones appear too straggling to be beautiful. It frequents granitic soils with slight mixture of the detritus from argillaceous rocks, and never grows far from watercourses. It is is very common on the banks of the Henry River, the Mann, and Mitchell Rivers, also on the Severn, above Dundee. All those are cold localities in the most elevated portions of New England, and I have never seen this tree in warmer regions, nor have I seen it growing in the vicinity of river *tea-tree.*

WHITE GUM.—Group *Leiophloiæ* (specimen No. 9).—*Bark:* Rough at butt for a few feet, but above that is smooth and streaky, showing long light and dark coloured stripes along the bole. *Leaf:* The leaf is from five to eight inches long, with well-defined marginal nerve and protuberant midrib. The veins are very distinct, alternate, but not regularly so: in many cases they are nearly opposite. Petiole, about an inch long, lanceolate. *Wood:* The wood is soft, and is not considered durable. It is generally difficult work with wedges, and, owing to the numerous sap veins, it is not a profitable timber for sawing. It is a bad fuel, and as the tree generally attains a diameter of from two to four feet, it is impossible to clear land by *burning off*, as the heavy logs cannot be kept alight. *Seed-vessel:* The seed-vessels are in umbels of three, four, or five florets, supported on very short pedicels. The peduncle is about three-tenths of an inch long. The capsule is a fifth of an inch in diameter, and is as frequently trivalved as quadrivalved. The valves are slightly protuberant, and a rim runs round the mouth of the calyx. It is about one-third longer than the operculum, and on the younger seed-vessels the pedicel appears to be part of the capsule. *Habits, &c.:* This gum grows chiefly alone, forming open forests. On rich black or red clayey soils it combines with apple, a little acacia, and native cherry, in the colder regions, as about Glen Innes; but the white box mixes largely in the forest on similar soils in warmer climates, as on parts of Strathbogie Run. Those combinations, however, are chiefly on ridges, as the gum forms the prevailing timber on the flats. It also grows on granitic soils, where peppermint mixes with it slightly. On basaltic soils the parasite *Loranthus aurantiacus* (mistletoe) frequently grows on this tree.

YELLOW BOX.—Group *Hemiphloiæ* (specimen No. 10).—There are two species of this tree; one has narrow lanceolate leaves, and the other broad ovate; but the timbers are in every other respect similar. The former, however, appears to have a greater range of soil than the latter, which grows chiefly in argillaceous or granitic formations. They are both distinguished by a bright saffron-coloured undercoating to the bark, which externally is of a reddish-brown colour, rough, but more resembling the common gum bark than that of the box. *Wood:* Hard and tough; very durable as material for fencing; makes good poles and shafts for drays, &c. *Leaf:* 2½ to 4 inches long; midrib stands slightly above surface of the leaf; marginal nerve well defined, alternate; petiole about an inch long, on some of which two leaves grow. *Seed-vessel:* The umbels generally contain seven florets; the peduncle is twice as long as the pedicel; the capsule and operculum are about equal in length, six-celled, and the valves are sunk. *Habits, &c.:* The narrowleafed variety enters into combination with almost every kind of timber growing in New England. On all its soils and in every climate it appears to retain its general characteristics with very slight modifications; but the broad-leaved yellow box grows only in the poorer soils in cold localities; they both, however, prefer high and dry ground to flats.

BLACKBUT.—Group *Hemiphloiæ* (specimen No. 11).—The tree resembles the stringy-bark (*E. obliqua*), but the branches are smooth, and the bark is thinner and not quite so fibrous. It appears to partake of the peppermint and stringy-bark. *Wood:* Soft, but fairly durable, free in grain and easily wrought, light in colour. *Leaf:* Opposite and alternate; those on one side of stem are at shorter intervals than those on the other—petioled, and a well defined but not prominent midrib; narrow marginal nerve. *Seed-vessel:* The umbels contain from six to eight florets. The operculum is about two-thirds as long as the calyx: the pedicel is one-sixth of an inch long, and the peduncle one-third of an inch. The valves are not protuberant, and the capsule is usually four-celled. *Habits, &c.:* This blackbut grows generally on granitic soils, but it frequently occurs on the junctions of basaltic soils with those of poorer formation. It combines with stringy-bark, iron-bark, oak, and various kinds of gum.

WHITE BOX.—*E. Hemiphloia;* Group *Hemiphloiæ* (12).—The average height of this tree is from 50 to 70 feet, and the diameter from 18 to 30 inches. The bark is persistent on trunk, and branches smooth. It is light-coloured and slightly fibrous, and is used for covering outbuildings, huts, &c.; but it is much more liable to crack than the bark of the *E. obliqua*, and is not nearly so durable. The *wood* is hard, tough, and durable; it is heavy and close-grained, and is generally difficult to split. It forms an excellent fuel, as it burns readily, throws out great heat, and leaves little ash. The leaves are of a bluish-green colour, slightly glaucous; the midrib is prominent, as also the marginal nerve; and the veins are better defined and further apart than in most other leaves of the genus *Eucalyptus.* The width of the leaf is about 2 inches, and length 5. The petiole seldom exceeds ½ an inch in length. On some trees the leaves appear to be partly alternate and partly opposite. The alternations on all are irregular. Many of the leaves on saplings are nearly circular, and are concave, as though the internal portion of the leaf grew more rapidly than the margin. *Seed-vessels:* The umbels generally contain seven florets, six surrounding, one standing in the centre. The pedicel is very short, and appears to be simply the termination of the calyx. The peduncle is nearly ½ an inch long. The calyx is three times as long as the operculum, and before the latter falls off, the former is marked by four or five prominent ribs. The vessel is four or five celled, and the valves are deeply sunk. In the fully developed seed-vessels the ribs disappear. The capsule narrows slightly above the valves and then widens out again at the mouth, giving it rather a bell shape. *Habits, &c.:* This tree occurs chiefly on good basaltic soils, in warm regions, similar to those occupied by gum and apple in colder parts of New England.

PEPPERMINT. Group *Rhytiphloiæ* (specimen No. 13).—*Bark:* Rough and wrinkled, similar to that of the apple-tree (*Angophera subvelutina*), but more harsh and solid. Of a dark brown colour, slightly fibrous. *Wood:* Light-coloured, soft, heart reddish-brown. It is generally said to be unfit for use as a timber, except for fuel; but I recently examined some pegs which I put in the ground in June, 1872, and found them to be perfectly sound and good, excepting the sap, which was slightly decayed. The straight bole is very free in the grain, and easily worked. From specimens of this tree about Glen Elgin it appears to be a fast-growing timber, attaining a diameter of 12 to 18 inches, and height of about 50 feet in twenty-five years. *Leaf:* Alternate, lanceolate, from 2½ to 4 inches long (those of saplings are generally longer, being as much as 6 or 8 inches in many cases); dark green colour; midrib well defined; narrow marginal nerve; veins indistinct; petiole half an inch to an inch long. *Seed-vessel:* Small; some trivalved and some quadrivalved on same tree. The umbels contain four, five, or six florets; the peduncle is about one-fourth of an inch long, and is four times as long as the pedicel. One or two florets generally stand in the centre of the umbel, and the valves are slightly protuberant. In most cases the umbel stands in the junction of the leaf-stem with twig. *Habits, &c.:* In the coldest portions of New England this timber grows on basaltic soils, as at Ben Lomond: but it is generally found on granitic soils, or those of an argillaceous formation. On purely granitic formation it forms open forests, but on the others it is generally in combination with yellow box, gum, or stringy-bark.

BOX MESSMATE—Group *Rhytiphloiæ* (specimen No. 14).—This timber appears to partake in some respects the nature of the white box *E. hemiphloia*), and in others that of the New England peppermint. The bark so much resembles that of the box that the tree is frequently mistaken for that timber. It is, however, thicker than box bark, and on being cut with an axe pieces frequently break off with a conchoidal fracture, owing to the large amount of sappy substance which it contains. In the grain it is somewhat like peppermint bark. *Wood:* The wood is soft and light coloured, very much resembling the peppermint: it perhaps contains more moisture. *Leaf:* In the leaf messmate differs from both the peppermint and box. It is generally much longer and more lanceolate than either; some are 10 inches long; they are alternate, and the petiole is from $\frac{3}{4}$ to 1 inch long. The veins are similar to those of peppermint. *Seed-vessel:* The seed-vessels, both in appearance and arrangement, are so much like those of the latter timber that I have been unable to detect the difference, if any, between them. In fact the general similarity between the two trees is so great that the only apparent difference is in the bark, and this might be called the white peppermint much more appropriately than box messmate, as there are no real points of similarity between it and the box further than the colour of the bark, and further they belong to different groups in the genus.

Bastard Box.—Group *Rhytiphlox.—Bark:* Rather lighter in colour than that of peppermint; resembles that of blackbut, but is persistent to branchlets. *Leaf:* in alternate pairs on young trees, but alternate on old ones; dull green with a mottled appearance, which is more observable on the under side of leaf, looking like grease showing through on patches. The leaves are curved, and are about 5 inches long in full-grown trees, but those of saplings exceed that length by 2 or 3 inches. They are lanceolate, and the midrib is prominent; the marginal nerve is narrow and veins well defined; petiole $\frac{3}{4}$ of an inch long. *Seed-vessel:* Small, ovate, truncated; the calyx is about half as long again as the operculum, and the umbels contain seven florets. *Wood:* Soft and free in grain, easily worked, but will not bear much exposure to the weather. *Habits, &c.:* This timber is never found in rich soils—generally in swampy granitic country, in combination with peppermint, grey gum, banksia, blackbut, and occasional stringy-bark. Ferns mix with the undergrowth. The only soils on which I have seen this timber are formed of the detritus of quartz or red granite.

Stringy-bark (*E. obliqua*).—Group *Pachyphloiæ* (specimen No. 16.)—The bark of this tree is fibrous and persistent throughout, and is thick. It is usually used for the purpose of covering outbuildings, and if properly stripped and put on it forms a very good roof, lasting for several years. The wood is easily split or sawn; it is generally straight and free in grain, and the average size of the timber being from thirty to forty-eight inches in diameter, with a straight bole of twenty or thirty feet, without branches, it is much in request by splitters and fencers. The leaves are alternate, and the younger ones are of a bright, glossy, green colour, looking as though varnished; the midrib is well defined, and the marginal nerve narrow, but not clearly marked; the veins form an angle with the midrib of about thirty degrees. *Seed-vessels:* The umbels contain six or more florets, generally with one or two standing in centre; the operculum is short and hemispherical, pedicel short and thick, and the peduncle three-tenths of an inch long; the capsule is slightly contracted at orifice, it is trivalved, and the valves protrude slightly. *Habits, &c.:* This tree grows in all classes of soil except black alluvial; on the red friable soils of the basaltic formations about Vegetable Creek it is a large tree, frequently exceeding four feet in diameter; on those soils it is always accompanied with wild hop (*Dodonea*) and wattle (*Acacia*); on granite and elvanite soils its undergrowth is generally saplings of stringy-bark; it is sometimes, however, on those soils accompanied by wattle; its timber combinations are iron-bark and various kinds of gum.

YELLOW IRON-BARK.—Group *Schizophloiæ* (specimen No. 17).—The bark of this tree is much less wrinkled and the wrinkles are narrower than that previously described, and it has a rich yellow sap-coating under. The wrinkles form diamond shapes. In the larger trees the bark is smoother than in the smaller ones. The wood is hard and tough; the heart reddish brown. It is a durable wood, and well suited for poles and shafts of drays. *Leaf:* Lanceolate; midrib is prominent on the under side, as are also the marginal nerves; bluish-green colour, and the petiole is about half an inch long, alternate. *Seed-vessel:* The umbels contain generally six florets, supported on long, thin, and pliant pedicels nearly half an inch long; they droop. The operculum is much shorter than the calyx, which contracts at the orifice. The capsule is six-celled, and the valves are sunk; the orifice is surrounded by a well-defined lip; the peduncle is about a quarter of an inch long, and is thin and tough. *Habits, &c.:* Frequents poor granitic soils; scrub oak generally grows in company with it, also stringy-bark, blackbut, and yellow box; the blue gum also grows on this soil. In swampy patches the plant known as "bottle-weed," a flesh-eater, *Drosera peltata* of botanists, occurs.

IRON-BARK.—Group *Schizophloiæ* (specimen No. 18).—This tree generally inhabits soil of a very poor character. On New England it grows on elvanite ridges most frequently; not often on purely granitic country, but frequently about the junction of granite with basalt. The bark is very thick and hard; the creases are deep and irregular; its general colour is dark brownish black, but between the creases it is reddish. The wood is very hard and durable. There is more evenness in size between the leaves of young and old trees than is usual between those of most other species of the genus *Eucalyptus*; they are about three inches long, and half-an-inch wide, of a bluish-green colour; dark and sombre looking foliage. They are alternate in pairs, the intervals between the pairs on one side of the twig being shorter than those of the other; after two or three alternations one pair is opposite. The petiole is three-tenths of an inch long, and the midrib is well defined, but does not stand above the plain of the leaf; the veins are delicate and regular, but the marginal nerve is not well defined. *Seed-vessel:* The umbel generally contains seven florets, and there are frequently two or three umbels on the same stem. The operculum is half as long as the calyx; the pedicel and calyx are of equal length, and the peduncle twice as long as the capsule. *Habits, &c.:* In rocky elvanite land this iron-bark mixes with yellow box, red gum, and stringy-bark, with a little stunted apple. The undergrowths are chiefly *Jacksonia scoparia* (dogwood) a species of blackwattle, and numerous small shrubs—five-corner, geebung, &c.

STRINGY-BARK.—Group *Pachyphloiæ* (specimen No. 19).—This tree differs from that previously described (specimen No. 16) in the leaf and seed-vessel more than in anything else. The leaf is of a dark-green colour, and the young ones lack the bright glossy appearance of those on the former species. The petiole is half an inch long, and the midrib well defined and slightly prominent. The operculum is two-thirds as long as the capsule, and the pedicel is short and very thick. The peduncle is about four-tenths of an inch long, and is also thick. The leaves and florets frequently appear to be covered with a dirty black substance resembling soot. Usually there are five florets in the umbel, some of which are bigger than others, and finish flowering before the others are open. Some of the fully-developed seed-vessels attain a large size; they are three-celled, and the valves form an upper hemisphere to the calyx, from which it is divided by a broad creased band. *Habits, &c.:* This tree is generally found in rocky elvanite soils, where the rock approaches in its granular character to the nature of sandstone. It combines with all timbers peculiar to this class of soil.

BASTARD YELLOW-JACKET.—Group *Rhytiphloiæ* (specimen No. 20).—This tree is very similar in bark and wood to the white box (*E. hemiphloia*), but the leaf is similar to that of the yellow box. It is of exactly the same size and appearance as that of that tree, but the petiole is much shorter, being only half an inch long. The seed-vessel is in umbels of three, four, five, or six florets. The pedicel is short, and the peduncle one-fourth of an inch long. The operculum is very small, and is one-third as long as the calyx, and almost flat. In its young state, before parting with the operculum, the seed-vessel is not more than one-sixteenth of an inch in diameter; after flowering it is about one-tenth. The calyx is sometimes three and sometimes four celled, and the valves do not protrude. Many of the leaves of this tree are affected by a disease which causes gnarled lumps on them; in the centre of these lumps is a small white insect, a species of grub, probably the larvæ of a small fly, which appears to be numerous about many specimens of the tree, all of which were affected with the disease. The excrescences may be caused by the larvæ. *Habits, &c.:* Frequents granitic and elvanite soils in company with box, messmate, stringy-bark, &c.

On Dromornis Australis (Owen), a new Fossil Bird of Australia.

By the REV. W. B. CLARKE, M.A., F.R.S., &c.

[*Read before the Royal Society of N.S.W.*, 6 *June*, 1877.]

IN the year 1869 a letter of mine appeared in the *Sydney Morning Herald* on a subject of some interest to Australian naturalists. (See Appendix No. 2.)

A discovery had recently been made of the fossilised femur of a bird resting on a block of granite, at a depth of 180 feet in the superficial beds of Peak Downs, in Queensland, about latitude 22° 40′ S.

This femur was submitted to examination by the Curator of the Australian Museum, and was compared by him and myself with New Zealand specimens of femora of the genus *Dinornis*. We came to the conclusion that the bone belonged to a species of Moa. (See Appendix No. 1.)

This was afterwards stated by me in a communication to the *Geological Magazine* (vol. vi, p. 283), in which I dwelt, perhaps prematurely, on the supposed evidence offered by this bone of a former connection between New Zealand and Australia, inasmuch as *flightless* birds could not have passed so wide an ocean as intervenes between these countries. In my "*Remarks on the Sedimentary Formations of New South Wales*," I have considered that connection in another light. (See Appendix No. 3.)

Professor Owen, to whom a cast of the bone was sent (the original still remaining in the Australian Museum), informed me that it had some characteristics agreeing with those of *Dinornis*, but that others led to the determination that it did not belong to the Moas, having nearer relation to the Emu.

Since that time, in the Transactions of the Zoological Society, the learned Professor published a description and figures of the bone, with comparisons which no one was better able to make than himself. (See Appendix No. 4.)

In that memoir he says: "Of the femora of *Dinornis*, I have selected that of *Din. elephantopus* (Transactions Zoological Society, vol. iv, p. 149, pl. 43, fig. 1) as nearest to the present fossil in regard to length, 13 inches; the breadth of the shaft is the same, or in the largest examples of *D. elephantopus* exceeds only by 2 lines."

Here we have some justification of the opinion I had ventured to express. But, in conclusion of his review, he adds: "I infer that in its essential characters this femur resembles more that bone in the Emu than in the Moa, and that the characters in which it more resembles *Dinornis* are concomitant with and related to the more general robustness of the bone, from which we may infer that the species manifested dinornithic strength and proportions of the hind limbs, combined with characters of closer affinity to the existing smaller, more slender-limbed, and swifter wingless bird peculiar to the Australian continent.

"From the proportions of the femora of *Dinornis* I infer also that those of the tibia and metatarse would be longer and more slender than in *Dinornis elephantopus*, and in a greater degree than is the case with the femur. Consequently, the stature of *Dromornis* would be greater in proportion to the solitary bone by which we know it than is that of the *Dinornis elephantopus*. We may, therefore, have a comfortable assurance that it indicates the former existence in Australia of a bird nearly of the stature of the ostrich, but with relatively shorter and stronger hind limbs. * * * * From the general analogy, not unfrequently pointed out, between the recent animal and vegetable forms of the Australian continent and the extinct ones of the European oolitic beds, together with the massive mineralized condition of the ornithic and mammalian fossils found deep in the enormous superficial accumulations of drift and trappean alluvium, we are led to surmise that Australia, or parts of that continent, have not been subject to the frequent movements by which the earth's crust has been modified in the European continent, but that it may have been subject exclusively to the subaerial conditions of change from the period of the oolitic deposits in our hemisphere. Thus the *Dromornis* of Queensland may have been contemporary with the impressors of the ornithicnites of Connecticut."

These remarks of the illustrious palæontologist are not without bearing on other points of inquiry on which I have ventured to speculate elsewhere.

But, as my object in this communication is to show what advance has been made in the history of *Dromornis*, I must go further into the subject.

Since 1869 I have been on the look out for additional evidence as to *Dromornis*, but not till 1876 did I meet with any.

In January of that year, when at Goree, near Mudgee, I received intimation that a large bone had been disinterred from a depth of 200 feet at the Canadian Gold Lead. On going that day, with my friend Mr. Lord, I found the bone in the possession of Mr. Deitz, a former correspondent of mine on mineral matters: but not (as I suspected from the first account of it given to me) a femur or other limb bone of *Diprotodon*, but a fragment of the *pelvis* of a bird, which was considered by some of the diggers to be the head of some animal. This fragment was placed in my hands for examination. On arriving in Sydney I took it to the Museum for comparison, and came to the conclusion that it had also resemblance to *Dinornis*, but was not the pelvis of the true Emu.

Photographs of it were afterwards sent by me to Professor Owen, and a model of it was made by the taxidermist of the Museum for that institution, from the Trustees of which I received a copy.

The original pelvis I sent on to Professor Owen by Captain Pile, of the "Patriarch." The latter had not reached its destination on the 31st January, 1877, the date of the Professor's last letter to me; but in a former letter, under date of August 1, 1876, he wrote thus:—"I have to-day received your note of 9th June, with the accompanying photographs. I make out the left acetabulum and surrounding parts of the pelvis of a bird about the size of *Dinornis ingens*, but differing in certain proportions of parts."

On the 5th December he writes: "As to the big wingless bird, the only bone yielding information testified against its Moa-ship. Your later pelvic fragment (in the photo.) does not speak decidedly *pro* or *con*. This gossiping commencement will keep till I receive your kindly transmitted box, when its contents will have my best attention, and the results will be annexed."

On 31st January he adds:—"I will not longer defer posting the previous note with this supplement, because, since writing on 5th December, I have had the lower portion of a *tibia*, found in the Gambier Ranges, sent from South Australia. It corresponds in size and condition of petrifaction with the femur figured in the paper, and being a more decisively characteristic bone than that, as both are, when compared with a portion of pelvis, I have sent a description of it, with accompanying drawings, to our Zoological Society. This bone determines beyond question the fact of the former existence in the Australias of a wingless or flightless bird of the size of *Dinornis elephantopus*, but of a genus nearer akin to *Casuarius* and *Dromarius*. The probabilities are that the femur from the breccia-cave of Wellington Valley, that described, your portion of pelvis and the South Australian tibia, are parts of the same genus if not species. It is more convenient and conducive to progress to record them, until proof to the contrary be had, as parts of *Dromornis Australis*. And we now have indications of the former extensive range of the bird on your great continent."

The bone from Wellington Valley was mentioned in the "Memoir on the Queensland Femur," and was described and figured in the "Palæontological Appendix" to Mitchell's work of 1838 (pl. 32, figs. 12-13) :—"The length of that bone was thirteen inches ; the breadth of the middle of the shaft was not quite three inches."

Whether any further communication from the distinguished Professor alter or confirm his present determination remains to be seen. But of this most interesting fact we may be assured that, in addition to the gigantic marsupials of which the public are generally aware, there also existed in past days over a wide region of Australia a gigantic bird, or birds, of which we shall soon know more ; and then we shall see fresh proof of the extraordinary fact which I noticed in connection with the Queensland femur (Address to Royal Society, N. S. W., 1870), that in all the tracts of land in the southern hemisphere, insulated or continental, flightless birds have roamed over extensive regions, and that, as in New Zealand, so in Australia, there were ornithic giants.

Whether, therefore, the inquiry be respecting *Dinornis* or *Dromornis*, Australia comes into the category with the *Moa* of New Zealand, the *Epiornis* of Madagascar, the *Dodo* of Mauritius, and the *Solitaire* of Rodriguez, all of which are now extinct.

In closing this brief account of the progress of inquiry as to an Australian fossil flightless bird, which I hope will have the effect of inducing researches by others, I cannot resist pointing out, in the words of Professor Owen, that there is another of the giants of the past of which more is required to be known. He says, in concluding his last letter to me—"How strange it is that no tooth, or portion of jaw, or fragment of skull of the contemporary great land lizard (*Megalemia*) comes to hand. Vertebræ I receive from time to time, with their evidences of extinct mammals. But there must be an end in finite working, and I am therefore sending the 'Researches on the Fossil Mammals of Australia' to the binder."

I may here conclude with an earnest request that gold-diggers, and others who work in deep soils and river banks, or in caverns, will preserve and consign for scientific examination all fragments as well as whole bones of fossilized animals, or birds, or reptiles. They cannot confer a greater favour on Palæontology than in acting on this suggestion, as hundreds of instances are known in which valuable relics of the kind have been mutilated and thrown away by the discoverers, as having no commercial value to themselves. It is highly probable that the gold leads in the neighbourhood of Gulgong, Home Rule, and Mudgee will furnish some interesting additions to the example now treated of, as I saw many fragments of marsupial bones, and some I considered bird bones were given to me at the Canadian ; and since, a portion of the jaw of a marsupial has been found in Mr. Lowe's paddock, and this has kindly been forwarded to me by him.

APPENDIX.

No. 1.

To the Editor of the Herald.

Sir,—The Rev. W. B. Clarke called at the Museum a few nights ago with the "shankbone" of some gigantic animal discovered 180 feet below the surface, in the neighbourhood of Rockhampton (I think). We compared the fossil with some of the Museum specimens, but as Mr. Clarke was otherwise engaged, the bone was left with me for further determination. I informed Mr. Clarke the next morning that it was the bone of a gigantic bird allied to the flightless Moas of New Zealand.

I must confess that I have never seen or heard of the remains of a *Dinornis* found in Australia; and when I suggested to Mr. Clarke that it could not well be any other than a bird bone, I was almost afraid that I had made a mistake, owing to the solid appearance of the specimen under examination.

Thanks to the splendid collection presented to the Museum by Dr. Haast, F.R.S., the well known New Zealand geologist, I was enabled to convince myself that the bone is the right femur of a species of *Dinornis*, which will be fully described hereafter.

I am, &c.,

May 18th, 1869. GERARD KREFFT.

No. 2.

DINORNIS.

To the Editor of the Herald.

Sir,—I am glad Mr. Krefft has announced the femur of *Dinornis* in this day's *Herald*, as too many of our discoveries are first made known in England.

The bone in question is a very important discovery. *But it is not mine;* it was brought to me by a gentleman who states that it was found in sinking a well on Peak Downs, between the heads of Theresa Creek and Lord's Table Mountain.

Two or three years since I forwarded to Professor Huxley, for examination, some bones of a *Trionyx* and teeth of Crocodile found in Crinum Creek. That district is therefore of a very interesting character.

The *Dinornis* bone was found under 30 feet of alluvial clay and mud, covering 150 feet of drift, and rested on what *is said to have been a granite rock*, which, however, was pierced in the hope of finding water, but of which only a little was reached.

I am enabled to state, from having broken up many hundred pebbles and boulders, that, besides any Tertiary deposits in that region, there is an enormous amount of fragments, some only partially rounded, of Silurian, Carboniferous, and Secondary ages, as well as those belonging to local igneous rocks, among which I detected two of an unusual character containing gold, which was proved on analysis at the Mint. These Pleistocene pebbles led to Mr. Henley's announcement of what he called his "Tertiary river," which was explained differently by me in a correspondence I had on the subject with the late Gold Commissioner at Clermont.

The *Dinornis* bone leads to the inference that views long ago expressed by me of the former connection of New Zealand with this country were correct.

But I am bound to say that this bone is not the first evidence of the existence of birds in Australia in Pleistocene times; for on reference to the Catalogue of Industrial Products of New South Wales, exhibited in the Australian Museum in November, 1854, and afterwards in Paris, you will find enumerated in the list of geological specimens exhibited by myself on those occasions, among other Quaternary relics, the following:—"No. 49, Osseous Breccia Bird Bones (Coodradigbee Cavern)." Thus New South Wales has preceded Queensland in the discovery of bird bones of Pleistocene age.

W. B. CLARKE.

St. Leonards, 19th May, 1869.

P.S.—The *Dinornis* bone is so completely filled in and mineralised by calc spar and iron pyrites as to present a solid mass, resembling more the condition of a reptilian than an ornithic relic; but the characters which I hastily compared with skeletons of birds, in company of Mr. Krefft, and afterwards, more leisurely, with Owen's figures and descriptions of *Dinornis*, lead me to confirm Mr. Krefft's opinion; and as I have since compared the bone with the bones of *Dinornis* in the Museum, there is no doubt as to the genus.

W.B.C.

No. 3.

Dinornis an Australian Genus.

To the Editor of the Geological Magazine.

Sir,—It will be interesting to your readers to know that evidence has at length been discovered of the former existence in Continental Australia of birds of the Pleistocene genus *Dinornis*.

A short time since a well was dug in that part of the Peak Downs in Queensland (about lat. 22° 40′ S.) between Lord's Table Mountain and the head of Theresa Creek, near the track from Clermont to Broad Sound.

The well passed through 30 feet of black trappean alluvial soil, so common in Australia, which rested on 150 feet of drift pebbles and boulders, on one of which (at that depth) rested a short thick femur, so filled in with mineral matter, calc spar, and iron pyrites, as to give the internal structure more the appearance of a reptilian than an ornithic bone. I have never yet seen any bone in Australia so much mineralized and yet retaining its distinctive osseous features. When placed in my hands it had been already broken in two, just as a bird's bones would be likely to break. But besides this, there are two crushed-in fractures of ancient date, which have broken in the surface of the bone, and if not made in the life-time of the bird, were probably made by the violence of the heavy drift in which it was found.

I had an opportunity of comparing it hastily at the Australian Museum, in company of Mr. Gerard Krefft, our able Curator, and was convinced of its being a bird bone, allied to *Dinornis*, to which opinion I was afterwards led by reference to the writings of Professor Owen. Since then Mr. Krefft has compared it with a collection sent over from New Zealand, by Dr. Haast, and has been enabled to determine it to be a bone belonging to *Dinornis*.

I take advantage of the departure of the mail to-morrow to announce this fact, waiting for a further account of the specimen from Mr. Krefft.

The Peak Downs were discovered by Leichhardt, in his famous expedition to Port Essington in 1845.

Since then the district has been traversed by Mr. Gregory, to whose journal as well as to that of Leichhardt your readers are referred.

The Peak Downs are now settled, and a considerable population has been digging gold on Theresa Creek and in other places, and mining for copper has made advances to the westward at Mount Drummond.

Some time since, my attention was invited to a statement made by the Gold Commissioner there, to the effect that a "*Tertiary river*" had been discovered, and I was requested to examine the facts alleged. On breaking up a vast amount of the pebbles and boulders said to have been found in this "Tertiary river" I discovered that there was no clear evidence of anything that could be called Tertiary, but that they were pebbles of probably Quaternary accumulation, consisting of Silurian, Carboniferous, and Secondary rocks, with the igneous rocks of the neighbourhood, which latter may be in part of Tertiary age.

In some of the creeks running more to the south-eastward from the Peak Downs, and like Theresa Creek, belonging to the Mackenzie River system (*e.g.* Crinum Creek) occur bones of *Trionyx* and Crocodile. A year or two ago I forwarded some of these to my friend Professor Huxley, whose determination I have not yet received.

The naked fact of the discovery of *Dinornis* in this country is of some value as to geological inferences.

I may add, in conclusion, that I look forward to further discoveries in the vast accumulations of drift that encumber some of the localities in the neighbourhood of the rivers watering the Leichhardt district, where, among other relics, are those of the Carboniferous formation, which now presents only the wreck of a mass of strata that once must have been partly continuous over an area comprising several degrees of latitude and longitude on one side or other of the Tropic of Capricorn.

W. B. CLARKE, F.G.S.

St. Leonards, New South Wales, 19th May, 1869.

P.S.—I have omitted to mention that, in the collection I exhibited at Paris in 1865, No. 49 consisted of *osseous breccia* (bird bones) from the Coodradigbee Cavern in New South Wales. So *Dinornis*, though new, is not the first of the order.

No. 4.

EXTRACT from the "Transactions of the Zoological Society of London"—vol. viii, part vi.

On DINORNIS (Part xix): *containing a description of Femur indicative of a new genus of large Wingless Bird*, DROMORNIS AUSTRALIS, *Owen, from a post-tertiary deposit in Queensland, Australia.* Read June 4th, 1872.

[Plates LXII and LXIII.]

In 1836 Sir Thomas Mitchell, F.G.S., Surveyor General of Australia, discovered in the breccia-cave of Wellington Valley a femur, wanting the lower end, mutilated, and incrusted with the red stalagmite of the cave, which I determined to belong to a large bird, probably, from its size, struthious or brevi-pennate, but not presenting characters which, at that time, justified me in suggesting closer affinities.

Three views of this fossil, of rather less than half the natural size, formed the subject of pl. 32, figs. 12, 13, of my "Palæontological Appendix" to Mitchell's work.

The length of this fossil was 13 inches; the breadth of the middle of the shaft was not quite 3 inches.

In 1869, the Rev. W. B. Clarke, F.G.S., made known the interesting discovery of a femur, nearly 12 inches in length, during the digging of a well at Peak Downs, in Queensland.

The well was sunk through 30 feet of the black trappean alluvial soil common in that part of Australia, and then through 150 feet of drift pebbles and boulders, on one of which boulders ("at that depth," 150?) rested a short thick femur, so filled with mineral matter (calc spar and iron pyrites) as to give the internal structure more the appearance of a reptilian than an ornithic bone.

Mr. Clarke submitted this fossil to the able Curator of the Australian Museum, Sydney, and states that "Mr. Krefft had compared it with a collection sent over from New Zealand by Dr. Haast, and has been enabled to determine it to be a bone belonging to *Dinornis*. The communication is accordingly headed "*Dinornis*, an Australian genus.""

So exceptional an extension of New Zealand forms of life to the Australian continent greatly added to my desire of further and more intimate acquaintance with this *second* evidence of a large extinct Australian bird, more especially as the femora of *Dinornis* received from New Zealand subsequently to the publication of Mitchell's work led me to perceive, from the antero-posterior compression of the shaft and the sessile position of the head of the femur from the Wellington Valley cavern, that it resembled that bone in the Emu rather than in the *Dinornis*."

My wishes on this point, as others connected with the palæontology of Australia, met with a prompt and hearty response. The Trustees of the Australian Museum directed the unique bird's bone to be moulded, and they forwarded to me a plaster cast.

Mr. Krefft was so good as to have three photographs taken of the fossil: one showing the back view of the bone, three-fifths of the natural size; the two others, the front views of the proximal and distant halves of the bone, of very nearly the natural size.

Part V.

On the Sphenoid, Cranial Bones, Operculum, and supposed Ear-bones of Ctenodus.

By W. J. Barkas, M.R.C.S.E., L.R.C.P.L.

[*Read before the Royal Society of N.S.W.*, 6 *June*, 1877.]

Leaving the bones that enter into the formation of that portion of the buccal cavity connected with the teeth, we come next to those that enclose the cranial cavity and that enter into the remaining portions of the endo-skeleton. Of these bones a few are yet absent from our cabinets; they are principally head-bones, if not altogether so, for it is probable that all the other parts of the endo-skeleton not in our possession were cartilaginous, and therefore incapable of fossilization; among the latter are the vertebræ. Not any vertebral segments have been connected satisfactorily with *Ctenodus*, in this respect *Ctenodus* seemingly agreeing with *Ceratodus*, the vertebræ of which are cartilaginous. If this fossil fish had possessed a bony spine we should certainly have discovered numbers of the segments, both in conjunction with undoubted bones of *Ctenodus* and either single or in masses, for other portions of the osseous system are comparatively abundant, the teeth, for example: yet for every tooth found there ought to have been imbedded in the shale, at the lowest computation, from eight to twelve vertebræ. Another fact tends to prove the cartilaginous nature of the spine of *Ctenodus*; such fishes as *Rhizodopsis*, *Megalichthys*, *Strepsodus*, *Cœlacanthus*, *Archichthys*, all of which are found in the same coal shales, possessed osseous vertebræ, and which having become preserved in the shale, are now obtained just as frequently as any other bones of those fishes. This absence of osseous vertebral segments in *Ctenodus* and *Ceratodus* at once removes these fishes from the *Ctenodipterines* of Eichwald, but *Dipterus* may still pertain to that group, as its vertebræ are osseous.

The sphenoid or basal bone occupies the space in the base of the cranium caused by the divergence of the pterygo-palatine bones as they proceed posteriorly from the symphysis. Judging from the great length of the bone, I conjecture it must have projected much beyond the floor of the cranium proper, much further than this bone does in *Dipterus* or even in *Ceratodus*, in which it reaches as far back as the third neural spine. In the case of *Ctenodus* the posterior projection is very greatly produced, much more so than in *Ceratodus*, while in *Dipterus* it extends very little further than the extremities of the pterygo-palatine bones. Although the basal bone of *Ctenodus* is of much greater length than the sphenoid of *Ceratodus*, it possesses the same fundamental conformation. This bone was first described by Messrs. Hancock & Atthey in the "Transactions" I have so often had occasion to refer to, in a paper entitled "A few remarks on *Dipterus* and *Ctenodus*, and on their relationship to *Ceratodus Forsteri*, Krefft"; but they did not give any illustrations. Mr. T. P. Barkas, F.G.S., in his "Coal Measure Palæontology," merely mentions the fact of some sphenoid bones being in his possession, and portrays one in an excellent lithograph. Messrs. Hancock & Atthey thus describe the bone in the paper mentioned above:—"The sphenoid is a much elongated depressed bone, with a wide lozenge-formed expansion near the anterior extremity; in other words, the posterior angle of the lozenge-formed expansion is much produced, while the anterior angle is only slightly produced. The frontal portion (the pre-sphenoid) is rounded, inclining to conical at the extremity, and fits in between the divergent bones that support the dental plates. The lozenge-formed expansion lies partly behind these bones; and the elongated posterior extension (the basi-sphenoid) is continued for a considerable distance further back, in the large species for nearly five inches. * * * The basi-sphenoid at its junction with the lozenge-formed expansion is usually thick and nearly circular; elsewhere it is flattened." A specimen in my cabinet differs slightly from the above description, in that the anterior projection is rounded, not showing any tendency towards a conical contour; nor does a transverse section of the basi-sphenoid tend to a circular form near its junction with the lozenge, as at that point it rises into a high crest on the buccal surface. I notice also in my specimen a point not mentioned by Messrs. Hancock & Atthey, and it is that on each edge just posterior to the lateral swelling in centre of the basi-sphenoid is a small oval depression like the depression of an articulation, and I am inclined to consider that it is the remains of a joint between this bone and the first rib, just as we see is the case in *Ceratodus*. I am not aware that the rib has ever been discovered *in situ*, but analogy would certainly lead one to infer that my conjecture is correct. For comparison with the above account, I give Günther's brief description of the basal bone of *Ceratodus*:—"It is lance-head shaped, broadest between the tympanic pedicles, tapering in front, and still more behind, filling out the entire space between the pterygo-palatines, and extending backwards far beyond the commencement of the vertebral column, to the level of the third neural spine. It is a thin bone, except in the middle of its length, where large medullary cavities are imbedded." It is perhaps unnecessary for me to add that the greater posterior extension of the sphenoid of *Ctenodus* shows that the head of that fish must have had a diameter antero-posteriorly much beyond that of *Ceratodus* and *Dipterus*. Of the remaining head-bones not much is known satisfactorily, as all the heads that have been disinterred are much crushed and distorted. Occasionally detached bones are discovered, but generally they are procured in masses of two to six bones anchylosed together, the sutures, however, remaining perfectly distinct. Mr. Barkas, in his "Coal Measure Palæontology," devotes a short chapter to three groups of cranial bones in his possession, in which he remarks:—"The external bony plates which covered the probably cartilaginous skulls of *Ctenodus*, *Dipterus*, *Asterolepis*, *Osteolepis*, *Coccosteus*, *Diplopterus*, and other Devonian and Carboniferous Fishes, bear but a slight resemblance to the arrangement of the true internal cranial bones which form the skull proper of osseous fishes. All attempts to classify them, therefore, can only be approximate; and, following as closely as I am able the plan of classification furnished by Prof. Huxley, I venture to indicate the following homological relationships of the three groups of bony plates already referred to, * * and provisionally suggest the following as their probable interpretation:—Supra-occipital, frontal, epiotic, parietal, post-frontal, supra-temporal; squamosal; post-orbital. The arrangements of the cranial plates of *Coccosteus*, *Osteolepis*, *Diplopterus*, *Dipterus*, and *Asterolepis*, may be seen by referring to pages 46 to 74, Hugh Miller's 'Footprints of the Creator,' by comparing which with the figures of the cranial plates of *Ctenodus*, now for the first time figured and published, it will he seen that there is considerable difference in the arrangements of the bones; the chief and most characteristic difference being the approximation of the occipital and frontal bones, the singleness of the frontal, and the separation of the parietal bones by having the occipital bone wedged in between them. The cranial plates of *Dipterus* perhaps most closely approach those of *Ctenodus*, but in *Dipterus* the parietals are between the occipital and frontal, and are in close contact with each other, while in *Ctenodus* the parietals are separated from each other by the width of the broad occipital plate." The groups of cranial bones mentioned above are illustrated in the "atlas" accompanying the above work. Mr. Atthey mentions that he has been able to distinguish among his specimens the anterior, median, and external occipitals, parietals, and three posterior lateral or skin bones, and he adds that these bones in *C. tuberculatus* "so closely resemble the same bones in *Dipterus* that they might be taken to belong to a gigantic specimen of that genus"; but on this point it will be noticed that Mr. Barkas, in the quotation I gave from his work, points out a marked difference between these two fishes in the arrangement of the occipital and frontal bones, *Dipterus* having the parietals between those bones, while in *Ctenodus* they are on each side of the occipital. Mr. Atthey may be correct enough in his statement, if I may judge from the names he gives, for the bones he has had the opportunity of examining are posterior to those described by Mr. Barkas. The whole of this subject, however, is so imperfectly known, each anatomist seemingly giving new names to the cranial bones, that it may possibly be that Mr. Atthey and Mr. Barkas are both often referring to the same bones, Mr. Atthey taking the nomenclature of Pander, Mr. Barkas that of Huxley.

On a slab in my possession are two masses of head-bones, one on each surface, as though they had originally been united in one shield, and before fossilization some catastrophe had happened and bent the roof of the skull through the middle, but whether this is so or not, the two masses are certainly head-bones of *Ctenodus*, as they present the pitted and granular appearance usually seen in such bones. What bones are present in these two pieces of the cranial shield I am not in a position to say positively, for there has not been any distinct account given of the cranial bones of *Ctenodus*, and they do not resemble any bones in the *Ceratodus*' skull, but this latter fact may arise from the fragmentary nature of my specimens. By comparing one of my specimens with Mr. Barkas's figure pl. x, fig. 244, however, I conjecture the bones forming the group to be the frontal, supra-occipital, median occipital, epiotic, parietal. In another fragment of a cranium there is a bone with an arrow-head projection which may correspond with Mr. Atthey's occipital, which is thus described: "In the latter (*C. tuberculatus*) it (the frontal border) projects and has a wedge-shaped process in the centre." If this be so, then we may translate this group as being composed of the supra-occipital, epiotic, and median occipitals. It must not be forgotten that in these names I am only employing conjecture.

In all the crania that have been examined the outer surface of the bones present a pitted and granular appearance, and are also somewhat glistening; in some of the bones the pitting is not so distinct as usual, but long depressed arborescent streaks are plentiful which radiate from a boss situated near the centre of the bone, the surface thus having a peculiar radiated aspect, and gives one the impression of a cartilage having become fossilized as ossification was advancing; a microscopical examination, however, shows, that the bone is osseous throughout. The bones are always small compared with the size of the cranium; vary much in contour, but in size they are pretty uniform, no bone predominating much over the others; they unite with each other by imbricated sutures that have apparently become anchylosed early in life to form a compact shield.

The opercula are of comparatively frequent occurrence in the shales of the Northumberland coal measures. They vary greatly in size, Mr. T. P. Barkas figuring one in his "Atlas of Carboniferous Fossils" that measures $6\frac{1}{4}$ inches in one diameter and $5\frac{1}{2}$ inches in the other; he also gives a lithograph of a section of another, $1\frac{1}{4}$ inch and 1 inch in its longest and shortest diameters respectively. Mr. Atthey owns an operculum of *C. elegans* which is only 5-16ths of an inch in its longest diameter. I have in my possession two opercula, one being $3\frac{1}{2}$ inches in its longest diameter, and the other 2 inches. The sizes of these opercula being so variable necessarily leads us to infer that they pertain to different species of this genus, and in this conjecture we are strengthened by the facts that these bones vary also in their conformation and thickness; my observations tending to prove that the larger the operculum, the nearer it approaches to the circular form and the thicker is the plate. The large opercle in my possession does not bear much resemblance to the same bone in *Ceratodus*, but the smaller one has a great similarity to the plate figured by Günther, "Philosophical Transactions" for 1871, pl. xxxv, fig. 1 *h*.

The literature concerning this bone is not large, Mr. T. P. Barkas describing isolated specimens in the "English Mechanic" and "Scientific Opinion." Messrs. Hancock and Atthey, in their paper on "*Dipterus* and *Ctenodus*," refer to it at some length, and in the following words: "The opercula resemble those of *Dipterus;* they are large, stout, slightly convex, irregularly circular plates, with one side of the margin a little flattened, and slightly produced at each end of the flattened space; the surface is punctate and granular like the cranial bones. We possess six or seven different forms of these gill-covers, two of which have been identified as belonging to *C. elegans* and *C. obliquus* respectively." The only illustrations that have been published are those of Mr. Barkas, to which I have already referred.

Before entering upon a description of the bones of the body of *Ctenodus*, I must refer to certain bodies that are supposed by Mr. T. P. Barkas to be otolites, and, as he considers probable, otolites of *Ctenodus*. Concerning these bodies I do not feel in a position to commit myself to an opinion as to their nature, although I have examined numbers of them both externally and internally, as I have never had an opportunity of investigating the structure of an undoubted ear-bone of either a living or a fossil fish. I shall, therefore, allow Mr. Barkas to speak in his own words, which I extract from his "Coal Measure Palæontology":—

"Fig. 175 represents a rare and little understood fossil, probably an otolite or ear-bone of a fish. Fig. 176, a transparent microscopic section of the same fossil, illuminated by transmitted light, and magnified 20 diameters; showing the minute structure of the preparation. In 'Scientific Opinion,' vol. ii, p. 173, after stating that I had five specimens of this fossil, I said, 'In external appearance these specimens closely resemble each other, but, when mounting a specimen a few hours ago, I found that, in structure, it very materially differed from that I had previously prepared for the microscope. The first supposed otolite which I mounted was beautifully transparent, of a deep lake colour, and appeared, when examined by objectives of high power, to be perfectly structureless. The present otolite, like that previously described, was very hard and difficult to reduce to a proper degree of thinness. Its structure is marked and peculiar, and its colour is a very deep red. Whatever these bones may be, they differ very materially in colour and structure, and probably belong to fishes of a different genera, or, at least, of different species. The last specimen, when under microscopic examination, is seen to be extensively permeated or covered by irregular nodular twisted lines, resembling to some extent the attached frustules of *Diatoma vulgare*, or the stems and polype cups of the smaller forms of *Sertularia*. Among those masses of nodular lines are scattered a number of small circular discs of various degrees of transparency."

"The fossil remains in the Coal Measures are generally somewhat heterogeneously mixed together, and, in some cases, the slabs of shale contain remains that evidently belonged to one fish. When that is the case, somewhat safe inferences may be drawn as to the leading characteristics of the fish the remains of which have been preserved. Upon a slab of shale in my possession there are a large mandibular tooth and various head-bones of *Ctenodus*, and associated with them is a very excellent specimen of a supposed otolite. If any inference is to be drawn from this association of fossils, it is that the otolite in question belonged to a *Ctenodus*, and that it is not improbable, as, unlike *Gyracanthus*, *Diplodus*, and many other coal-measure fishes, the *Ctenodi* had ossified head-bones, opercula, and ribs, and, in all probability, were possessed of otolites.

"I have in my possession upwards of 200 upper and lower compound teeth of various species of *Ctenodus*. It is improbable that small bones, such as the otolites of the smaller *Ctenodi*, should be found, and the discovery of the otolites of the larger *Ctenodi* would be much less frequent than the discovery of their teeth, because each fish possessed four, or it may be eight teeth, and would only possess two otolites. Besides, the teeth are large and easily recognized, and the otolites may easily be overlooked in the process of breaking and examining the shale. The argument of the smallness of the number found is, therefore, no reason why those found should not belong to the genus *Ctenodus*.

"Since the publication of the above remarks in 'Scientific Opinion,' Messrs. Hancock and Atthey have published a paper in the 'Annals and Magazine of Natural History,' and in the 'Transactions' of the Tyneside Naturalists' Field Club, in which they attempt to prove that the lenticular bodies which I described as otolites are not otolites, but vegetable fungi, to which they have given the generic name *Archagaricon*, a name which indicates that they resemble hardened fossil mushrooms. Their chief arguments in favour of the vegetable nature of the fossils are the minute structure of some of the specimens, which resemble, to some extent, the structure of certain fungi; and the fact that while fossil bones are easily destroyed in nitric acid, the supposed otolites are not perceptibly affected by the action of the acid. In reference to the fungoid characters of those bodies, Mr. W. Carruthers, of the British Museum, in his review of the contributions to fossil botany published in Britain in 1869 ('Geological Magazine,' 1870, p. 182), says: 'The authors describe a number of lenticular bodies from the Cramlington Black Shale, which, from their resemblance to *Sclerotium stipitatum* (Berk. & Curr.), they consider to be fungi. These fossil bodies are supposed by Messrs. Hancock and Atthey to be fully developed plants, producing spores, and related to the higher fungi. The authors have overlooked the fact that this "doubtful" (Berk.) production, which led them to take this view of these bodies is only a *Mycelium*-tuber, the fructification of which is yet unknown.'

"In minute structure these fossils vary, and, as some of them appear to be entirely structureless, structure alone is not sufficient to justify their being considered vegetable. With respect to the effect of nitric acid on the fossil, my experience has shown that nitric acid does not visibly affect the forms of the supposed otolites: while it decomposes teeth and other remains of fishes and reptiles, it nevertheless produces so much of chemical change upon them as to render the previously transparent dilute nitric acid somewhat milky in appearance, indicating the presence of calcareous matter in the otolite. Taking all the facts of the case into consideration, it appears more probable that the fossils are otolites of fishes, rather than hardened fungi."

Mr. Barkas's description of this fossil are, to my knowledge, perfectly accurate, and if I had only attended to their structure I should have considered the bodies as vegetable; but, besides the fact of one specimen being found accompanied by undoubted remains of *Ctenodus*, there are also two other points in favour of the otolite conjecture, and which have not been noticed by either of the above palæontologists, viz.: (1) that the shale in which these bodies are embedded does not contain any vegetable remains, at least, I have never seen any; (2) that it is difficult to conceive of any mushroom-like fungus becoming fossilized in coal-shale to such a degree of hardness, for they are more dense than the strongest fossil tooth or bone. No doubt there is something to be said on both sides, we must, therefore, for the present consider the nature of these bodies as obscure; they may be otolites of *Ctenodus* or other fish, or they may be fungi.

Part VI.

On the Scapula (?), Coracoid, Ribs, and Scales of Ctenodus.

By W. J. Barkas, M.R.C.S.E., L.R.C.P.L.

The next bone I have to notice is as yet doubtful as to its nature, its discovery being rare; when discovered it has been occasionally found associated with remains of *Ctenodus*, but whether it is really a portion of the skeleton of that fish is not determined. Its shape is also such as to render its diagnosis uncertain; it does not resemble any bone in *Ceratodus*, but bears a certain degree of likeness to the carpal bones of *Gyracanthus*. This much can be said about it, that it is a bone belonging to the scapular or the pelvic girdle of some fish, and the reasons that I speak of it now are that it has been found associated with *Ctenodi* remains, and also that the markings on its surface differ little, if at all, from the ornamentation of undoubted bones of *Ctenodus*. With this provision, therefore, I shall enter into its description, and I may state that it has not to my knowledge been either described or figured. The bone is triangular in shape, the apex being much thicker and stronger than the base; the basal extremity is a thin plate with an irregular border; the upper and lower borders that proceed forwards to form the apex are thick and strong, the upper being gently curved downwards to the apex, the lower presents an abrupt concavity close to the point which gives a hooked appearance to that part; the apex is rounded, and fits into the articular cavity of the bone that I shall next mention, an undoubted coracoid of *Ctenodus*; the portion between the two borders rapidly thins as it proceeds from the apex towards the base. The whole surface is pitted and striated with a horizontal tendency, but nowhere does it present the reticulation found in other fossil fish or reptile bones. Such being the conformation of the bone, I infer that it pertains to the scapular arch and is the scapula itself. Should this bone be hereafter proved to be a scapula of *Ctenodus* or any other fish, it will present one great point of difference from the majority of scapulæ, in that its articular extremity is convex and fits into a cavity in the coracoid, instead of *vice versa*. The coracoid of *Ctenodus* has been obtained both by Mr. T. P. Barkas and Mr. Atthey, but its discovery is comparatively rare. When discovered it is generally associated with other remains of *Ctenodus* that are undoubted; in fact Mr. Atthey reports that he has obtained a portion of the body of *Ctenodus obliquus* in which the pair of bones are *in situ*. The coracoid was referred to by Messrs. Hancock and Atthey in their paper on *Ctenodus* and *Dipterus*, but it was not figured. I am not aware that Mr. Barkas has published any account of it, though he has specimens in his cabinet. As Mr. Atthey's description resembles the specimen in my possession I shall quote it. "Their general character is that of a flattened elongated bone, with one end a little expanded, arched slightly, and gradually thinned out to a fine edge: it narrows a little towards the other end: one of the lateral margins is slightly thickened and is somewhat convex: the opposite margin is a little concave. From the narrow extremity a strong wide process is given off at right angles, and extends considerably beyond the concave margin. These bones vary a good deal in size and form: some are comparatively narrow and much elongated, others are short and broad, but all have the right-angular process at the narrow extremity. The largest are four inches and three-eighths, and the smallest five-eighths of an inch in length." The account is incomplete, as it does not refer to the glenoid cavity at the narrowed extremity that is formed by the prolongation of the lower border, and the abrupt termination of the upper margin in what is termed the pectoral condyle. Into this cavity, as I have already remarked, the rounded apex of the supposed scapula in my possession fits. A comparison of this fossil bone with the coracoid or clavicle of *Ceratodus* after its cartilages have been removed shows a close resemblance; there is, however, not any sign of a suture in the coracoid of *Ctenodus*.

The vertebral column of *Ctenodus*, as I have mentioned in Part V of these papers, was probably cartilaginous, as no remains of them have been disinterred.

Jugular plates, we may infer, for the same reason, were absent.

The ribs of this fish are osseous, and are found in comparative abundance both disassociated and associated with teeth, head-bones, &c.; Messrs. Atthey and Barkas having great numbers in their cabinets. They have been figured by Mr. T. P. Barkas in this "Atlas." Mr. Atthey thus describes them: "They are well arched towards the proximal extremity, which is considerably enlarged; and the central channel is quite small, the cylindrical wall of bone being very thick: the ossification of the ribs is, in fact almost complete. The largest ribs are from six to eight inches long." A rib in my possession shows another very remarkable character of these ribs, the presence of an united fracture. Ribs that have been fractured during life and have thrown out "callus" which has become ossified enough to be fossilized, are frequently discovered; as many as three fractures have been observed in a single rib. A microscopical examination displays all the structure usually found in the "callus" of a reunited bone; a full account of this structure was given by Dr. Embleton in a paper read before the Northumberland and Durham Medical Society.

The exo-skeleton may still be considered in a state of doubt, as the chief authorities, Mr. Barkas and Mr. Atthey, differ. Mr. Atthey asserts that he has discovered the scales of *C. elegans* and *C. obliquus*, and gives descriptions and figures of three, one belonging to the former and two to the latter species; while Mr. Barkas doubts their being scales of *Ctenodus*, and this he does in the following words, quoted from his "Coal Measure Palæontology":—"Although nearly 1,000 teeth of *Ctenodus* have been found in the Northumberland Coal Formation, and a large proportion of those teeth of considerable size, and although many teeth of the *Ctenodi* have been discovered in Staffordshire and elsewhere, it is a remarkable fact that, up to the present time not a single specimen of a large scale has been found at all resembling the reputed scales of *C. elegans*, and there are not any uninterpreted or undescribed scales discovered in the Northumberland or Staffordshire Coal Measures that can with propriety be assigned to *Ctenodus*. As scales are vastly more numerous than teeth, if 1,000 teeth of scaled fishes have been discovered, and each fish had only four or six teeth, it is surely improbable that all the scales belonging to those fishes would have eluded discovery." This argument is a common one in Palæontology; Mr. Atthey applied it to prove that it was not probable that *Ctenodus* had incisor teeth, but we have seen that his own future discoveries disproved his deduction. The reputed scales of *C. elegans* are thus described by Messrs. Hancock and Atthey, in their paper on "*Dipterus* and *Ctenodus*." In *Ctenodus* the scales are elongated and parallelogrammic, with the posterior end well rounded, and the sides nearly parallel or a little hollowed or concave: they are in length nearly twice their width, and, though imbricated, can scarcely be called truly cycloidal: they are delicate and large for the size of the fish, and are longitudinally ridged or grooved; the ridges, becoming curved and nodose, form a sort of rosette in the centre of the exposed imbricated portion." These scales were obtained from what they considered to be a complete fish of that species, but they add that it was "much crushed and disturbed"; certainly the engraving they publish of the fossil does not give much promise of founding any discoveries upon it. The scales of *C. obliquus* appear to have better evidence in their favour, for the above conjoint authors state, in a foot-note to a paper entitled "Descriptive Notes on Fish Remains found in the Coal Measures at Newsham," that they had obtained "a fine specimen of the greater portion of the cranium and part of the trunk of a large *Ctenodus* with the opercular plates attached; a considerable number of the ribs are exhibited in connexion with the head, disposed in natural order. Everywhere mixed up with this interesting specimen these peculiar scales are found, much broken, indeed, but occupying both sides of the body portion of the fish, in such a manner as to leave no doubt on the subject. The scales are very similar to those described in the text, differing only specificially, the margin being wider; the smooth central area has the same peculiar minute surface structure, and the upper surface is minutely granulated in the same manner." In the paper itself he portrays the scales: "they are parallelogrammic in form, are thin and delicate, and apparently represent three species, though the distinguishing characters are slight.

"The first, the largest and most perfect specimen, measures two inches and a half long, and upwards of two inches wide. The sides are parallel, the anterior extremity is a little arched outwards, and the posterior or exposed extremity is rounded; the angles are rounded off; the central area, under an ordinary hand-lens, appears quite smooth, and is bordered by a rather narrow margin having several concentric undulations or lines of growth, and marked with minute radiating striæ; no growth lines are visible within the marginal border. On examination with the inch object-glass, the central area is found to be finely reticulated with slightly elevated bony fibres, the meshes being sunk, so that the surface is minutely punctate. This is undoubtedly the under-side of the scale; the upper surface is revealed on fragments, and, at a rupture near the centre of the rounded exposed extremity, is minutely granular. Of course, in the latter case, it is only the cast of the upper surface that is seen; and at this point it is evident that the granules are enlarged and become arranged so as to form imperfect and very irregular vermicular grooves.

"The second species is less perfect than that just described; the greater portion, however, of the scale is preserved; but the border of one side is gone, as well as the posterior margin, and part of the anterior. The sides are slightly convex, and so is the anterior extremity, the angles being rounded; the border is wide, and distinguished by several concentric lines of growth, and five minute radiating striæ, as in the first species. The central area is likewise similar; but the minute surface-structure is finer, and the bony network has the meshes drawn out in the long axis of the scale; the punctures are not so large and distinct. This fragment (for fragment it is) measures two inches long, and one inch and one-eighth wide.

"The third species, which has lost the greater portion of the rounded posterior extremity, and is in other respects imperfect, is upwards of an inch and three-fourths long; it seems to have been more nearly square than either of the other two forms, and is characterized by a very narrow border, which shows only one or two concentric lines of growth and minute radiating striæ. The bony network of the central area is fine and indistinct, with a longitudinal arrangement of the meshes, as in the second species; the punctures are numerous, rather large, and longitudinally oval.

"The last description is apparently of a mere cast of the under surface; but a small portion of the scale, exhibiting the upper surface, is adherent, and proves that it is minutely striated in an irregular broken manner, the striæ for the most part having a longitudinal disposition.

"The peculiar rectangular form distinguishes these from all the cycloid scales with which we are acquainted; and they are much thinner than any other of the *large* scales of the Coal Measure fishes. The only scale that can be compared to them in this respect is that usually attributed to *Rhizodus*—the scale which we described some time ago as belonging to *Archichthys*. But this scale is pretty regularly rounded, is more coarsely granulated on the surface, and usually exhibits concentric lines of growth over the whole surface; it is also generally found split open, exposing to view the internal structure, when the concentric lines of growth and minute radiating striæ are sharply defined over the entire surface. The scale of *Ctenodus* is never seen with the internal structure thus exposed: at least we have never seen the concentric lines of growth and radiating striæ pass beyond the border, the under surface being usually exposed to view. This is well shown in our second species, the specimen being preserved on one slab in relief, the cast of the under-side in intaglio on the other."

Concerning these scales I myself can say nothing. I have examined hundreds of teeth, ribs, head-bones, opercula, &c., of this fish, but I have never seen a scale in association with them; and I know that no other palæontologist than Mr. Atthey had ever discovered any, previous to my departure from England, though many have diligently searched in the same pit. I do not doubt Mr. Atthey's statements at all, but it is strange, as remarked by Mr. Barkas, that *Ctenodus* scales should be so rare while all its other parts are comparatively common. Granting, then, that Mr. Atthey's discoveries are correctly diagnosed, for I have never had the opportunity given me of even seeing these specimens, there can be no hesitation in affirming their close similarity in form to the scales of *Ceratodus*. Reasoning from analogy would certainly lead one to infer that *Ctenodus* had scales.

The forms of the fins and tail are also unknown to me, but Mr. Atthey, from the one crushed specimen of *C. elegans* he possesses, and to which I referred in speaking of the scales, thinks that "the fins, as far as they can be made out in *C. elegans*, are arranged as in *Dipterus*. The tail fin is heterocercal and rhomboidal, and the anal and ventral can be traced immediately before the caudal." As this specimen is the only one upon which any trace of a fin or tail has been detected, and as it is acknowledged to be much injured, it will be advisable to leave this portion of the fish's structure to be determined by the investigations of future inquirers.

I have now entered in great detail into all the fossil remains of this fish that have been discovered, and we have seen that only in two points are there any marked differences between *Ctenodus* and *Ceratodus*, viz., in the arrangement and shape of the bones entering into the formation of the upper portion of the cranium and the ossification of the ribs. If we include those bones that are supposed to pertain to *Ctenodus*, but that are not yet distinctly proven to do so, we must add two other differences, the peculiarity of the scapula and the presence of otolites. With the exception of these four points, *Ctenodus* is identical with *Ceratodus* in its fundamental construction, so far as it is known, even in those parts that yet may be considered somewhat doubtful, such as the scales. When we take into consideration the distant period in which *Ctenodus* lived we can hardly expect that the type could have been handed down to the present time, countless ages intervening, without a few alterations of structure due to the differences of circumstances. During the Coal period the river mouths and brackish estuaries in which *Ctenodus* lived were the abode of huge Selachians armed with terrific teeth, and often with enormous dorsal and pectoral spines, much larger and more powerful than those of the present day; against these *Ctenodus* would have to defend itself when in the waters: for this purpose the solid thick shield of the cranium and the ossified ribs were probably sufficient. Then when this fish made its way out of the waters on to the dry lands or upon the swampy coasts, its life would be in danger from the huge Batrachians that swarmed; it would then require strength in the fore-arm to force its body back into the waters, resulting in the development of the scapula and coracoid for greater muscular attachment. Finally, the much greater size of *Ctenodus* would necessarily require a larger and firmer surface for the attachment of the powerful muscles that propelled the huge body through the waters, for, judging from the size of the teeth, ribs, opercula, &c., it has been estimated that some of the species were much over six feet in length. With none of these dangers has the modern fish had to contend; therefore, in the great battle of the "survival of the fittest" less strength has been required of it, and consequently in the process of time an alteration would take place in the skeleton, to render it compatible with existing circumstances.

With regard to the food of *Ctenodus* nothing can be ascertained, as fossil dung (coprolites) has never been found associated with its remains, but from the shape and arrangement of the teeth we can easily infer that it fed upon crustaceous and testaceous animals, and probably upon some of the smaller fishes like *Palæoniscus*. Some amount of certainty is given to this guess by the fact that the coprolites of fishes that swam in the same waters as *Ctenodus* have been obtained, and in them we find remains of the above forms of animal life.

On the Tertiary Deposits of Australia.

By Rev. J. E. Tenison-Woods, F.G.S., Hon. Mem. Roy. Soc. N. S. Wales, Hon. Mem. Roy. Soc. Victoria, Tasmania, and Linnean Soc. N. S. Wales, Adelaide Phil. Soc. &c.

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The subject of Australian tertiary geology has not, as far as I can learn, occupied much of the attention of the Royal Society of New South Wales. Owing to the very extensive development of the palæozoic, metamorphic, and volcanic rocks on the eastern cordillera of our continent, the tertiary formations have escaped attention; yet they are certainly an important element in our geological history, and deserve a speedy elucidation at the hands of naturalists in New South Wales. The marine cainozoic rocks of Australia cover at least a fourth part of its surface. The interest they possess, not only for ourselves but for Europe, can scarcely be overstated. As far as they have been studied they have revealed facts which are of almost startling importance to the science generally, and lately some of the discoveries will materially modify long received conclusions. This will appear as I proceed with the following paper, which I intend as a brief *résumé* of the present state of Australian tertiary geology. Such an epitome has long been wanted, not only by men of science, but by the public generally. The time is not far distant, let us hope, when a popular exposition of Australian geology can be prepared. The materials are sufficient, or nearly sufficient. While awaiting this, what I here bring before the notice of the Society may serve as a contribution to the subject, and I am encouraged to the task by the fact that most of what I shall state is new to the public.

Before I refer to what has been done, I beg to draw attention to the special interest the subject has for the natural history of New South Wales. There can be no question that tertiary formations are extensively developed in this Colony. They are no doubt chiefly volcanic or alluvial, with drifts and travertine of various ages; but their nature and position have not been studied—the marine formations have hitherto absorbed all the attention of geologists in Australia. This has not been owing alone to the special attractions they must ever have and the facilities for their study, but also because no satisfactory attempt at the correlation of strata can ever be made until something like a basis has been established by fossils of the relative position of marine strata. But as on the east and south sides of Tasmania, so in New South Wales, tertiary marine strata are not known. This is a significant fact, which has a far more important influence on our geological history than is supposed. But while marine strata are not visible, volcanic strata, freshwater deposits and drifts, all clearly tertiary, are abundant. No attempt, or at least no successful attempt, has been made to classify them. It is possible that nothing short of an actual and careful survey would reveal the age and relative position of these rocks, yet something might be done even by amateurs. That all our volcanic rocks possess features of their own, by which they may be recognized almost as surely as if they contained fossils, is a probability which investigation is daily raising to a certainty. In Victoria the miscroscopical and analytical researches of Mr. Ulrich have revealed astonishing facts. Already the augitic and hornblendic rocks are found to arrange themselves chronologically, and, as far as the learned and industrious mineralogist has gone, show an important bearing on the question of auriferous rocks. It may be said to be almost established that no volcanic emanations belonging to different periods, *e.g.*, the miocene and pliocene, will be found to have the same mineralogical characters. This then of itself would simplify the question of our tertiary volcanic geology, and when once taken in hand will not leave us long to wait for valuable conclusions. In the meantime I draw attention to the subject as a most interesting and untrodden field for observation, and I trust that my remarks on tertiary Australian geology may induce observers to stray into a field where an easy and abundant harvest awaits them.

Tertiary marine strata cover the whole or very nearly the whole southern portions of the Australian continent, from about the 125th to the 145th meridian of east longitude. There are interruptions to these beds, more or less; on the east side the formations get more and more narrowly confined to the sea, until they disappear altogether. On the Australian Bight they are uninterrupted, and extend very far from the coast line. They are all very rich in fossils, very well preserved in some cases, and in others masses of casts and broken shells. The peculiar character of these shells will be dealt with presently.

The interruptions to the continuity of the tertiary beds are of much interest. Throughout their course on the level country they are continually broken into by islands of red granite rocks, which are nearly the only elevations in the vast sandy plains of the deserts. Besides these small interruptions there are mountains, notably two large ones. The first, on the eastern side, is the South Australian chain, beginning at Cape Jervis at the mouth of St. Vincent's Gulf, and terminating in what was formerly erroneously regarded as the horseshoe bend of Lake

Torrens. A little further on the eastern side of this range the tertiary beds succeed in unbroken plains to the valley of the Murray. A little to the east of the boundary between South Australia and Victoria the country becomes singularly overlaid by basalts of middle tertiary or later tertiary origin, while a remarkable dome-like area of tableland forms an extensive interruption of some two or three thousand square miles in extent. This is apparently lower mesozoic, cut through by the Wannon and Glenelg Rivers. To the east it is again interrupted by the supposed lias or trias ranges of the Grampians and Victoria ranges. The tertiary rock still maintains its prevalence near the coast, and probably no more complete series of the deposits can be found anywhere than between Warrnambool and Cape Otway. This latter feature is the projecting portion of a range which forms a remarkable interruption, but at Geelong and on the western side of Port Phillip the tertiary formation again appears. The spur of the Dividing Range which abuts upon the sea at Wilson's Promontory is probably the final barrier to the tertiary beds, though some of them may yet be traced close to the sea in Gippsland.

Other and minor interruptions there undoubtedly are, but generally it may be said that a great semi-circular basin of tertiary rocks occupies the southern portion of the Australian continent, much in the way originally represented on the very clear sketch map of the geology of Australia by the late Mr. Jukes. A more detailed map has been recently given to the public by the Victorian Government, on which the same general features are given, but the detailed information attempted is not so reliable. Many of the places marked there as silurian in South Australia are really occupied by tertiary rocks, notably the eastern side of the shores of St. Vincent's Gulf, north of Willunga.

Various attempts have been made at some kind of classification of these beds, but no satisfactory system has yet been adopted, and it may be doubted whether the materials are as yet extensive enough for the purpose. Professor Duncan is of opinion that the whole of the deposits should be included under the general title of cainozoic, until the existing fauna shall be well enough known to admit the percentage system to be applied. This also will require a far better knowledge of the fossils than we have at present. The fauna of different beds in widely separated localities show that the results obtained so far are somewhat perplexing. Yet there are certain characters which seem to prevail. In order to understand these, I must give an account of what has been done towards the classification of Australian marine tertiary fossils. Strezelecki was the first in the field, but this only resulted in the determination of a single species. The next attempt was that of Professor Busk in 1859 (*Proceedings Geological*

Society). This was confined to Polyzoa. My humble efforts followed in 1862 (*Geological Observations in South Australia*), but this resulted in little more than a few figures and names. Professor Duncan immediately afterwards took the corals in hand, and in a series of papers in the *Geological Society's Proceedings*, threw great light on the nature and affinities of our fossil corals, from materials supplied by myself. In 1865 I published figures and descriptions of several of the more remarkable *Brachiopoda* occurring in the Mount Gambier formation, with a few *Echinodermata* and some conchifera (*Pectinidæ*). These were published and the figures lithographed by me in the Proceedings of the Adelaide Philosophical Society. In 1869 *Dr. G. C. Laube, in the Sitz. d. k. Akad. d. Wissen. Wien* (*Vienna*) *B. lix. Ab.* 1, 1869, *p.* 193, figured and published a very extensive catalogue of the *Echinodermata*, naming a number of new species from the Murray River beds. Shortly afterwards Professor M'Coy commenced the publication of his decades of Australian Palæontology, which left nothing to be desired in the figures or descriptions of the species named. But as the decades include other besides tertiary fossils, the descriptions, so far, do not describe many species; all, however, of the highest interest. In 1874, during a missionary visit to Tasmania, the Council of the Royal Society there placed at my disposal for classification a number of fossils in the Society's Museum, collected by Dr. Milligan, Mr. Stephens, and Mr. R. M. Johnston. The collection showed me at once that the great tertiary formation of Australia extended to the north-west portions of Tasmania. Among well recognized forms I saw many new and interesting species all new to science, and I therefore described them, the figures being executed by that accomplished natural-history artist, Mrs. Charles Meredith. Subsequent investigations by Mr. Johnston enabled him to write several most interesting papers on the deposit, all of which appeared in the Proceedings of the Royal Society of Tasmania: and at the same time he placed so valuable and so complete a series of fossils at my disposal that I was enabled to make a very full comparison of the Tasmanian beds with those of Australia. In all, I succeeded in settling the characters of from seventy to eighty fossils new to science, only very few of which have been hitherto found in Tasmania alone.

In the meantime the Geological Survey of Victoria has been very active, and a series of reports and papers have appeared with important papers on the fossils, from Professor M'Coy and Baron von Müller. Mr. Etheridge, jun., of the English Geological Survey, has also taken an active interest in the matter, and two valuable papers have appeared. In the first (*Geological Society's Proceedings*) he has described a new *Hemipatagus*—*H. Woodsii* (*Lovenia*, var.?), and then given a complete *résumé* of all that has been published on the subject of the Australian fossil Tertiary Echinodermata. In the second (*Annals of Natural History*) he has described some new *Brachiopoda*. But a most valuable accession to our Australian geologists has been in the arrival of Professor R. Tate, of the Adelaide University. He has entered upon his labours with a zeal and industry which bids fair soon to place him far in advance of all other observers in Southern Australia. Already his syllabus of the lectures given shows that he has made important discoveries, and in his private correspondence with myself has made known facts of the highest interest, to which I may refer just now. I may mention, also, that in my correspondence with T. Davidson, the most eminent of British, nay of European palæontologists, in his particular department (the Brachiopoda), I have forwarded all the fossils I could meet with belonging to this most interesting order. I take this opportunity of stating that from no scientific man have I ever met such kindness and courtesy. Trouble seems nothing to him, and his brilliant talents and vast knowledge are cheerfully at the service of the youngest amateurs. His observations on the Brachiopoda are full of interest, and I would place them in full before the Society, but that I know Professor Tate is preparing a monograph for publication on the same subject, which will shortly be accessible to all.

I will now proceed to notice how far the investigation of the fossils has thrown light upon Australian geology, and what relation our tertiary beds bear to similar formations in Europe. And first as regards the term tertiary. We do not pretend by that term to recognise many of the fossils here as identical with what are known as tertiary fossils in Europe. The formations which make up that group are thus classified because they contain either a certain percentage of species still existing, or because by their general contents they make a gradual approach in their typical organisms to the fauna and flora of the present day. Now in Europe the knowledge of the existing fauna, though hardly complete as far as marine life is concerned, is sufficiently so to enable naturalists to say with tolerable accuracy what percentage of fossils in any given bed belong to species which still exist. But in Australia our knowledge of marine life is almost confined to what is called the littoral zone. And to make this partial knowledge still more disadvantageous, I have not met many, or indeed I may say any truly littoral species, in all the tertiary beds I have examined. Neither have we any formation preserved to us, as far as I have been able to ascertain, which can be called the remains of a coast or littoral deposit. This circumstance renders us unable to apply the percentage test, and thus deprives us of those opportunities of classification, or rather correlation, with European deposits which would justify the employment of such terms as oligocene, miocene, &c. This Professor Duncan has pointed out, and has suggested the employment of the word cainozoic as a general term to distinguish those lower tertiary beds which contain the commencement of our modern fauna or new life. While quite agreeing with the learned professor in this, my long acquaintance with all the tertiary formations and my familiarity with the fossils induce me to offer a few suggestions which I think may carry our knowledge a little further. If we cannot apply the percentage system, we can, at least, form general conclusions from superposition, distribution, &c., as to the chronology of the series—if I may so speak. And it seems to me that we must not entirely disregard what I may term a family likeness in the deposits. We must remember that at the present day the existing fauna of widely separated seas, which have scarcely any species in common, have a general resemblance, in the prevalence of certain genera in certain habitats. Thus I suppose there are no seas where some forms of *Littorina*, *Patella*, *Trochus*, *Buccinum*, *Cardium*, *Pectunculus*, and *Mytilus* do not inhabit the rocks and sands. And some of the species bear so close a general resemblance that it is only after a careful comparison we can see specific differences. Now, we ought to see a similar general resemblance in the faunas of very widely separated areas which belong to the same epoch; and this, in fact, we do see, and, as far as my observation goes, almost justifies us in correlating our deposits with similar formations in Europe. I believe, however, that it is a generally received opinion that, as we go further back in time, so we find a wider range for species, until in the earliest deposits we find little specific variety all over the world. It is not quite so certain, however, that where widespread specific identity begins to fail, that close affinity still shows the influence of the former rule. It seems to me, however, that it is so, and it has an important bearing on facts which I now adduce. At present in Australian seas we have a series of molluscan provinces, all united by one general Australian *facies*, yet all with distinct characters peculiar to each. To any one conversant with Australian conchology it would be easy to tell at a glance to what province any given collection of shells belonged. For my own convenience I have been accustomed to divide the Australian seas into five molluscan provinces outside the tropics. These are,—1, Sydney, or Eastern; Victorian, or South-eastern; 3, Adelaide chain; 4, the Tasmanian; 5, South-western; the latter ranging from Port Eucla to Cape Leuwin. Now each of these provinces has species of its own and species in common. Observation as yet will not permit us so far to say with certainty how many of the species now identified are no more than local varieties. However, we can be certain that for those species which have a wide distribution, we see a great difference between specimens gathered in different provinces. Take for instance *Mytilus latus*, Lamk., or the common Australian mussel, which is one of the few shells common to Australia and New Zealand. In the latter place it is a large and often partly yellow shell. In Tasmania it is a brilliant olive green, changing with age into a dull purple. In New South Wales it is a tumid shell of dull olive, and in Victoria it is of the Tasmanian colour and shape, though with peculiarities of its own. This is by no means so favourable an instance as the less known *Patella tramoserica*, which has received a good many names from naturalists in its time. But from those or other instances that might be alleged, we find pretty certainly manifest at the present day local differences of form, character, &c., in otherwise identical species. Now it seems to me that there is not the same variety in our tertiary beds, and that this greater or less variability in remote districts might be made to form a valuable guide to the chronology of the deposits. One thing, however, is certain, which is that the species common in our tertiary beds have a much wider range than any species have now. To prevent the fact being applied too far, let us bear in mind that the deposits are not littoral, but rather that of the laminarian zone. 2nd. That colour, which is an important element in estimating variety in existing shells, is absent from the fossils. 3rd. The tertiary area at our disposal for investigation, though wide, is not nearly so extensive as the area of the provinces enumerated by me. Still, making all those deductions, my observations incline me to the conclusion that we have in our tertiary formations a much greater uniformity in marine life, and species more constant in character, than what is witnessed in the present Australian seas. This fact may seem of small importance in estimating our chronology, but I venture to submit that it is a clue which will lead in the end to valuable data. Whether we could ever hope by its aid to erect sub-divisions in our tertiary formations may appear doubtful, yet it must be of importance until the percentage system can be applied.

The oldest portions of our tertiary beds, as far as we can judge from the contained fossils, appear to be about Schnapper Point, Mount Martha, and Western Port. Here the blue clays, and the general appearance of the contained fossils, forcibly remind one of the eocene beds of West Barton, in Hampshire; and as Professor M'Coy has long ago pointed out, there is a good deal more than mere external resemblance. Some of the fossils closely imitate in character the fossils known in the English beds by what the learned professor has termed "mimetism." The resemblance is so close that some might even suppose the identity of the fossils. This is especially seen in *Voluta antiscalaris*, M'Coy, and

V. anticingulata. But these fossils, it must be added, are also found in newer formations, such as Table Cape in Tasmania, and Muddy Creek in Western Victoria. The general character of the Mount Martha and Schnapper Point beds is first in the beautiful state of preservation in which the fossils occur. The most delicate markings and fine edges are as fresh as if they were just dredged up from the deep. The clay in which they are found is of a light blue or ash grey colour. *Foraminifera* are not common, at least not so common in this finely levigated mud as in many of the higher beds. *Polyzoa* are also the exception. Pedicillate corals are, however, numerous, few of existing species, but of characters similar to those now living in the Japanese and China seas. There are none peculiar to this formation, at least as far as the beds have been explored, and that, it must be admitted, is only slightly. An undescribed *Nisso*, and a beautifully marked *Pleurotama*, also caught my attention, as well as a *Fusus*, so like the beautiful and delicately spined *F. pagodus* of the Philippines, that it has, I believe, been named *Fusus pagodoides* by Professor M'Coy.

Above those beds, and not separated from them by any very clear line of demarcation, we find a series of different deposits of some thickness and very wide spread. The characteristics differ in different localities. In the Geelong beds, and then westward from Cape Otway to Warrnambool, we meet with clays and muds, sometimes intercalated with plant remains, and a long succession of horizontal or slightly inclined stata. The precise number of the beds exposed has not been clearly ascertained, but they represent a very long series of deposits and an extensive period in our tertiary geology. To the north of Warrnambool they are found at a place called Hamilton, or around it, in the form of light brown clays, very rich in fossils. They are overlaid in places by a thick hard rock of ferruginous or ochreous limestone, entirely composed of polyzoa and the fragments of shells. The whole district is overlaid by much later outpourings of volcanic matter, so that the tertiary rocks become hidden, but there is little doubt that they are underneath, as, when wells or shafts are sunk to any depth, if they pierce through the basalt, the polyzoan limestone is reached. Now and then we find outcrops of granite, but even there traces of the tertiary formation appear. At a creek near Harrow, in Western Victoria, about 600 feet above the sea, we find, on the slopes of the granitic formation, a thin clay of a few inches thick, full of highly ferruginous fossils. These are hard and glazed, and have evidently owed their preservation to their ferruginous character, since the beds wherein they were deposited have entirely disappeared, and the fossils lie entangled in the grass, which is almost rooted in the granite. They are all of species common in the

Geelong beds, such as *Cucullæa corioensis*, *Pecten yahlensis*, (Tenison-Woods); *Cassidaria reticulospira* (M'Coy); *Placotrochus deltoideus* (Duncan).

Not very long ago it would have been difficult to name many of the fossils found in this immense series of deposits, but since the labours of M'Coy, Laube, Duncan, Etheridge, already referred to, and my own humble efforts, so large a number of the organic remains have been arranged and classified that it would be quite beyond the limits of this paper to give even a list of names. I propose, however, with the permission of the Society, to publish subsequently in the Proceedings a list of the names, authorities, and exact references where they may be found, as an easy aid to palæontological researches, which is very much required.

In Tasmania we find the same deposits, but under different conditions. The matrix is rather a muddy gravel than clay, and contains fragments of what are evidently the remains of a basaltic rock. There are also an immense number of rounded quartz grains, and the whole formation suggests the proximity of some granitic and basaltic rocky shore. The fossils are not different from those of Victoria, but only different from the character of the fauna in the same locality now. In describing over, I think, ninety fossils from those beds, I did not meet half-a-dozen similar to those now existing on the coast, and those only of shells which are now of rare occurrence. *Fissurella concatenata* (Crosse) is a case in point, and one or two which are doubtfully referred to European forms still existing, or of miocene age. Corals abound throughout the formation, whether in Victoria or Tasmania. One form, *Placotrochus deltoideus*, seems to prevail everywhere, and is very common; but no characteristic eocene form, such as *Turbinoli*. *Balanophyllia* is a genus which is richly represented, but the species in Tasmania are different, and one closely allied form, *Dendrophyllia*, has two species departing very widely from any known forms. In Victoria no reef-building coral was found, but in Tasmania I discovered a *Heliastræa* (*H. tasmaniensis*, Dunc.) to be not uncommon, together with a *Thamnastræa* (*T. sera*, Dunc.) not hitherto found in Australia. The general conclusion forced upon palæontologists by the fossils is that the seas were then much warmer than they are now. The types approach nearer to the fauna of the Philippine Islands and China Seas than anything now living near Australia. It is true that two or perhaps three species of *Trigonia* are found, but these are rather abnormal forms. The strictly Australian ones, such as *Elenchus*, *Cominella*, *Bankivia*, *Trochocochlea*, *Phasianella*, *Thalotia*, *Siphonaria*, &c., are not represented even generically, except a doubtful *Thalotia*.

It is a remarkable circumstance of the fauna of these beds that there has been discovered at Table Cape, Tasmania, one almost perfect skeleton of a wallaby, *Halmaturus* (?), imbedded in a soft yellow sandy clay full of marine fossils. They are principally small *Turritellæ*, *T. Warburtoni*, *mihi*, and others. There is nothing whatever to lead one to suppose that the animal was not deposited at the same time as the shells. It may have been carried out to sea by a flood from some coast stream, or it may have been dropped into the sea by a bird of prey. There it lies, however, firmly imbedded among the fossils, a land animal among marine shells. I was not able to ascertain whether the remains could be referred to any existing species. The specimen lies in the Museum of the Royal Society at Hobart Town, where unfortunately there are no marsupial skeletons for comparison. It seemed to me to be the remains of an animal stouter in proportion to its length than any we are acquainted with now. The fossil is of great interest, because first of all it points out the great antiquity of the marsupial fauna of Australia; and secondly, will serve as a guide to the interpretation of some of our cave remains.

At Portland, nearly on the western limit of Victoria, we have a commencement of a newer tertiary formation, known as the Mount Gambier or Polyzoan limestone. It is quite different in character from the lower strata we have been considering, and has been fully described in two publications of mine—viz., "*Geological Observations in South Australia*," and "*Two Lectures on the Geology of Portland*"—both of which are now in the Society's library. It has also been continually noticed in the reports of the various geological surveyors to the Mining Department of Victoria. I shall not therefore describe it now, but refer to some features which have not been previously noticed. First of all the deposit is distinguished by the abundance of *Polyzoa* and *Foraminifera*, of which, indeed, it is principally (nay almost entirely) composed. The greater part is a kind of marble, very loose and friable, which seems to be composed of broken foraminiferæ. The other fossils may be easily enumerated. They are few and far between, and may be said to comprise *Echinodermata*, *Brachiopoda*, and *Pecten*, and even these are scarce, except one urchin. This is *Lovenia Forbesii* (Woods and Duncan).* This lies on strata a few inches thick, with no other fossil, showing how curiously they must have flourished in the days of their existence. Now that we have the deep-sea dredging as a guide in estimating the conditions of life at great depths on the ocean floor, we easily understand what we see here. Sometimes the dredge of the "Challenger" would come up full of one kind of echinidæ, as if there was nothing else to be found. Here we see a similar thing in former times. There are also a few

* This fossil urchin was first named by me as *Spatangus*, but subsequently described by Professor Duncan as *Hemipatagus*. The same Professor has recently shown (in Q. Jour. Geo. Soc., 1877, p. 56), by a careful examination of many specimens, that the fossil is a *Lovenia*.

little belts of *Terebratula compta* (Sow.) The deposit is evidently one prevailing at great depths, and very different from its fauna from what we see at the same depths now. In Portland there is a good opportunity for observing the sequence of the tertiary beds and the volcanic outpourings. Tertiary marine strata and recent basaltic rocks are regularly intercalated. Some of these volcanic rocks have evidently been poured out under the sea, and there are two recent craters still visible in the midst of the waves, namely, what are called the Lawrence Rocks and Lady Julia Percy Island. The latter is about seven miles from the shore, and is a crescent-shaped island of almost tabular elevation entirely composed of volcanic ejectamenta. I propose, however, to give a paper on the tertiary volcanic phenomena of Australia, and therefore will not pursue this subject further.

The tertiary beds are found almost universally, unless where interrupted by the volcanic rocks, granite hills, or islands, as we may call them, until the Great South Australian chain or Adelaide Range is reached. They are, however, very much concealed near the coast by very recent pliocene and pleistocene deposits. The beds exposed on the banks of the Murray have never been submitted to a detailed examination by an experienced palæontologist until Professor Tate has taken them in hand. Some of his conclusions have been communicated privately to me; but I refrain from saying more on the subject, as the public will soon hear of them from himself. The same remark must apply to the tertiary beds on the western slopes of the Adelaide chain, about the mouth of the Onkaparinga River. These beds have been long known to me as containing quite a different series of organisms. They seem to me as older than even the Western Port beds; but my opportunities for examination were very limited. Professor Tate informs me that he has found characteristic upper mesozoic fossils among them, though he regards the beds as tertiary.

I find that at a meeting of the Geological Society of London, February 7, 1877, a paper was read from Professor Tate, on new species of *Belemnites* and *Salenia*, from the middle tertiaries of South Australia. The fossils were named by him *B. senescens* and *S. tertiaria*. They were obtained at Aldinga, where, he said, the fossils were for the most part identical with those of the Murray River beds. The *Salenia* was hitherto supposed to be extinct, and a characteristic mesozoic form, but a living species had been dredged up by the "Challenger." In the discussion which ensued, the President, Professor P. Martin Duncan, remarked upon the interest attached to the discovery of this Belemnite, which added another to the curious examples of the survival of older forms of life in Australia. He thought it could hardly have been derived from secondary strata. The *Salenia* was evidently tertiary, and, as it was somewhat cretaceous in its aspect, added another to the cretaceous forms which had outlived the cretaceous period. This and similar discoveries showed the impossibility of comparing Australian and English strata on purely palæontological data. Mr. J. S. Gardiner remarked, in connection with the discovery of cretaceous forms still living in modern times, that American cretaceous beds may be like our eocene. If a Belemnite lived on into the tertiary period, this might give quite another reading to those supposed cretaceous beds, whose determination rests mainly upon their flora. Mr. A. W. Waters said that two years ago he exhibited to the Society Belemnites from Ronca. Since then it has been shown that in the deposit at Ronca there are boulders from older beds, so that although his Belemnites are not rolled, and he regarded them as probably tertiary, the evidence must be considered incomplete. These *Belemnites* were like liassic forms, but very unlike those discovered by Mr. Tate. The Rev. J. F. Blake said that Professor Tate's specimens were more like oolitic than cretaceous forms, and they certainly did not belong to the genus *Belemnitella*. The carrying on of cretaceous forms into tertiary times favours the idea of a non-uniform deposition of beds, and a more continuous succession of life in Australia than in Europe. Professor Rupert Jones said that in 1857 *Belemnites* found in a tertiary deposit north-west of Germany were exhibited at the meeting of the Naturalists' Association at Bonn. Professor Seeley remarked that it was impossible from the material before the Society to determine the species to which the *Belemnite* belonged. The characters were not sufficiently clear to show whether it was a true *Belemnite*, or might form a distinct but allied genus. He agreed with Mr. Gardiner with regard to the resemblance of American cretaceous shells to those of the English tertiaries. Professor Duncan reminded Mr. Blake that there is a sharply defined cretaceous formation in Australia.

If I should venture to suggest anything in this matter, it would be that our tertiary formations are older than the period hitherto assigned to them. I do not think either that our cretaceous formation, which is near the equator and remote from these beds, is quite so clearly defined as imagined; neither is it safe to say that the southern analogues would be so very different from our lower tertiary beds, though I am far from saying that they would be the same. They may, however, be nearer to each other than is at present believed.

Westward of the Onkaparinga and Aldinga beds we have the tertiary formation well represented in some parts of Yorke's Peninsula. At Kadina, Moonta, and the Wallaroo mines generally, fossils are found at a small depth below the surface, mostly Echinoderms (*Arachnoides australis*, *Lovenia Forbesii*). These are well known forms of the Murray River beds, and perhaps they occupy the same geological horizon. They completely, or almost completely, cover the cupriferous veins, which are in true hornblendic or dioritic dykes. The deposit seems widely spread on Yorke's Peninsula.

Westward of these deposits we have the thick fossiliferous formation of the great Australian Bight, which extends for 300 leagues in an unbroken wall, abutting on the ocean at heights ranging from 300 to 600 feet, and all one mass of fossils. I believe this to be a geological phenomenon almost unequalled in extent and peculiarity on the surface of the earth. All the fossils I have seen from these beds have been familiar forms from Victorian or South Australian beds. I should imagine, from the description of the beds themselves, and the fossils submitted to me, that they were nearer to the Mount Gambier formation than those of the river Murray. I have however, never seen a good series of fossils from the cliffs of the Australian Bight, and no doubt they would be of the highest interest, and modify many of our conclusions made. I cannot help thinking that there has been no slow upheaval in the case of the Australian Bight. The cliffs, sometimes 600 feet high, abut upon the ocean without any sign of that wearing process which surely slow and gradual upheaval would cause. There is very strong, nay conclusive evidence, that the close of the miocene period, or rather the dawn of the existing fauna, was ushered in by extensive volcanic disturbance; and this, no doubt, caused very great changes of level and upheaval, some of which was clearly sudden and extensive. It is difficult to interpret the facts in any other way. It seems to me pretty clearly established that the whole central parts of the coast of Southern Australia were almost suddenly upheaved from the sea.

I now append a few notes on the *Brachiopoda* of the tertiary in Tasmania which has formed the subject of my inquiries for some time past. I accompany it with an outline sketch to assist in understanding some of the species to which I refer. I have submitted all the specimens to Mr. Thomas Davidson, Professor M'Coy, and Professor Tate, and I append after each species their remarks.

A *Rhynchonella cœlata*, M'Coy MS.: Rounded trigonal, with a strong mesial fold, with many fine imbricated ribs. "From several miocene beds in Victoria."—M'Coy. "A most beautiful species, very closely related to *R. nigricans*, from New Zealand. Some examples in external shape cannot be distinguished, but I have not observed on any recent *R. nigricans* such prominent and strongly marked imbricated striæ. The fold and sinus seems more strongly marked on the fossil form. The ribs also seem smaller and more delicate than on real *nigricans*."—T. Davidson. "Aldinga, one specimen."—Professor Tate.

No. 1. *Waldheimia imbricata, nobis, W. macropora,* M'Coy, MS. "Called so from pores which separate it from *W. flavescens,* to which I drew attention many years ago when printing that name. I do not, however, know how it can be separated from Davidson's *W. Garibaldiana.*"—Professor M'Coy. "This species has much the character of *W. flavescens* or *Australis.* I have not a good collection of Australian recent species of *Brachiopoda,* but have one that has a good deal of general similarity to this fossil from Table Cape, Tasmania, but none that has exactly the same shape. It would be well to compare with *W. flavescens.* It is a new but allied species, and has also a little resemblance to my *W. Garibaldiana,* although I think not the same species. The sub-pentahedral elongated shape is remarkable, but it is difficult to guess at the variations a species may assume by the inspection of a single specimen."—T. Davidson. "The commonest Brachiopod in the middle beds of the Murray cliffs."—Prof. Tate.

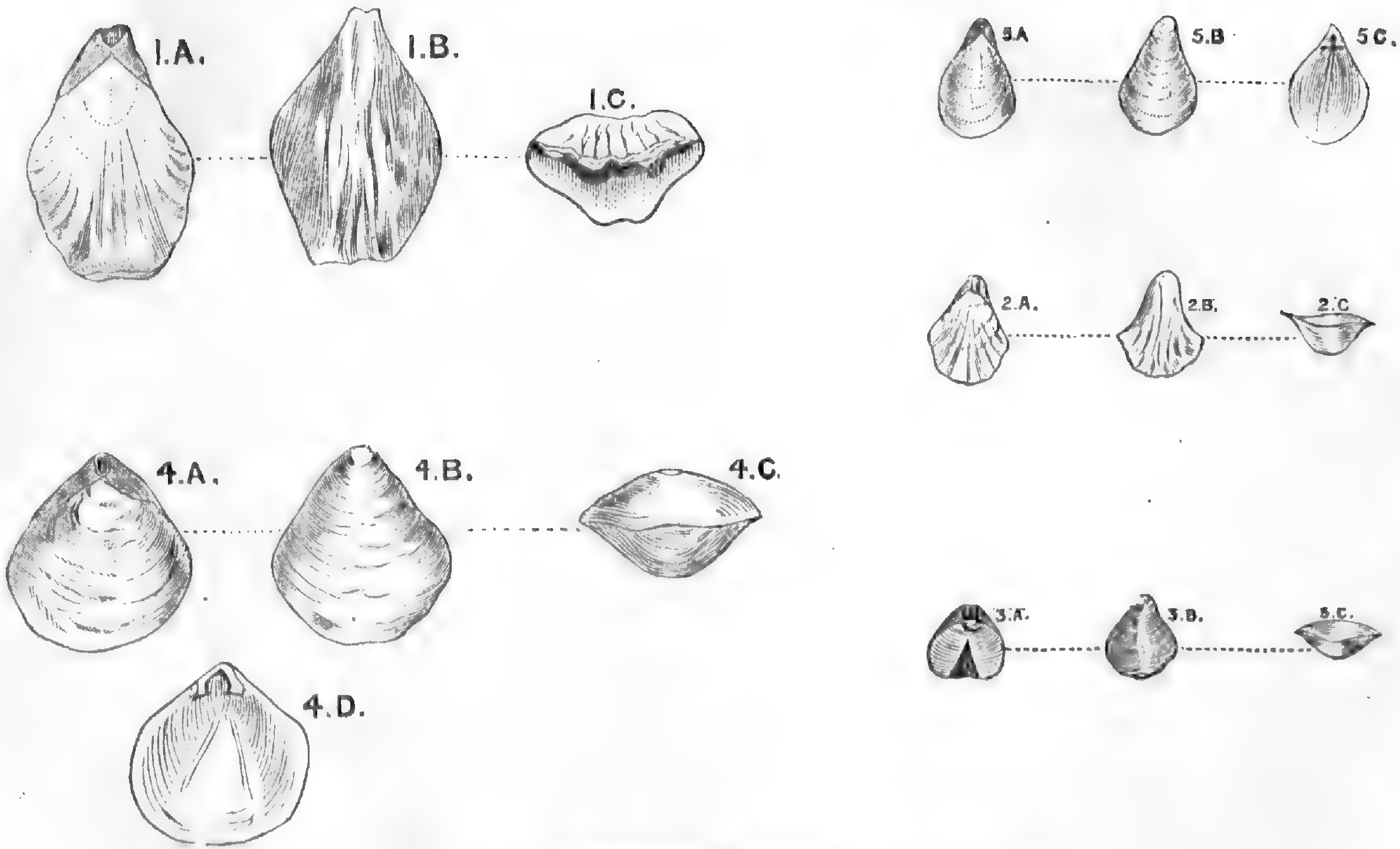
No. 2. Young of preceding, T. Davidson. Professor M'Coy did not recognize it with certainty. Professor Tate thinks it may be a *Terebratulina* common to Aldinga and Table Cape.

No. 3. *Waldheimia corioensis,* M'Coy, MS.: "I do not know this species with a broad depression on the smaller valve. It seems to me to be quite new."—Davidson.

Terebratula gambierensis. Ether. Ann. Nat. Hist. 1875. "A biplicated species approaching to the Italian tertiary *T. pedemontanæ,* but still distinct, being more regularly oval. It is, however, very difficult to distinguish the numerous closely allied biplicated *Terebratulæ* from the Jurassic, Cretaceous, and Tertiary periods. It is singular that, although biplicated species of *Terebratulæ* are so abundant in the Jurassic, Cretaceous, and Tertiary periods, that hitherto not a single species so constructed has been found alive or in the recent conditions."—T. Davidson. "Common at Aldinga. Another variable species, sometimes without biplications."—Professor Tate.

No. 4. *Terebratula vitreoides,* n. s. A small, smooth, orbicular species, with very conspicuous concentric lines of growth. Foramen small. I only figure and name this fossil provisionally, of which Mr. Davidson says, "This is another of those undecided forms that resemble many things described as distinct species. It has some resemblance to *T. vitrea* or to *T. orbiculata,* Sequenza. I would not like to assign it positively to any of the species, although I would not assign to it any very distinguishable features. I think you should publish a description and figures of these very interesting species, not only on account of the species, but of the formation and locality from whence they come."

No. 5. *Terebratula Tateana,* n. s. Small, smooth, without ribs or folds, closely allied to *T. compta* (Sow.) Beak somewhat produced. The specimens sent to Mr. Davidson too small or imperfect for determination.



EXPLANATION OF PLATE.

No. 1. *Waldheimia imbricata*: *a* dorsal valve, *b* ventral valve, *c* front view of margin.
No. 2. Young, sp.? *a* dorsal valve, *b* ventral valve, *c* front view of margin.
No. 3. *Waldheimia coriensis*, M'Coy: *a* dorsal valve, *b* ventral valve, *c* front of margin.
No. 4. *Terebratula vitreoides*, n. s.: *a* dorsal valve, *b* ventral valve, *c* front view of margin, *d* loop.
No. 5. *Terebratula Tateana*, n. s.: *a* dorsal valve, *b* ventral valve, *c* loop.

Discussion.

The Chairman said the paper was particularly interesting to him, and the discussion of the subject brought many things to his remembrance. He was born on the tertiary formation of East Anglia, and had lived for years in the tertiary district of Dorsetshire, as well as on those of the continent. He had also written on the subject of tertiary formations. He would take the liberty of making one or two remarks on the valuable paper just read. First, relating to the genus belemnites as tertiary. In the county of Suffolk, belemnites occur in great abundance *over* the tertiaries. But they so occur with gryphytes as drift in the boulder clay. It now appears, however, that not only is belemnites found to have tertiary species in Australia as well as elsewhere, and that there are a great number of instances in which fossils belonging to one particular epoch have survived to a more recent period. It is the case in parts of India; and in Australia plants assumed to be younger are found in beds of our carboniferous formation. It is in such cases proved that there is a passage from one formation to another without those immense breaks which geologists once thought necessary. He had one other remark to make respecting the coasts of Australia. The great banks of tertiary deposits along the Australian Bight overlie granite. In his "Notes on the Geology of Western Australia" (see Geological Magazine, vol. iii, p. 503 and p. 551), will be found a statement made to him by the late Captain Stanley, R.N., respecting a depth of water off the Bight amounting to nearly four miles, which in his "Notes" he shows to be possible. This might be so, even if elevation has since taken place. Between Cape Howe and Cape York no marine tertiaries have yet been found, though tertiary fossils have been brought from New Guinea. Along the east coast there appears to have been a sinking of the land in places which can be explained, in accordance with the Barrier Reef theory of Darwin, Probably this has been the case in earlier than tertiary times. with the district between Sydney and the elevated area of the Blue Mountains at the back of Penrith, and elsewhere on the coast, and thus notwithstanding elevations, there have been subsidences.

The Rev. W. Scott moved a vote of thanks to Rev. Mr. Woods. This was the first time they had had a paper read by an honorary member.

The motion was carried unanimously, and the Chairman conveyed the thanks of the Society to Mr. Woods.

Rev. Mr. Woods, in reply, expressed the pleasure he felt in having any part in the investigations of this Society. In reference to Mr. Clarke's statement as to the belemnites,—possibly they were derived fossils. It was said that no such interpenetration was admissible. If they were derived, we should expect to find them under different conditions. What he had seen convinced him that it was a mass of fossils accumulated in the sea. It was said there were, in the Bight, fossils found in North Australia. He had noticed one or two tropical forms there. As for the strata, he would hardly be prepared to say they were the same as the Murray cliffs, but the fossils were clearly tertiary. As to the subsidence of the eastern side of the continent, Mr. Clarke was more competent than any other man living to form an opinion. As to the depth found by Captain Stanley, he (Mr. Woods) thought four miles hardly a reliable one in those early days. As far as he had heard, there seemed to be a gradual shelving; but there was evidence of great subsidence, or of upheaval.

On some New Australian Polyzoa.

By REV. J. E. TENISON WOODS, F.G.S., &c., Hon. Mem. Roy. Soc., N.S.W.

[*Read before the Royal Society of N.S.W.*, 4 *July*, 1877.]

THE following two new species of SERIALARIA belong to the family *Vesiculariadæ* (order INFUNDIBULATA, sub-order 3, CTENOSTOMATA). It is now some years since I noticed the first, but had no opportunity to examine it until the year 1874, when by the aid of that experienced microscopist and scientific statist, Mr. W. H. Archer, F.L.S., &c., I was able to determine its character. I may say here that Mr. Archer made all the necessary investigations with the aid of his very extensive microscope apparatus, and the drawings were made by Mr. J. R. Y. Goldstein of Warnambool, under the direction of Mr. Archer.

SERIALARIA—*Lamarck*. Character :—Polypidom confervoid, horny, fistular, and branched. Cells, tubular, uniserial, and unilateral, disposed in close parallel companies in internodes at stated intervals.—Johnston, " Brit. Zoophytes," vol. i, p. 368.

SERIALARIA AUSTRALIS. sp. nov.

S. polyzoarium with the internodes completely occupied by seven to ten tubular cells, adnate to one another, perpendicular to the frond, curved, and lengthening towards the end of the series. Internodes serial, or giving off two others at right angles. Two long ligulate processes proceeding apparently from the terminal cell mouths of each internode. These are about twice the length of the internode. Mouth of cell somewhat crescentic, with a thickened margin.

Found after storms in masses amongst seaweed in Guichen Bay, South Australia. It is of light brown colour, and very like a mass of aphides. The transparent fistular branches, whence the cells arise, are corrugated and constricted at the internodes. In section they appear rhomboidal. Some of the cells seem to be provided with a conical cap. Are these ovicells ?

This species is very close to *S. lendigera*, Lamarck, but it is much more stout and solid, the cells are in a *double series* and quite fill up each internode, while there are frequently long vacant spaces in the British species. The ligulate processes are double at the end of each internode, while they are often single and only occasional in *S. lendigera*. See *Johnston, Brit. Zooph.*, 1st edit. (1838), p. 251, fig. 40. In Ellis's *Nat. Hist. of the*

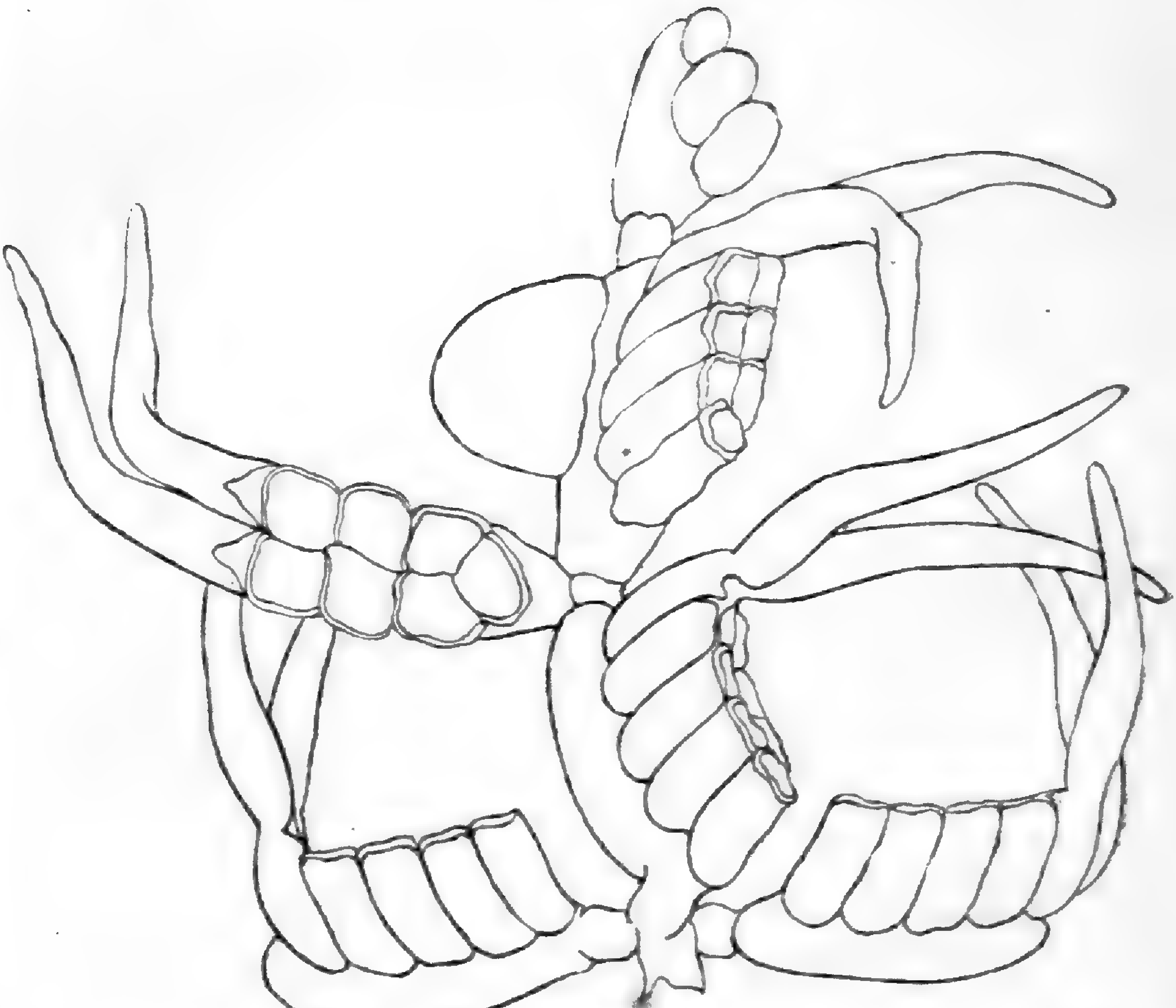
Corallines, Lond., 1755, at p. 27, we find the following notice of that species:—"*Corallina exigua, caule geniculato, scandens, vesiculis ex unoquoque geniculo sic dispositis, ut syringam Panis referent. Fucoides Lendigerum capillamentis cuscutæ instar implexis.* Nit Coralline. This extremely small climbing coralline arises from very minute tubes by which it adheres to fucuses and other marine-bodies, and is so disposed from its jointed shape that it climbs up and runs over other corallines and fucuses as dodder does over other plants. The vesicles have the appearance of rows of denticles are placed in such a regular order on the end of each joint that when they are magnified they represent the antique figure of Pan's pipe. I have called it the Nit Coralline from Mr. Ray's calling it the Nit-bearing Fucoides. The small vesicles closely-jointed together in little speck-like figures among the irregular capillary branches gives us some idea of that form." I may add that the Australian species does not, as far as I am aware, climb over sea-weed as above described.

SERIALARIA SPIRALIS. sp. nov.

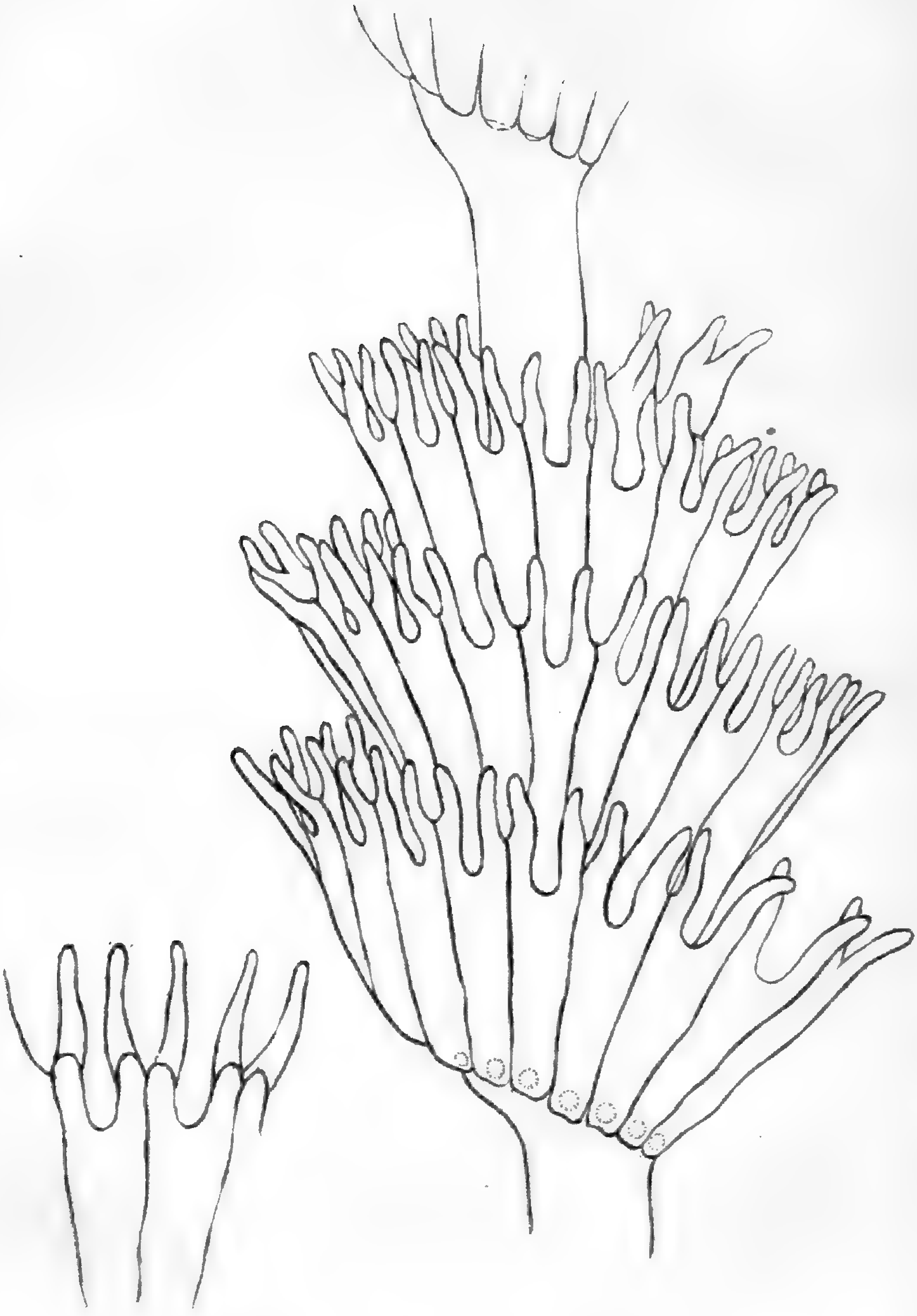
S. p. dichotomously branched with clusters of cells in series of twenty to twenty-four, disposed spirally round the axis of the branches. Cells flat, nearly four times as long as wide, each provided at the mouth with two divergent hollow spines half as long as the cell.

Common at various places on the southern coast of Australia and in Tasmania. The spiral disposition of the cells distinguishes this species from all others. In appearance it is like little masses of fine knotted fibre or a delicate moss. Under the microscope it seems at first like a series of little conical cups placed one within another, and surrounded with spines. It is not easy to trace the gradually ascending spiral series of cells, as their transparency blends their different parts into a confused mass. The cells on the summits of the branches are usually incomplete. and have their spines truncate and hollow. The clusters of the internodes form an easy receptacle for grains of sand, shell, and *foraminifera*, which also tends to confuse the aspect of the structure. Ovicells in large oval cups at the base of some of the spirals. Colour, dark brown.

It is to be remarked that neither of the above species polarises. whereas the calcareous polyzoa all show well defined peculiarities of structure under the polariscope. It would be an interesting inquiry to determine the nature of the substance which we call *horny* in these organisms.



SERIALARIA AUSTRALIS. *Tenison-Woods.*
(Highly magnified.)



Serialaria spiralis. *Tenison-Woods.*
(Highly magnified.)

On the occurrence of Chalk in the New Britain Group.

By Archibald Liversidge, Professor of Geology and Mineralogy in the University of Sydney.

[*Read before the Royal Society of N.S.W., 4 July,* 1877.]

In the following brief notice it is my wish to communicate to the Society a description of the physical properties and chemical composition of one of the geological specimens recently brought from the above group of Islands.

The specimen which I now have the pleasure to lay before you is not only interesting in itself as an example of what is known as an organically formed rock, since it is built up almost entirely of the calcareous skeletal remains of organic forms, but it is interesting in a still higher degree, as it apparently indicates that a most important geological discovery has been made of the presence of chalk in an hitherto unknown and even unsuspected locality.

In October last the Rev. G. Brown, Wesleyan missionary, brought (amongst other specimens) from New Britain and New Ireland (New Britain Group, latitude 4 degrees south, and 150 degrees east longitude) certain grotesque figures of men and animals, which had been carved by the natives of the above islands out of a soft white somewhat pulverulent material, having much the appearance of plaster of Paris or chalk.

Some of these figures were deposited in the Museum, and a fragment broken off from one of them was placed in my hands for identification.

On examination, the remains of numerous foraminifera are at once detected, the forms of the larger ones being plainly visible even to the unaided eye; under the microscope the whole mass of the rock is seen to be almost entirely composed of the shells and fragments of shells of foraminifera, the remains of globigerina being most abundant.

To obtain the shells of the foraminifera free from the cementing calcareous matter, it is only necessary to gently rub the surface of the specimen with a soft tooth or nail brush under a stream of water, when the whole surface of the fragment submitted to the operation speedily becomes studded with the minute shells and fragments of shells of foraminifera, now left standing out in relief.

To obtain the foraminifera perfectly free from the accompanying powder, it is sufficient to dry the collected *debris* and to place it upon the surface of some clean water contained in a glass beaker or other vessel; the larger and more cavernous foraminifera float on the surface of the water, while the broken fragments, much of the amorphous powder, and many of the denser foraminifera, are deposited at the bottom of the vessel as a sediment. The very light and finely divided parts are got rid of by decanting the milky supernatant liquid.

In the sediment the microscope reveals the presence of the smaller foraminifera, of a few sponge spicules, and minute grains of what are evidently siliceous and igneous rocks.

The further examination showed that the material is limestone, having a very close resemblance to chalk, both in chemical composition and in physical properties; in colour it is not the dazzling white of some chalk, but bears a closer resemblance to the light grey varieties.

Although it is essentially composed of carbonate of lime, still it is not perfectly pure; there are certain impurities present, in the form of alumina, iron, silica, manganese, and other substances; but reference will again be made to this question later on.

To ascertain whether my supposition that the rock might be regarded as chalk and not merely as a soft white friable recent limestone, or as a deposit such as is now forming over parts of the beds of the Atlantic and Pacific Oceans, I took an early opportunity, when writing, to enclose a portion of the material to Mr. H. B. Brady, F.R.S., of Newcastle-on-Tyne, who has devoted himself to the study of foraminiferous deposits, and who is recognized as one of the first authorities upon these matters. I have since received a reply from him, in which he says:—

"First, let me speak of your chalk from the New Britain group. I suppose you have ascertained that it is a cretaceous chalk, and not a friable tertiary limestone. All the foraminifera, or nearly so, are south Atlantic recent deep-sea species, *Globigerina bulloides*, *Gl. inflata*, *Pulvinulina Menardii* (a thick variety which I do not think is yet named), *P. Micheliniana*, and probably *P. Karsteni*, *Pullenia spheroides*, *Nonionia depressula*, *Bulimina Buchiana*, fragments of *Dentalina*, *Uvigerina*, &c.; also a characteristic *pulvinulina* with thick shell and honeycombed surface, not yet described, of which I have quantities in the "Challenger" material * * * The whole of the "Challenger" foraminifera have been handed over to me to work out."

In answer to a question as to the locality and mode of occurrence of the material used for the carvings, The Rev. G. Brown wrote to me as follows:—

"The chalk of which the figures are formed is, I am informed, only found on the beach after an earthquake, being cast up there in large pieces by the tidal wave; it is only found, as far as we know at present, in one district on the east side of New Ireland."

We have now to consider its chemical composition in somewhat closer detail, and to compare the results furnished by it on analysis with those yielded by specimens of typical or true chalk.

Chemical Composition of Specimen from New Ireland.

Hygroscopic moisture, *i.e.*, water driven off it, 100° C	1·202
Carbonic anhydride	35·337
Iron sesquioxide...	1·597
Alumina	3·131
Silica	7·933
Phosphoric acid	Minute trace
Manganese protoxide	·623
Lime	45·278
Magnesia	·476
Potash	·308
Soda	·260
Chlorine	·105
Combined water and loss	3·750
	100·000

Specific gravity, 2·199 at 59° F.

The specific gravity was taken from a mass weighing about 78 grammes, which was allowed to soak in water for about one hour and a half, in fact until all air bubbles ceased to be evolved; a small quantity of the block scaled off when immersed in the water—a correction for which had to be made.

The above figures show that in round numbers about 81 per cent. of the specimen consists of calcium carbonate; thus it is undoubtedly a far less pure limestone than the ordinary white chalk, as the following figures indicate:—

Chemical Composition of Chalk from other Places.

A specimen of chalk, from near Gravesend, which was analyzed by Mr. W. J. Ward, yielded the following results:—

Calcium carbonate	98·52
Magnesium carbonate	·29
Calcium sulphate	·14
Manganese binoxide	·04
Phosphoric acid	traces
Organic matter	—
Insoluble matter, chiefly silica ...	·65
	99·64

Mr. David Forbes, F.R.S., also examined some specimens of chalk, the analyses of which are here cited. The first analysis shows the composition of a piece of white chalk from Shoreham, in Sussex; and the second of a piece of grey chalk from Folkestone.

	White Chalk.	Grey Chalk.
Calcium carbonate	98·40	94·09
Magnesium carbonate	·08	·31
Phosphoric acid } Alumina and loss }	·42	trace
Sodium chloride	—	1·29
Water	—	·70
Insoluble rock debris	1·10	3·61
	100·00	100·00

(*Vide* "Geology of England and Wales." Woodward, p. 239.)

Another sample of chalk obtained from a well at Driffield was found by Mr. T. Hodgson to have the following composition:—

Moisture	5·20
Calcium carbonate	93·30
Magnesium carbonate	·15
Iron sesquioxide and alumina ...	·20
Silica	1·15
	100·00

The specimen from New Ireland closely resembles in chemical composition the chalk-like rock occurring in New Zealand.

Dr. Hector, C.M.G., F.R.S., Director of the Geological Survey of New Zealand, publishes in his Annual Report for 1875-6, the description and analysis of a limestone made by Mr. Skey, chemist to the Survey, as follows:—"No. 1,767. Chalk, contributed by Mr. H. Higginson, from South Canterbury, very closely resembles some taken from the same district by the Survey some time since. These samples, as to their physical and chemical character, also their general appearance, exactly represent the chalk of the cretaceous formation as occurring in England."

Analysis.

Carbonate of lime	84·12
Carbonate of magnesia	2·10
Clay	12·57
Iron oxides and alumina, soluble in acid	1·21
	100·00

It is, however, far less impure than the "chalk mud" of the Atlantic, for the analysis quoted by Professor Sir Charles Wyville Thomson, F.R.S., in his "Depths of the Sea," p. 469, show that the "chalk mud" contains merely some 60 per cent. of calcium carbonate, and with as much as from 20 to 30 per cent. of silica, and varying proportions of alumina, magnesia, iron, and other substances.

The same author mentions that the typical chalk is free from silica, and so it would appear to be from the above quoted analyses; but the "insoluble rock debris" of the late talented David Forbes, F.R.S., probably consisted largely of silica.

The only locality for chalk in the Pacific Islands to which I can find any reference occurs in Professor Dana's work on "Corals and Coral Islands." See p. 308. But this even is not true chalk; it is merely a recent limestone derived from disintegrated corals, and which resembles chalk.

Mr. Dana there says—

"The formation of chalk from coral is known to be exemplified at only one spot among the reefs of the Pacific.

"The coral mud often looks as if it might be a fit material for its production. Moreover, when simply dried, it has much the appearance of chalk, a fact pointed out by Lieutenant Nelson in his memoir on the Bermudas (1834), and also by Mr. Darwin, and suggested to the author by the mud in the lagoon of Honden Island. Still this does not explain the origin of chalk, for, under all ordinary circumstances, this mud solidifies into compact limestone instead of chalk, a result which would be naturally expected. What condition then is necessary to vary the result and set aside the ordinary process?

"The only locality of chalk among the reefs of the Pacific, referred to above, was not found on any of the coral islands, but in the elevated reef of Oahu, near Honolulu, of which reef it forms a constituent part. It is 20 or 30 feet in extent, and 8 or 10 feet deep.

"The rock could not be distinguished from much of the chalk of England; it is equally fine and even in its texture, as earthy in its fracture, and so soft as to be used on the blackboard in the native schools.

"Some imbedded shells look precisely like chalk fossils. It contained, according to Professor Silliman, 92·80 per cent. of carbonate of lime, 2·38 of carbonate of magnesia, besides some alumina, oxide of iron, silica, &c.

"The locality is situated on the shores, quite above high-tide level, near the foot of Diamond Hill. This hill is an extinct tufa cone, nearly 700 feet in height, rising from the water's edge, and in its origin it must have been partly submarine. It is one of the lateral cones of Eastern Oahu, and was thrown up at the time of an eruption through a fissure, the lava of which appears at the base. There was some coral on the shores when the eruption took place, as is evident from imbedded fragments in the tufa; but the reef containing the chalk appeared to have been subsequent in formation, and afforded no certain proof of any connection between the fires of the mountain and the formation of the chalk.

"The fine earthy texture of the material is evidence that the deposit was not a subaerial sea-shore accumulation, since only sandstones and conglomerates, with rare instances of more compact rocks, are thus formed. Sand-rock making is the peculiar prerogative, the world over, of shores exposed to waves, or strong currents, either of marine or of fresh water. We should infer, therefore, that the accumulation was produced either in a confined area, into which the fine material from a beach may have been washed, or on the shore of a shallow, quiet sea—in other words, under the same conditions nearly as are required to produce the calcareous mud of the coral island. But although the agency of fire in the result cannot be proved, it is by no means improbable, from the position of the bed of chalk, that there may have been a hot spring at the spot occupied by it.

"That there was some peculiar circumstances distinguishing this from other parts of the reef is evident.

"This, if a true conclusion, is to be taken, however, only as one method by which chalk may be made; for there is no reason to suppose that the chalk of the chalk formation has been subjected to heat; on the contrary, it is now well ascertained that it is of cold water origin, even to its flints, and that it is made up largely of minute foraminifera, the shells of rhizopods.

"Professor Bailey found under his microscope no traces of foraminifera, or of anything distinctly organic, in the chalk."

The entire absence of any remains of foraminifera must, I venture to think, completely destroy any claim for the Oahu limestone to be regarded as chalk proper.

Neither can the Atlantic ooze, rich though it be in coccoliths and the shells of foraminifera, be regarded as chalk. It is true that it may in future geological ages fulfil Professor Wyville Thomson's prediction and become such, but even of that we cannot be certain. At present it is a soft calcareous mud, and a very impure one. When consolidated and converted into dry land, instead of forming a brilliant white chalk limestone, a hard compact argillaceous or siliceous slaty limestone may be the result.

The true white chalk so familiar to Englishmen is found over an area extending from the southern part of Sweden to Bordeaux, a distance in round numbers of 850 miles, and again from the northern part of Ireland to the Crimea, *i.e.*, about 1,140 miles.

I am, of course, referring to the extent merely of the soft white limestone known emphatically as chalk, not to the areas occupied by that great variety of rocks which are classed with the chalk, and which are collectively known as the rocks of the chalk or cretaceous period, from the fact that they contain certain fossils in common.

Rocks belonging to the chalk or cretaceous period have a very wide distribution, being found in Europe, Asia, Africa, America, and in Australia from Western Australia to Queensland, and New Zealand.

It may, perhaps, be mentioned as an argument in favour of the probability of the New Ireland limestone being properly regarded of cretaceous age, that we have cretaceous rocks in Queensland as far north as 11° S., and in New Guinea, still nearer to New Ireland, we have rocks which undoubtedly belong to the mesozoic or secondary period, for amongst the geological specimens brought by Signor D'Albertis from the Fly River, and submitted to me for examination, there were *belemnites*, an *ammonite* (this ammonite bears a very close resemblance to a liassic form) and other fossils, such as *carcharadon teeth* and *pectens*, all of which may or may not belong to the cretaceous age.

It would be by no means a startling thing to find that these secondary beds had an extension to the New Britain group of Islands, a distance of only a few hundred miles, which would comprise an area by no means equal to the extent of country occupied in Europe by the typical white chalk.

It should, however, be mentioned that no true white chalk has yet been found either in Queensland or in New Guinea.

In conclusion, it may be stated that the principal reasons in favour of the rock being regarded as chalk are that physically it is almost indistinguishable from most typical specimens of that rock, and that it has had the same organic origin; the foraminifera alone are not, unfortunately, sufficient to rigidly determine the geological age of the specimen, because they are types which have been persistent from the cretaceous period to the present time.

On a Method of Extracting Gold, Silver, and other Metals from Pyrites.

By W. A. Dixon, F.C.S., Cor. Mem. Nat. Hist. Soc. Glasgow.

[*Read before the Royal Society of N.S.W.*, 1 *August*, 1877.]

Some three years since, Mr. Wood, Under Secretary for Mines, suggested to me that the extraction of gold from complex minerals was a subject well worthy of investigation, and one which if brought to a successful issue would be of great value to New South Wales and Queensland. Both these Colonies yield minerals containing gold, and that often in considerable quantity, but so mixed up with sulphides of copper, lead, iron, and other metals, that none of the ordinary methods of treatment extract more than a very small proportion of it.

Acting on this suggestion, I obtained some pyrites from Mariner's Reef, Gympie, which in the rough yielded on analysis :—

Copper	6·2 per cent.
Lead...	·19 ,,
Gold...	3 oz. 3 dwts. 2 grs. per ton.
Silver	32 oz. 9 dwts. 3 grs. per ton.

Another larger portion from the same reef, after being ground and washed so as to remove as much as possible of the quartz, which was found to amount to about 60 per cent. of the rough mineral, gave—

Copper	17·02	or	Copper pyrites	48·45
Lead	2·01		Iron ,, ...	35·95
Antimony	3·9		Galena	2·31
Gold and silver ..	·22		Sulphide of antimony ...	5·44
Iron	31·41		Sulphide of arsenic ...	·68
Sulphur	37·86		Gold and silver	·22
Silica	7·16		Silica	7·16
Arsenic and loss	·42			
	100·00			100·21

Gold ...	12 oz. 10 dwts. 0 grs.	per ton.
Silver ...	62 oz. 9 dwts. 16 grs.	

I had also a small lot of copper pyrites from this Colony containing 24 per cent. of copper, and gold equal to 78 oz. 8 dwt., and silver 4 oz. 2 dwt. 10 grs. per ton; arsenical pyrites containing when thoroughly roasted 11 ozs. 18 dwts. 0 grs. per ton; iron pyrites containing when roasted 5 ozs. 6 dwts. 3 grs. gold per ton.

As much attention has been given, by others more conversant than myself with mechanical manipulation, to the extraction of gold and silver, by grinding with mercury in variously designed apparatus, with comparatively small success so far as these complex ores are concerned, I have confined my attention principally to those chemical relations of gold which would enable me to obtain it in solution. I may note, however, that in Germany ores containing more than 1 per cent. of copper, or 7 per cent. of lead, have not been found suitable for amalgamation; and that an increase of density of the accompanying gangue from the presence of heavy spar, &c., or of tenacity from the presence of clay, seriously reduce the yield of precious metals, consisting in their case principally of silver; and that nearly all the gold is lost in the tailings, with about 15 oz. of mercury per ton of ore treated.

The loss of silver by amalgamation, working with ores considered suitable for that process, has been found to vary in Germany from 5 to 10 per cent. of the contained quantity.*

With the Comstock silver ores in America the loss is 12 per cent. by barrel amalgamation, whilst with the same ores by pan amalgamation the yield never exceeded 80 per cent., seldom 75 per cent., with a general average of 66 per cent.†

At the Port Phillip Works at Clunes, Mr. Latta reports that the average loss of gold by amalgamation in a period of seven years was 6 dwts. 10 grs. per ton, the highest loss being 7 dwts. 15 grs., the lowest 4 dwts. 8 grs., the pyrites being free or nearly so from copper and lead.‡

In treatment by fusion it is found at Kongsbeck in Norway, that after repeated fusion slags carry away 1 oz. 2 dwts. of auriferous silver per ton; and in Lower Hungary by a similar process the loss is in the slags 1 oz. 12 dwts. per ton, besides a loss of 3½ per cent. of the total silver in the smoke.

Rivot says: "The yield of gold and silver from pyritical ores does not exceed 65 per cent. of the assay, which is itself open to losses. According to many synthetical experiments, the loss is greater in assays of richer than of poor ores, amounting always to more than 30 per cent, and with fahlore and ores containing arsenical pyrites to more than 50 per cent. The loss incurred when working on a large scale is less than in laboratory assays.

* Watt's Dictionary of Chemistry, article Silver.
† S. A. Phillip's Mining and Metallurgy of Gold and Silver.
‡ Trans. R. Soc., N.S.W.

The difference between the yield on the large scale and the percentage by assay may exceed 30 per cent., even when the metallurgic method is quite perfect; but as the American methods are far from perfect, the difference is still greater.*

Many of the trials made during this investigation yielded negative results, and in others the yield of the precious metals was so small as to be of no practical value, and I shall therefore only give an outline of the methods adopted with a few results selected from numerous experiments.

The quantity of material operated on in all cases was 3,667 grains, from which quantity one-tenth grain represents 1 oz. per ton.

The first process which suggested itself for the extraction of gold was to take advantage of the solubility of sulphide of gold in solutions of alkaline sulphide, for if this could be effected it would render the roasting of the ores unnecessary.

In 1859, Henderson included in his patent for the extraction of copper, a process for extracting gold as sulphide. His directions are that the pyrites be fused to obtain a matt which is to be fused with two parts of salt cake (crude sulphate of sodium), and the matt run into pigs. These placed in water crumble to pieces; and the gold is obtained in solution, whence it may be recovered by precipitation with an acid.

In 1868, a process was patented in America for the extraction of gold by "sulphur and its salts," but of this I have no details.

The first experiments were made by treating portions of each ore with solution of sulphide of sodium containing a slight excess of sulphur. The experiments were varied in concentration of solution, in time of digestion from one to seven days, and in temperature, some being conducted at ordinary temperatures, others at 212° F. Twenty experiments were made altogether, and in no case was a trace of gold obtained on neutralizing with acid, filtering off the precipitated sulphur, and igniting. From arsenical pyrites much arsenic was obtained in solution.

Henderson's process was tried with Mariner's Reef ore, proceeding exactly according to his directions, but although the regulus disintegrated in water as described by him, I could not, in two trials, obtain any gold in solution. This process was modified, with equally unsatisfactory results, by fusing with sulphide of sodium, by fusion with sulphate of sodium and charcoal, and by heating finely powdered ore to a dull red with sulphite of sodium, without fusion.

The extraction of gold from its ores as chloride was proposed by Price, who, in January, 1857, patented a process in America for the extraction of gold from its ores by fusing them with sulphide of iron, and treating the regulus with aqueous chlorine

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* *Rivot Ann. Min.* [6] VII. 1. *Watt's Dict. Chem., Second Supplement, p.* 572.

or an acidified hypochlorite. This introduced a source of difficulty, as the chlorine would have to convert the sulphide into ferric sulphate before any gold could be obtained in solution.

Ziervogel proposed treating roasted pyrites with chlorine, and his process was used at Chemnitz.

This process was afterwards patented in the United States by G. F. Deetken, in 1863, and has been used with tolerably satisfactory results in California in two establishments. The process is there carried out as follows:—The concentrated pyrites are subjected to a thorough calcination, and when sulphurous anhydride ceases to be evolved, the residue is withdrawn from the furnace and cooled. It is then sprinkled with water, and turned over several times until uniformly damped, the exact condition in this respect being a matter of considerable importance. It is then placed in a large wooden vat, having a false bottom, and chlorine gas from a generator is admitted below until it is seen floating above the material. The tank is then closed, the current of gas stopped, and the whole left at rest for ten or twelve hours, when the cover is removed and water is run on. This dissolves the chloride of gold formed, and the solution is run into earthenware or glass vessels, where the gold is precipitated as a bronze-black powder by the addition of a solution of ferrous sulphate.

As it had been found that gold alloyed with much silver was not readily attacked by chlorine from the chloride of silver formed encrusting the granules, Patero and afterwards Rösner proposed the use of chlorine dissolved in a concentrated solution of salt.

The disadvantage of the chlorine method of extraction is, that with ores containing copper, the whole of that metal has to be removed before the chlorine becomes available, and also all the sulphur which otherwise becomes first oxidized to sulphuric acid.

With a view to removing the copper, I carefully roasted a quantity of ore in a muffle, at a dull-red heat, with constant stirring for seven hours, and extracted the residue with water and sufficient sulphuric acid to convert all oxide of copper into sulphate. The dried residue was found to contain 1·5 per cent. of sulphur, and I therefore recalcined the whole for seven hours longer, and extracted the copper as before, when the sulphur was found to be reduced to 0·46 per cent. A similar result was obtained in successive trials, and as this amount of sulphur would require as much chlorine, as upwards of 3,300 ozs. of gold per ton, a more perfect method of getting rid of it was evidently required.

Another portion of ore was therefore partially calcined, cooled, and damped with brine, and the whole again calcined until fumes were no longer evolved.

The residue extracted with water and acid as before was found to contain 0·12 per cent. of sulphur and traces only of copper.

On assaying a portion of the residue, it was found to contain—

Gold ... ... 3 oz. 14 dwt. 8 grs. per ton.
Silver ... ... 39 oz. 18 dwt. 14 grs. „

A portion was ground up with mercury and sufficient water to make it of the consistence of thick cream, in which the mercury was well broken up for an hour, and afterwards carefully washed, the tailings being gone over as often as any mercury was found. This yielded—

Gold ...1 oz. 0 dwt. 5 grs. leaving 2 oz. 14 dwt. 3 grs.
Silver...6 oz. 16 dwt. 10 grs. „ 33 oz. 2 dwt. 4 grs.

Another portion, shaken up with a solution of salt and pieces of iron to decompose the chloride of silver, and the residue ground up as before, yielded—

Gold ... 1 oz. 1 dwt. 0 grs. leaving 2 oz. 15 dwt. 8 grs.
Silver...34 oz. 3 dwt. 5 grs. „ 5 oz. 15 dwt. 9 grs.

These results showing that even after the almost complete removal of sulphur, or at all events what would be considered complete on the large scale, the greater part of the gold present was untouched by the mercury, I proceeded to examine the effect of chlorine, of which I give the following as typical results:—

A portion treated with chlorine gas exactly as above described yielded gold, 16 dwts. 10 grs., leaving 2 oz. 17 dwts. 22 grs.

A portion treated with $\frac{3}{4}$ oz. of calcium hypochlorite and sulphuric acid with sufficient water shaken up in a bottle for twenty-four hours (it then smelt strongly of chlorine) was filtered through an asbestos filter, the residue well washed, and the gold precipitated—yielded 1 oz., leaving 2 ozs. 14 dwts. 8 grs. The dried residue was found to be free from sulphur.

A portion mixed with brine and the same quantity of re-agents as above and otherwise similarly treated, yielded gold 1 oz. 2 dwts. 5 grs., leaving 2 ozs. 12 dwts. 3 grs. The residue digested with water containing $\frac{1}{2}$ oz. hyposulphite of sodium, the solution acidified and treated with sulphureted hydrogen, gave—

	ozs.	dwts.	grs.
Gold	0	3	0
Silver	22	14	19

Roasted arsenical pyrites, treated with hypochlorite of calcium and sulphuric acid as above gave—gold 11 ozs. 15 dwts. 5 grs., leaving 2 dwts. 19 grs. Roasted iron pyrites similarly treated gave—gold 5 ozs. 1 dwt., leaving 5 dwts. 3 grs.

The two last results show that with these simple pyrites the treatment with hypochlorite and acid gives very fair results, and this being a process involving no troublesome apparatus it might be sometimes applied with advantage.

It is difficult to account for the fact, that in the case of the more complex mineral the chlorine even in large excess exerts so little action on the gold, and that when all the copper has been removed previous to treatment; but in every trial similar results were obtained. It seems probable, however, that the state of aggregation of the metal has some influence on its solubility in chlorine, and that as a mispickel dissolves gold, it was therefore obtained in the residue in a finely divided state, less so in the iron pyrites residue, and least divided in the complex ore. In the last, mere traces of gold were obtained by re-treating the residues from the first treatment by chlorine.

The only other salts of gold which possess sufficient stability to render their use possible for its extraction are the auricyanides of the alkali metals and bromide of gold. Bromine would, however, be more expensive and more troublesome to use than chlorine, and moreover in one or two trials gave me smaller results than were obtained by chlorine. Skey* has described a method of testing for gold by the use of bromine water, and also with tincture of iodine. I have been unable to obtain any reaction either with tincture of iodine or with solution of iodine in iodide of potassium, which, considering the unstable character of the gold iodides, is scarcely to be wondered at.

Prince Balgration and Elsner† have observed that precipitated gold is soluble in cyanide of potassium if exposed to the air, and the latter says also in ferrocyanide of potassium. A patent was applied for in America in 1868 for the use of cyanide of potassium for the extraction of gold from its ores, but I have no particulars of the process. It seemed to me, however, that the high price of this salt, its instability when exposed to the air and in solution, and its extremely poisonous properties, precluded its use for this purpose. On trying the reaction between precipitated gold and cyanide of potassium, I found that it was extremely slow if the gold was at all dense. In presence of alkaline oxidizing agents, however, I found that the solution of the gold was sufficiently rapid. Thus, on standing over night, the quantity of gold and cyanide of potassium solutions being similar in each case—with the cyanide alone, traces only of gold were dissolved, but with the addition of calcium hypochlorite, ferrocyanide of potassium, or binoxide of manganese, all the gold was dissolved; with chromate of potassium, a small quantity; with permanganate of potassium, none.

With ferrocyanide of potassium alone I did not obtain any gold in solution after standing some days, but I thought that with suitable oxidizing agents it might be obtained in solution according to the equation—

$$4Au + 2K_4FeCy_6 + 7O + 4H_2O = 4AuCy_3 + Fe_2O_3 + 8KHO.$$

* Chem. News, XXII, 245. † Watt's Dict.: Cyanides of Gold.

In the cold, however, with the exception of ferricyanide of potassium, none of the above oxidizing agents had any effect, but heated to 212° Fah. the reaction with all of them was sufficiently rapid, and I found that this was also the case with permanganate. This reaction promised to be of considerable value, as the gold and silver would both be obtained in solution, from which the former could be precipitated by filtering the hot solution through finely divided metallic silver, of which an equivalent quantity would be dissolved, which, with the silver originally present, could be precipitated as sulphide. By treating the solution with ferrous hydrate, the cyanide of potassium could be retransformed into ferrocyanide, which has the important advantages of being exceedingly stable and non-poisonous. I found, however, that copper in any form precipitated both gold and silver from the solution, or at all events that these metals were not dissolved until the copper had all gone into solution; also, that if the copper was present as sulphide, the silver was transformed into sulphide which is insoluble. Any copper dissolved cannot be precipitated as sulphide, but I found that it could be removed by digesting the solution with ferrous hydrate, the solution being kept alkaline.

A portion of roasted arsenical pyrites was digested at 212° for twelve hours with ¼ oz. ferrocyanide of potassium, 32 grs. oxide of manganese (20 lbs. per ton), and sufficient water made alkaline by soda to make a cream—the solution yielded 9 ozs. 8 dwts. 19 grs. gold per ton, leaving 1 oz. 9 dwts. 15 grs. This was the best result obtained with this pyrites, the yield with other oxidizing agents and by more prolonged digestion being all somewhat lower.

With Mariner's Reef pyrites trials were made with each oxidizing agent in succession, the duration of the digestion being varied from twelve to fifty-six hours; whilst with the soluble oxidizing agents the quantity used was in some cases little over the theoretical amount, and sometimes ten times as much. In some of the experiments all the oxidizing agent employed was added at once, in others at successive intervals; and I found that after four or five times the theoretical quantity had been added, a further increase had little or no influence on the result. With binoxide of manganese, on the other hand, from thirty-five to forty times the theoretical quantity gave the best results. The material used had been roasted with salt and extracted with acid, and contained so little copper that 50 grs. digested with nitric acid, the solution made alkaline by ammonia, and made up to 50 CC, had only a faint colouration in a cylinder 3 inches deep. It contained—

	ozs.	dwts.	grs.
Gold	8	0	19
Silver	49	11	5

and yielded from 3 ozs. 12 dwts. to 5 ozs. 1 dwt. of gold, and from 46 ozs. to 46 ozs. 3 dwts. of silver per ton. This showed that all the silver which had been converted into chloride during the roasting was obtained in solution as cyanide. With the gold, on the other hand, all the results showed that with complex pyrites a portion only could be obtained in solution either in mercury or in water as cyanide or chloride, whilst none could be obtained as sulphide.

There being therefore no method by which the precious metals could be removed and the base metals left, it remained to fall back on one of the first principles of metallurgy, viz., to remove the base metals at the earliest stage possible, and leave the precious metals as a residue. In ordinary metallurgic operations this end is attained by dressing and successive smeltings. I however arrived at the conclusion that smelting was not a desirable process, as it is expensive and the gold and silver would at last be found alloyed with a large quantity of copper, whilst considerable quantities of these metals would be lost by volatilization and in the slags. These losses have been found elsewhere to be large, even when tested against the usual assay, which as Rivot observes is itself open to losses. That the loss of gold by any process involving smelting must be considerable is evident, when we consider that glass will hold a large amount of gold in solution. Thus, calculating from the quantity of gold used to form ruby glass, which is perfectly colourless when first melted, I find that it contains 10·88 oz. of gold per ton, imitation topaz 8·21 oz. of gold per ton, imitation garnet 27·18 and 46·33 ozs. per ton, by two different receipts. The gold is added in the form of purple of Cassius, that is, finely divided metallic gold mixed with oxide of tin; this usually contains 30 per cent. of gold which I have taken in calculating the above numbers, or of chloride of gold—an oxidizing agent being added at the same time. In smelting operations the ferric oxide would act as an oxidizing agent, and when once in solution it seems improbable that any practicable amount of smelting in presence of other metals would reduce and collect all the gold.

Thinking, however, that in spite of these objections a process of smelting was the only one which was likely to be successful, I turned my attention to the removal of the copper, so that I might obtain it separate from the gold and silver. Although many wet extraction processes have been used with success elsewhere, none of them appear to be quite suitable to the circumstances obtaining in these colonies. Perhaps the most successful has been the Longmaids' process as improved by Henderson, and so far as the recovery of gold and silver are concerned by Claudet. Worked in Great Britain, it has rendered available immense quantities of copper ores too poor to be treated by any other method; but there salt costs from 10s. to 15s. per ton, whilst here it is seldom less than £3. There scrap iron is cheap, here if consumed in any quantity it would be very expensive, whilst inland carriage would immensely add to the cost of both. Again, in Great Britain the sulphur in the ores being used for the manufacture of sulphuric acid, it pays the whole or the greater part of the mining and carriage and the whole cost of the preliminary preparation and roasting, whilst the residual oxide of iron free from copper and sulphur is nearly of the value of hæmatite for fettling puddling furnaces; here both would be valueless.

With regard to Claudet's process for extracting the small quantity of gold and silver obtained in solution along with the copper by precipitation with iodide of zinc, the very small cost of which (9d. per ton of ore) has been noticed in the report of the Victorian Commission appointed to inquire into the treatment of pyrites, and others, I may note that this is only the *additional* cost of extracting those metals beyond that incurred in extracting the copper. It is only applicable to ores containing minute quantities of gold, and besides it is requisite that the whole of the copper be in solution as cupric chloride, as otherwise cuprous iodide is precipitated. As the formation of cupric chloride involves the use of more salt and its precipitation of more iron than cuprous chloride, the process has been abandoned in many places where tried.

As the formation of sulphate of copper during the calcination of pyrites is believed to take place in two stages, represented by the equations—

$$CuS. + 3O = CuO. + SO_2, \text{ and}$$
$$3CuO. + SO_2 = CuSO_4 + Cu_2O.,$$

I tried whether the addition of successive portions of raw ore would not gradually convert the greater part of the copper into sulphate during the roasting. After well roasting a quantity of pyrites, I extracted the sulphate formed with water from a sample; this was then dried, and the copper present as oxide was dissolved by dilute hydrochloric acid, and its amount determined. It was found to be equal to 6·54 per cent. of copper.

To 700 grains of the remainder (from which the sulphate had not been extracted), I added 40 grs. of fresh pyrites and roasted sweet at a dull-red heat in a small muffle, which took about an hour, treated a portion as before, and found the copper present as oxide to be 6·01 per cent. The remainder was again made up to 700 grs. with once-roasted ore, 40 grs. raw pyrites added and roasted sweet, when other 40 grs. was added and the calcination continued until complete, when the copper present as oxide was found to be 4·79 per cent. The oxide was thus steadily reduced, but the process was evidently too slow to be of use practically.

I then calcined 400 grs. of pyrites, mixed the residue with 200 grs. of raw ore and again calcined, then added 100 grs. of raw ore, and continued the operation until fumes were no longer evolved, when the residue was found to contain 6·46 per cent. of copper as oxide. This process was therefore of no value; but I noticed that after each addition of pyrites considerable quantities of white vapours were evolved, and as the ore contained but little arsenic this could only arise from the formation of sulphuric anhydride. I therefore proceeded to determine how much sulphuric acid could be obtained by calcining a mixture of raw pyrites and roasted residue.

A combustion tube was fitted with a smaller tube leading through water in a Woolfe's bottle, the second neck of which was connected with an aspirator, and mixtures of raw and roasted pyrites were heated to a dull-red in the combustion tube, a current of air being maintained through the whole apparatus, and the ore occasionally stirred with a bent wire. In this arrangement however I found that a large quantity of the white fumes escaped condensation, and I therefore substituted for the Woolfe's bottle a flask containing a small quantity of water, the exit tube of which was connected with an inverted Liebig's condenser. The water in the flask was kept gently boiling, and I found that by this arrangement the condensation was very good. 100 grs. of raw pyrites containing 37·86 per cent. of sulphur, mixed with 50 grs. of the same which had been well roasted and the copper extracted, was thus treated. The residue in the tube was digested with hydrochloric acid, and the sulphuric acid formed determined in one-half of the solution, whilst in the condensed water sulphuric acid was determined in one-fourth :—

½ of residue gave barium sulphate... ...	31·65 grs.
¼ of condensed water gave barium sulphate	35·82 „

calculated on the 100 grs. used, this gave—

Sulphuric acid in residue = 8·68 sulphur.
„ „ water = 19·86 „

Total... 28·54 sulphur.

Similarly, 100 grs., with 20 grs. residue gave—

½ residue, barium sulphate	31·69 grs.
¼ water „ „	34·59 „

which calculated on 100 grs. used gave—

Sulphuric acid in residue = 8·70 sulphur.
„ „ water = 19·00 „

Total... 27·70 sulphur.

On reducing the roasted ore to 15 grs., a smaller return was obtained; but these results showed that by proper management nearly three-fourths of the sulphur present in the ore could be obtained as sulphuric acid, either in the free state or in combination with copper and iron—this quantity is nearly sufficient to dissolve both the copper and iron, the latter as ferrous sulphate, the theoretical quantity required with the ore operated on being 29·67 per cent. of the sulphur converted into sulphuric acid—and opened at once a prospect of the attainment of the desired result.

As it was probable that such a result would not be attained on a large scale, I proceeded to examine the action of aqueous sulphurous acid, and found that by treating ore calcined at a low temperature therewith, a considerable quantity of sulphate of iron was obtained in solution along with the sulphate of copper; also that, as Muspratt had observed, aqueous sulphurous acid readily attacks finely divided metallic iron, forming sulphite and hyposulphite.

The form the process now presented itself in, was, to calcine the ore at a low temperature and extract the sulphates of copper and iron formed with the mixed sulphurous and sulphuric acids formed during the roasting, then to reduce all the iron to the metallic state and remove it in the same manner, when the gold, silver, antimony, and lead would be left. The only points that remained to be decided were, how to reduce the iron to the metallic state, and to obtain the copper from solution.

The reduction of the iron was necessary, because the sulphuric acid obtained would be too dilute to act on the ferric oxide, and the quantity would be insufficient to form ferric sulphate, whilst sulphurous acid has no action on the ferric oxide. I first attempted the reduction of the iron by hydrogen at a faint-red heat, which gave the metal in a form very suitable for the action of sulphurous acid. This had to be abandoned, however, on account of the cost and the danger of explosion. Coal-gas reduced the iron readily, but at a low temperature much finely divided carbon was deposited amongst the iron, which rendered wetting it difficult, and the powder was very pyrophoric. Reduction by finely ground carbon at a low-red heat, I found could be so managed as to obtain the iron as a metallic powder which was readily attacked.

For the removal of the copper from solution the use of metallic iron had to be abandoned, on account of the quantity required to precipitate it from its solution as sulphate, which on the large scale is found to be about three times the quantity of the copper precipitated. As it would be advantageous to recover some of the sulphuric acid, the use of sulphuretted hydrogen presented itself, but after repeated trials the exceeding bulk of the precipitate presented an obstacle which on any considerable scale would be insuperable, and has indeed been found to be so where tried.

I therefore determined to try whether it could not be recovered by crystallization; and the result of many trials showed that by taking a cold saturated solution of sulphate of copper, and, after adding sulphuric acid, saturating it with sulphurous acid, I had a solution which would render all but traces of the copper and sulphate of iron in well-roasted pyrites soluble without dissolving any. In fact it deposited crystals on being mixed with the calcined ore from the sulphates of copper and iron withdrawing crystallization water. By then washing by displacement with a solution of sulphate of copper saturated in the cold made boiling-hot as long as the escaping solution deposited crystals on cooling, the residue was obtained saturated with a solution of sulphate of copper which would not deposit crystals. This solution could be so displaced by water equal to one-half the bulk of the residue as to leave only 0·67 per cent. of copper in a soluble form, whilst if an equal bulk of water was used the copper left was ouly 0·12 per cent. Practically, therefore, it was possible to remove all the copper in such a way as to deposit it in crystals without increasing the bulk of the fluid, so that no evaporation would be required.

The mixed crystals of sulphate of copper and sulphate of iron evolve on calcination large quantities of sulphurous and sulphuric anhydrides, which could be condensed in a solution of sulphate of copper and used to extract a future lot.

I now proceeded to treat twelve pounds of the dressed pyrites of which an analysis is given above. One-half pound at a time was calcined in a muffle having the draft-holes closed with clay, and an iron door fitted at the front. From the back of the muffle an iron pipe led into a small upright leaden tower fitted with moveable perforated leaden trays, so that the evolved gases passing over the trays in succession finally escaped to the chimney at the top. On the upper tray water was allowed to drop through a trapped tube, and dripping from tray to tray flowed off through a pipe at the bottom, whilst steam was admitted at the bottom in sufficient quantity to keep the lower half of the tower warm. Half a pound having been calcined, the copper and sulphate of iron was extracted with water containing sulphuric and sulphurous acids, the residue was reduced with carbon at a dull-red heat, and the metallic powder being spread on the trays was subjected to the action of the gases from the second half-pound, the residue from which was treated as before, and to the gases from the third and so on, until the whole was operated on. The last half-pound was, after reduction, treated with dilute sulphuric acid, my parcel of ore being exhausted. The whole of the soluble matter was then extracted with water, which reduced it to a small bulk which was almost entirely free from iron but contained a small quantity of copper as sulphide.

It was therefore calcined on an iron tray, and the copper extracted by dilute sulphuric acid. The dried residue weighed 21½ ozs., and being melted with some oxide of iron and a little carbonate of sodium and carbon gave a brittle button weighing 5¾ ozs. To remove the antimony, as being the most convenient for laboratory use, this button was fused with carbonate of sodium and nitrate of potassium, which left a button weighing 3¾ ozs., which was cupelled to obtain the gold and silver. These were parted with nitric acid; the finely-divided gold, folded up in lead foil, was again cupelled, giving a button weighing 37·54 grs. The silver was precipitated as chloride, to which was added a small quantity precipitated from the copper solution, and on fusion with carbonate of sodium gave a button weighing 158·65 grs. The first cupel bottom was ground up and fused with sodium carbonate, and charcoal, when it gave a button of lead weighing 2 ozs.

The mother liquors from the sulphate of copper crystals were evaporated to dryness (this evaporation was necessary in the experiment to recover all the copper, but would be unnecessary on the large scale, the mothers being then used again and again indefinitely so long as there was fresh material to be extracted), and the whole of the sulphate was dried. One-half was heated to a full-red heat, to reduce the sulphates to oxides; the other half was heated to a dull-red to decompose the sulphate of iron, then mixed with carbon and a little sand and heated to fusion, when the oxides were added and metallic copper obtained, which with a prill obtained on re-fusing the slags weighed 31¼ ozs.

With the exception of using extraneous sulphuric and sulphurous acids for the extraction of the copper and sulphate of iron formed during the calcination, the whole process was carried out as nearly as practicable in a laboratory as it would be on a large scale. There are good working methods for smelting out the lead and antimony with the gold and silver, and for separating these metals, which I need not detail. The large quantity of sulphate of iron extracted from the roasted pyrites by the use of sulphurous acid would give on calcination more than enough sulphuric acid to extract the oxide of copper formed. The average quantity of sulphate of iron obtained from this ore was about one-half the weight of the sulphate of copper produced.

To conclude, the yields obtained from 12 lbs., as compared with those shown by analysis and assay, were—

	Analysis.	Yield.
Copper	17·02 per cent.	16·5 per cent.
Lead	2·01 ,,	1·04 ,,
Antimony	3·9 ,,	Not recovered.
Silver	62 ozs. 9 dwts. 18 grs.	61 ozs. 13 dwts. 22·7 grs.
Gold	12 ozs. 10 dwts. 0 grs.	14 ozs. 11 dwts. 23·2 grs.

These numbers are very satisfactory; and, although it is scarcely to be expected that the results would be equally satisfactory working on a large scale, it seems more than probable that returns better than those by any other process would be obtained.

Whilst experimenting on the removal of copper from solution, I found that this could be conveniently done by filtering the slightly acid solution through ground matt obtained from the same ore by simple melting. This method of separating copper from solution may be of advantage in treating poor copper ores or pyrites containing small quantities of copper; but it is obvious that for ores in which gold and silver form an important constituent, it is not so advantageous as the process already described—as, firstly, the gold and silver, so far as contained in the matt used for precipitating the copper, would remain with that metal, and be lost; secondly, the sulphuric and sulphurous acids, which in the process above described are obtained by calcination of the sulphates of copper and iron, and are available for the extraction of roasted ore, giving with those evolved during the roasting a superabundant supply of acid, would be lost. Neither of these objections would, however, have any force if copper were the only metal to be extracted. The matt obtained by simply melting poor cupreous pyrites, with the addition of sufficient roasted ore to form a flux for the silica present, consists of sulphide of iron containing more or less sulphide of copper; and by filtering through a bed of this matt the solution of sulphate of copper obtained by calcining and extracting a larger portion of the ore, the copper is deposited, whilst the iron goes into solution. I expected to find that the whole of the iron could be thus removed from the matt which would be converted into sulphide of copper, but found that in all cases the action stopped short of this. The percentage of copper in the treated matt varied from 30 per cent. to 33 per cent., approaching therefore to copper pyrites, which contains 34·6 per cent. of copper. From this residue refined copper could be made in three operations.

This method of treatment, as well as the one above described, for the separation of the various metals, have in common with ordinary copper smelting the advantage that no materials except those yielded by the ore are required, with the exception of fuel, water, and air.

In working ores on the large scale for the recovery of gold and silver by the process, which I have founded on the experiments, of which I have given a brief *résumé*, it is advisable to obtain the sulphides as free as possible from vein stuff before proceeding to the actual treatment. To this end the crushed ore may be washed when any free gold contained in the quartz may be recovered by amalgamation, or in particular cases the ore may be subjected to a preliminary smelting. The method of getting rid of the quartz must depend entirely on the price of labour, fuel, &c., and the composition of the ore. I have found, on the one hand, that nearly all the gold and silver are obtained in a matt if it amounts to from one-half to two-thirds of the original ore, whilst if the matt is smaller both gold and silver are left to a considerable extent in the slags; but there are few ores which would give such a proportion of matt without preliminary dressing. On the other hand, ores containing sulphide of silver lose much of that metal by washing; the sulphide being exceedingly friable it is carried away in the slimes, which are often richer in silver than the original ore.

The method of treatment of the concentrated ore, or regulus, is the same whether the sulphides are rich in the precious metals or not, but requires variation according to—1st the presence or absence of copper; 2nd, the proportion of copper; and 3rd, the presence or absence of lead.

To begin with the simplest case, viz., with pyrites free from copper. The apparatus required consists of—1, a roaster, A; 2, a reverberatory furnace, F; 3, an arsenic flue, B (if the pyrites are arsenical); 4, a leaden combination chamber, C; 5, a leaden condensing tower, D; 6, a series of lixiviating tanks and coolers. It is best to construct the furnace, roaster, arsenic flue, converting chamber, and tower in one line, so that the waste heat from the reverberatory furnace heats the sole of the roaster and converting chamber. The reverberatory furnace is constructed in the usual manner, but the sole is made simply of brick, and flat, with an opening in the centre or side, *f*, through which the charge may be raked out into an iron hopper waggon, G. The roaster, A, is built as a muffle, with a sole of brick, or cast-iron plates laid at a slight incline, to facilitate the transference of the charges. At the lower end there is a depression of about six inches, forming a recess, E, which extends half-way over the reverberatory furnace, and has an opening, which can be closed with a slide, through which the contents of the recess may be at once transferred to the furnace. At the end of the roaster is an arsenic flue if required. Farther on is the combination chamber, built of sheet lead, supported by an external framing of wood; the sole is of sheet lead, supported on iron plates over the flue, *cc*. The sole is divided into eight stages, each of which is an inch higher than the one nearer the roaster. Beyond the combination chamber is a condensing tower, which may be built of brick, laid in a putty of clay and coal tar, or better, sheet lead, supported by an external framing of wood. The condenser is filled with coke or pebbles, supported on iron bars covered with lead, allowing a free space for the entry of the gases evolved in the roaster. Sur-mounting the coke is a perforated sheet of lead, with suitable openings for the escape of the residual gases, which may be conducted by a pipe to the chimney. On the perforated lead plate water is delivered at intervals by a self-acting tumbler, kept supplied from a cistern. The water escaping through the holes in the lead plate is uniformly distributed over the coke, and trickles downwards, escaping over the sole of the combination chamber, flowing over each stage in succession, and from the lowest to a wooden cooler, whence it is again pumped to the cistern.

The roaster should have two or three small fireplaces at intervals underneath the sole, to get it to a working heat, which may be closed when this is attained, the flame from the reverberatory furnace, mixed with a sufficient quantity of air through openings in the flue, then supplying sufficient heat.

The roaster sole being heated to a dull-red heat, 2 cwt. of the dressed pyrites, or ground regulus, is mixed with from ten to fifteen per cent. of previously roasted ore, and charged into the upper end of the roaster, so that it occupies about 2 feet of the length, and spreads across the sole, which it should cover to the depth of one and a half inches. The ore soon becomes ignited, evolving sulphurous, sulphuric, and arsenious oxides. The last is condensed in the arsenic flue, and the two former pass through the combination chamber to the condensing tower, and are there absorbed by the descending water.

In an hour's time the charge is moved two feet to the left, and a second charge of the mixture is placed in the space cleared. At the end of another hour the first charge is moved two feet to the left, the second to the space cleared, and a third is introduced, and so on until at the end of twenty-four hours the sole of the roaster is covered. The upper part of the roaster should be at a very dull red heat, whilst the lower should be sufficiently hot to decompose any sulphate of iron formed.

On the sole of the recess E from 35 to 40 lbs. of coal dust, charcoal dust, or other carbonacious matter is now spread, and the calcined residue from the first charge is turned over on top of it, each charge in the roaster is moved downwards, and a fresh charge of mixture introduced. In another hour a similar quantity of carbon is spread on top of the charge in the recess, and the second charge is turned over on top, and so on until eight successive charges of roasted residue and carbon are in the recess.

The contents of the recess are then transferred to the reverberatory furnace, through the opening *e*, the whole is well stirred up and spread over the sole. The furnace is closed, and kept at a moderate-red heat for eight hours, the furnace being kept full of a smoky flame to assist reduction. The oxides are thus reduced to the metallic state, and the heat should be kept so low as to prevent the reduced iron from agglutinating into masses. At the end of eight hours the reduced metal is withdrawn from the furnace at the opening *f*, into the hopper waggon G, which is immediately closed, so as to prevent access of air. The furnace is again charged from the recess, which has meanwhile been filled.

When the hopper is cool enough to be handled, the contents are rapidly transferred to a vessel containing water, best by placing the waggon over the vessel and withdrawing a slide in its bottom, so as at once to thoroughly wet and cool the contents.

One-eighth part, or thereby, of the cooled metal is now placed in the upper stage of the combination chamber, over which water from the condenser, charged with sulphurous and sulphuric acids, is flowing. In one hour the charge is moved to the second stage, and a second charge is introduced, and so on until in eight hours the chamber is filled, and that furnace charge exhausted. The metal is rapidly acted on by the acids, and converted into sulphate, sulphite, and hyposulphite of iron, but by the combined action of the air and water, assisted by the heat from the flue, the first largely predominates. The charge on the lowest stage is now removed, and may be at once lixiviated with water, but it is best to keep it for a few days in a moist state, to finish the conversion into sulphate. It is then lixiviated with water, which removes sulphate of iron (also zinc, nickel, and cobalt if present), and leaves a residue containing the gold and silver, mixed with quartz, excess of carbon, and free sulphur. The carbon and sulphur are then burned off, and the gold and silver separated from the quartz by washing, amalgamating, or otherwise. If the extraction of the sulphate of iron is effected with boiling water, and the liquor run into coolers, that salt may be obtained in a marketable condition; or the crystals being calcined at a dull-red heat yield a fine red oxide of iron suitable for painting, and sulphuric acid which may be condensed.

If the ores contain copper in small proportion only, the roasting, reduction, and solution of the iron are conducted precisely as above described, using, however, as little carbon as possible for the reduction, so as to obtain the residue nearly free therefrom. The copper is then found in the residue principally as sulphide. This residue is roasted at a dull-red heat, and the copper is extracted by treatment with condenser liquor and crystallization, as described below, the gold and silver being obtained from the residue as before.

Ores or sulphides containing much copper are roasted at a dull-red heat, the mixing with roasted ore, roasting, and condensation of the gases being conducted as before. The well-roasted ore is withdrawn from the furnace and cooled. The cooled residue is then shaken into a lixiviating tank partly filled with a solution of sulphate of copper, containing sulphuric acid and sulphurous acid, obtained as below described; the mixture is allowed to digest, and treated with successive portions of the acid solution until the escaping liquor contains free sulphuric acid. The lixiviation is then carried on with a cold saturated solution of sulphate of copper from the coolers, which is made boiling hot in a leaden or copper boiler, until the specific gravity of the entering and escaping solutions is the same. The whole of the copper liquors are run into wooden coolers, where crystals of the sulphates of copper and iron are deposited. When the lixiviation has been carried as far as possible with the copper solution, it is drawn from the tank until it stands only an inch or so above the solid contents, and 12 inches of water are carefully floated on top, and the drawing off the copper solution continued from below until the water is only an inch above the solid contents, when a second wash is run on, and in the same manner a third if necessary. The copper liquors are run to the coolers as long as they mark above 20° of Twaddel, below that strength they are run to a separate tank to be used for the first wash of another lot.

If the ore contains silver, a little is found in solution in the copper liquor, and is separated therefrom by filtering it through a bed or beds of cement copper, or, better, of precipitated sulphide of copper, before running the liquor to the coolers. The silver is recovered from time to time by roasting the precipitate, extracting the copper by condenser liquor, and melting the residual silver.

The residue in the lixiviating tanks is drained, dried, mixed with one-fourth of its weight of carbon, reduced, and otherwise treated as above described, to obtain the gold and remaining silver.

The crystals of sulphates of copper and iron in the coolers are removed from time to time, drained and dried. One ton of the dried crystals is charged into the muffle furnace, fig. 2, B, and there exposed to a full cherry-red heat, so as to convert the whole of the sulphates into oxides. The sulphurous and sulphuric acids evolved are conveyed to the condensing tower, F, which is supplied with sulphate of copper solution from the coolers, slightly diluted with the weaker wash liquor by which the acids are condensed, and used for extracting roasted ore. When vapours are no longer evolved the calcined residue is removed from the muffle. A similar charge of dried sulphate is heated in the muffle furnace at C to a dull-red, so as to convert the sulphate of iron into oxide, and when fumes are no longer evolved the charge is raked out, mixed with 2¼ cwt. of coal or charcoal dust, and charged into the reverberatory furnace, A, where it is melted, when sulphurous and other gases are evolved causing the mass to boil. When boiling ceases the oxides from B are added to the charge, and the melting heat continued until the whole is in a tranquil fusion, when the slags are raked off and the rough copper run into moulds.

If the ore contains lead it is found in the residue containing the gold and silver; and if present in sufficient quantity the residue may be smelted, and the gold and silver recovered by cupellation.

If not present in sufficient quantity to smelt, but still so much as to interfere with the amalgamation, the residue is roasted, treated with a little condenser liquor, washed, and the lead extracted with solution of caustic soda, when the gold and silver may be amalgamated. The solution of lead in caustic soda is mixed with sawdust or carbon, evaporated to dryness, heated strongly, and the carbonate of soda dissolved out with water, and again rendered caustic by lime, when the lead remains as an insoluble residue mixed with carbon.

The advantages of this mode of treatment are, that the sulphides are entirely got rid of, whilst if through inattention in the roasting some sulphides remain, only the small proportion that has escaped requires to be re-roasted, instead of the whole mass of ore as is usually the case. In the extraction of copper from the sulphides the whole of the copper may be obtained in the form of crystals, from which the copper may be recovered without evaporation of liquors; and in the whole of the operations, with the exception of smelting for copper, the temperatures are so low, that the cheapest materials may be used for the construction of furnaces. The temperature being low, the loss of silver by volatilization is reduced to a minimum, whilst there is absolutely no loss of gold, except through the careless spilling of the material. Lastly, as neither salt, iron, or other material is consumed in the process, a large source of expense in all previous wet methods of treatment is avoided; and the process is adapted for use wherever the ores are found.

[One diagram.]

(To accompany Paper "On a Method of extracting Gold, Silver, and other Metals, from Pyrites,"

by W. A. Dixon, F.C.S., &c.)

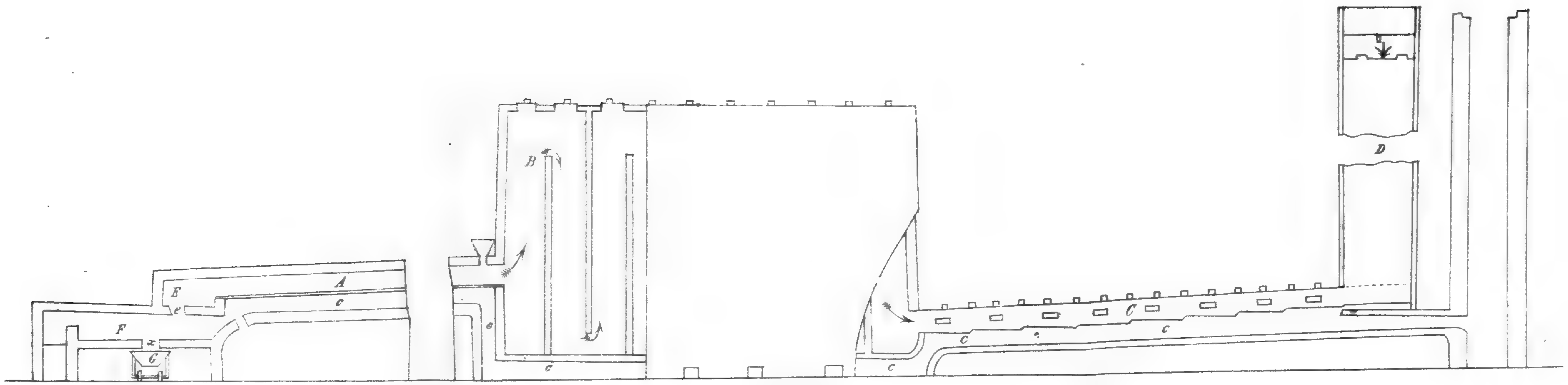

FIG. 1.

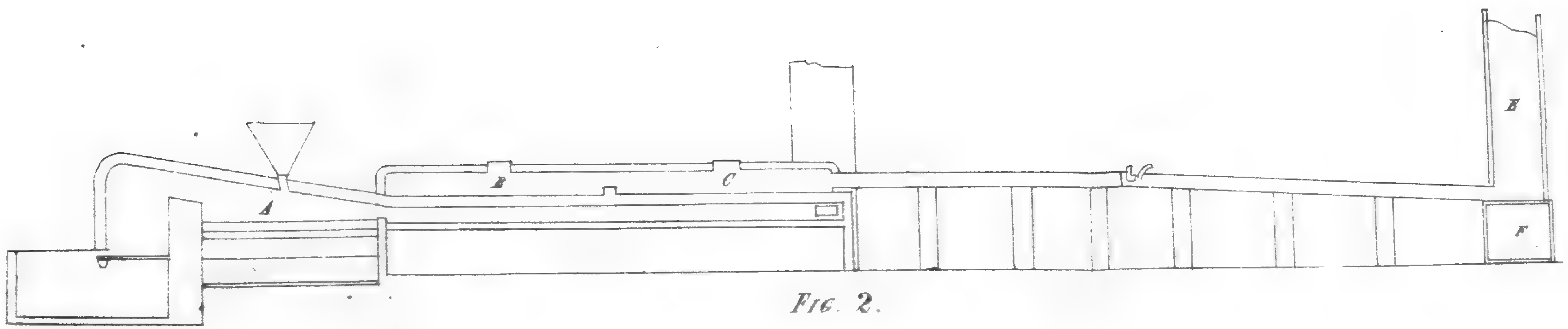

FIG. 2.

PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE,
SYDNEY, NEW SOUTH WALES.

Palæontological Evidence of Australian Tertiary Formations.

By the Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Hon. Mem. R. Soc., N.S.W., Tasmania, Victoria, Linn. Soc., N.S.W., &c.

[*Read before the Royal Society of N.S.W., 5 September, 1877.*]

At a recent meeting of this Society I read a paper on "Australian Tertiary Geology," on which I proposed to prepare at some future time a complete list of our described Australian Tertiary fossils. This task has occupied a good portion of my leisure since, but it will be yet some time before it is completed, as I have been induced by Prof. Tate to delay the publication until some work he has in hand on some of our Tertiary Gasteropoda is published. In the course of its preparation the question of the age or position of our Tertiary formations has come very prominently before me. I do not mean to say that I have been able to arrive at any very definite conclusion on the subject, for a comparatively certain or permanent conclusion may be very distant from us; but I think the Palæontological evidence has never fairly been collected together—the data are scattered in various publications, and I think I can hardly do better than group them, so that the facts may be seen and their weight better appreciated. My knowledge of some of the beds and most of the fossils, and of the existing fauna, extends over many years, and it may be as well for me to try to arrange them, as a help to others who may come after me.

I said in my former paper that it was not easy to judge by the percentage system, as our knowledge of the existing fauna is so imperfect, yet I think, upon consideration, that the imperfection of this knowledge has been exaggerated. We do know a great deal of the Mollusca, the Echinodermata, the Polyzoa, and the Brachiopoda; for the Echini alone we may say our knowledge cannot be much extended; the Corals, too, have been tolerably well worked out. So that after all there is quite material enough to form an opinion. Well, then, my object is to show in this paper what that material is, and what its affinities are. With this view, I shall examine what fossils we have in our Tertiary rocks which are still existing, and what differences there are (if any) between their present habitats and their former ones. I shall next inquire what are the extinct fossils, which are found elsewhere as fossils, and where they are found. I shall then inquire into the relations of those fossils which have no living or fossil representatives elsewhere. This inquiry means, Where do we find anything *like* our fossils? The solution of these questions, as far as our knowledge goes, will materially help to clear the ground of at least some of the obscurity which at present rests upon it.

But, before I do this, I must define what I mean by our Tertiary formations. I do not mean the raised beaches, or the more recent Pliocene formations. The evidence of all these is clear and unquestionable. I mean only the great Tertiary formation which extends, with the interruptions I have already described, from the river Murray to Gipps Land, and from Tasmania some distance inland in South Australia. In this formation there are many subdivisions, as I have already indicated, and some no doubt are much older than others. They are spoken of as one formation by European geologists; but the Pliocene of Italy, the Miocene of Vienna, Touraine, and Malta, and the Eocene of Paris and London, are not more widely separated than the Murray and Tasmanian beds, the Muddy Creek, Western Port, Onkaparinga, and Australian Bight. I shall deal principally with the Tertiary rocks which are represented in Victoria, in the south-eastern district of South Australia, and North Tasmania. There are various subdivisions in these rocks. They have been generally classed as Cainozoic by Professor Duncan, the learned President of the Geological Society. They are variously regarded as Lower Miocene and Pliocene by geologists in Australia. A succession is established by the Victorian Geological Survey, and to this I may say that I adhere: regarding the Tasmanian beds as the equivalents of the Muddy Creek and Geelong formations, and regarding the Mount Gambier limestones and the Polyzoan beds at Cape Otway as the uppermost of the series.* As I am not in a position to say anything of the fossils of the Aldinga beds and those of the Australian Bight, I must not be understood to include them in this examination; but I may state that it is probable that the Bight strata are the equivalents of the Murray cliffs, and I regard the Aldinga formation as lower than anything we have in Victoria or South Australia.

I now proceed to examine the recent species found as fossils in our Cainozoic rocks. I may include generally the far greater portion of the *Foraminifera*. I am not aware that many purely extinct forms have been discovered. They are tertiary in character. Knowing the wide vertical and horizontal range which these species have, we must not expect any conclusive evidence from them; and even if we would, they have never been carefully examined. *Amphistegina vulgaris* is very abundant in the Muddy Creek beds, and of large size. The following were determined

* Prof. Tate thinks he has reasons for believing that the Mount Gambier limestones are older than the Muddy Creek and Geelong beds.

for me by Professor Rupert Jones, many years ago:—*Polymorphina lactea*, *Textularia pygmea*, *T. agglutinans*, *Globigerina bulloides*, *Cassidulina oblonga*, *Rosalina Bertholetiana*, *Rotalia ungeriana*, *R. Haidingeri*, *R. reticulata*, *R. rotula*. There are no *Nummulites* or any of the characteristic forms of our Eocene beds.

Turning now to the Polyzoa, we must say in this case also that a careful examination is wanting. A *Retepora*, very nearly allied to *R. monilifera*—if not identical with it—is common at Mount Gambier, so is the existing *Salicornaria sinuosa* (Hassal), and *Cellepora pumicosa* (Busk). Some of the *Escharidæ* have been doubtfully referred to existing species; but it must be remembered that by far the larger portion of our living Australian Polyzoa are of families which would inevitably be destroyed ere they could be entombed in our rocks. They are jointed with horny joints in a single or multiple series of cells, and these horny joints would rapidly perish, and thus cause the destruction of the whole. It is among the *Lepralia* that I should look for the most important results, for these are well preserved, and are abundant in the living and fossil states, yet neither have received much attention. I am somewhat familiar with the various forms of *Membraniporæ* living on our southern coasts, and I have carefully searched for fossils like them at Mount Gambier, but without success. If ever there were a field where a careful observer might make most useful researches and extend our knowledge, this is one. It is, I may say, quite untrodden, and the facility with which the study could be approached, and the beauty of the forms to be dealt with, ought to make it equally attractive. As far as my own observations extend, I should say that we have but a small portion still existing of those which were likely to become fossils.

Referring to the corals, because that is the order which is most convenient, for I need hardly state that in point of organization they rank below the Polyzoa, it is singular that, while the Mount Gambier formation abounds in Polyzoa, Corals are almost entirely absent. In fact, I can remember none except a rare cast of *Placotrochus* occasionally. But at Muddy Creek, Geelong, and Table Cape, Tasmania, they are numerous. Now the existing forms among all these localities are only four in number, namely, *Flabellum candeanum*, *F. distinctum*, *Deltocyathus italicus*, all Edw. and Haime, and a new species of the genus *Sphenotrochus*, which I have named *Sphenotrochus variolaris*. The first is a well known form in the Red Sea and off the coast of Japan; the second occurs at Japan and in the Miocene fauna of Touraine. Both these localities are tropical, and very different from the condition under which the same corals would have to exist were they flourishing in Australia in the localities where they are found as fossils. *Deltocyathus italicus*, Edw. and Haime, is another species which still exists, that is to say a variety of it, but in the Carribean Sea, and it is also found in the Miocene formation of Europe. *Sphenotrochus variolaris* is only known hitherto on the east coast, and is rare. Now, out of about forty described fossil forms, and probably as many more undescribed, four existing is a very small proportion, and this let it be remembered only in very remote and tropical countries, and under totally different conditions, that is to say, surrounded by a totally different fauna from that which surrounds them now. We have in Australian seas at present about thirty forms of coral known as living, but hardly more than three of them are included in our Tertiary formations.

I will now deal with the Echini of the same beds. We have twenty-four well characterized species described from our Australian fossils. This probably includes two described by me in 1865, and described again by European palæontologists who had not seen my work, namely, *Echinolampas Gambierensis*, subsequently named *E. ovulum* by Laube, and *Brissiopsis Archeri.** See *Proceedings Philosophical Society, Adelaide*, 1865. Out of this number we have only three living species—*Echinanthus testudinarius* (Gray), *Echinarachnius parma* (Gray), *Schizaster ventricosus* (Gray). The first is a species with rather a wide range, being generally an Indian Ocean (Red Sea inclusive) and Pacific species, being found also at California. It is commonly tropical, but not at all uncommon at Port Jackson. In all my examinations of collections and specimens, extending over many years, I have never seen it from the south-west of Australia, or near where it is found as a fossil now. *Echinarachnius parma* is found, we may say, all over the world. I have seen specimens from almost every part of the coast, though it is more common within the tropics. *Schizaster ventricosus* is said to be Australian, but I have never seen a well authenticated specimen from Australia. It is not common in New Caledonia and some of the tropical islands of the Pacific. Thus we see, of our three living species, one is not now Australian; and, of the other two, one is not found in the same localities; and all are more properly tropical species, though they are sometimes found outside it.

Referring now to the Mollusca, we find the same paucity of living forms, and nearly all with a different habitat. As far as we know, the fossils still living are *Limopsis Belcheri*, *Pectunculus laticostatus* (Lamck.), *Corbula sulcata* (Linn.), *Cylichna arachis* (Quoy and Gaim), *Fissurella concatenata*, Crosse, *Ancillaria mucronata* Sby, *Liotia lamellosa*, mihi, *Dentalium lacteum*, *Limopsis aurita*, Sassi, *Trivia europea*, *Liotia discoidea*, Reeve, *Eulima subulata*, Donovan, *Syrnola bifasciata*, *Natica polita*,

* It appears that there is a peripetalous fasciole on this fossil, which removes it to the genus above named. I had described it as *Hemiaster*.

mihi. Of these, *Fissurella concatenata*, *Natica polita*, *Cylichna arachis*, *Liotia discoidea*, *L. lamellosa*, and *Syrnola bifasciata*, still are found living on the east coast of Australia, and near the beds where they are, found fossil: but they are not common, with the exception of *Cylichna*, which has a wide range. The European shells are perhaps more open to question. I would not like to give their identification as more than probable. The other shells are found now in very different places. *Corbula sulcata* occurs on the coast of Africa within the tropics, *Limopsis Belcheri* at immense depths off the Cape of Good Hope, *Pectunculus laticostatus* in New Zealand, but both the latter are found in St. Vincent's Gulf and N. Tasmania. We see thus that the proportion of living species is very small, not eight per cent., and that of these so few are found in the same localities and the rest so variously scattered that we can conclude nothing as to the habitat except that some of them are found in warmer seas, and only one in colder, that is *Pectunculus laticostatus*. *Dentalium lacteum* is an Indian shell. It is doubtful if *Ancillaria mucronata* was not described from a fossil. I have never seen a living specimen.

On the whole then, the living species are not eight per cent. of the actual number described. We have about 120 described mollusca (including Brachipoda), nearly thirty Echinoderms, about forty Corals, and say twenty Polyzoa. But of the sethere are not twelve in existence. This according to European standards would place our Tasmanian and Muddy Creek beds on a level with or even below the Upper Eoçene; and if from this estimate of living species we reject the three recent Echini which are found in the Murray beds, but not in the beds mentioned above, we shall bring our percentage still lower.

I now address myself to the question of those fossils which are found in Australia in other Tertiary formations elsewhere. In the Polyzoa we have only one, which is the living species *Saliconaria sinuata* referred to above. Our Corals are represented sparsely in other strata. *Deltocyathus italicus*, Edw. and Haime, occurs in the Miocene of Europe, *Conotrochus M'Coyi* in the older Pliocene of Sicily, and *Balanophyllia cylindracea*, Mickelotte, in the Miocene of Tortonia. Few of our urchins are found among the fossils of other formations besides those which still exist, as I shall show further on. *Echinarachnius parma* was found by Mr. Darwin in a Tertiary deposit at Patagonia, whose age has not been determined. Among the mollusca there is scarcely any identity or at least no very satisfactory identity with extinct species in other deposits.* At first sight many of our fossils have been referred to forms found in Tertiary deposits of Europe and America, but

* *Limopsis aurita*, Sassi, is not uncommon in our lowest beds. *L. insolita*, Sby and Hutton, is, according to Prof. Tate, a synonym.

in the end sufficient differences have been perceived to cause them to be regarded as distinct. In nearly every case these identifications have been with well known Miocene or Eocene forms. We may however take what Professor M'Coy has called the "mimetism" of our Volutes in the oldest of our Tertiary rocks as instances of at least quasi-identity with well-known Eocene forms of Europe. Some of our fossil Brachiopoda are extremely like described species from the Malta Miocene, but we have the very best authority, that of Mr. Davidson, for regarding them as distinct. Prof. Tate thinks that the Brachiopoda have no affinity with the Italian forms, though there is a similitude in some species. He looks upon them as unique in facies.

I shall now proceed to examine the question of the relations of our Tertiary fossils, that is to say, failing complete resemblance or identity, what fossils do they resemble the most, and what is the geological horizon to which those fossils belong? In dealing with this question, I must say a few words on what is generally recognized as the Mesozoic facies which the Australian fauna possesses. Unless we estimate this beforehand, we might be led astray as to the character of our extinct Tertiary fauna. And it is also necessary to refer to it to pursue another inquiry of considerable interest, which is—Do we find in our Tertiary rocks stronger and stronger Mesozoic resemblances as we go down, so that our present fauna may be said to be what is left of a very slow extinction of the Mesozoic fauna?

I need not dwell upon the evidence of our existing fauna, which is familiar to every naturalist; still I may say that it has been somewhat overstated. In the marine fauna it is slight; in the mollusca I know of nothing except our possessing some species of *Trigonia*. These are, however, very distinct from the Secondary forms. In the Tertiary beds we have three species. Two are like our existing species in trifling particulars (*T. acuticostata*, and *T. Howittii*—M'Coy), and one is very much like the middle Secondary forms (*T. semiundulata*—M'Coy). A very remarkable instance of a surviving ancient form, which is even palæozoic in character, is found in a large *Pleurotomaria* (*P. tertiaria*, M'Coy). *In the Aldinga beds of South Australia, which I think will be found older than any Tertiary beds of Victoria or Tasmania, and perhaps even passage beds between our Tertiary and Secondary rocks, we have learned through the careful researches of Professor Tate, that *Salenia* and *Belemnites* still exist. Now *Salenia* is a cretaceous form, and I need hardly dwell on the significance of such fossils as *Belemnites*; yet they were associated with truly characteristic fossils belonging to our Australian Tertiary deposits.

But, while so much has been said about the Mesozoic aspect of our Australian fauna, very little has been made of the Miocene

* There are two species of *Pleurotomaria* still living in the West Indies.

aspect of our natural history—yet it is very marked. Attention has been already called by European botanists to the similarity between the plant remains of Miocene age in Europe and the present flora of Australia. The common corals now living in Australia are Miocene fossils of Touraine, Mayence, &c. Our *Conocyathus sulcatus*, E. and H., is very common at Port Jackson. For my own part, I am not very certain about the identity; but the corals are extremely close in any case, and of such marked and peculiar characters, that their occurrence in remote places, and separated by so great an interval of time, is very singular. *Conocyathus sulcatus* is very Turbinolian in its aspect, with four cycles of costæ and only three of septa; the second and third of the latter uniting like many Eocene Turbinoliæ, but with pali and no columella. If we bear in mind the survival of European Miocene forms amongst us, of course it very much weakens the inference that might be drawn from any identity of species between our Tertiaries and beds in Europe whose horizon is well known.

Speaking of the corals generally, we have more affinities with Miocene forms than any other formation; but a few genera are common to both Eocene and Miocene formations. We have no truly Eocene forms such as *Turbinolia*, which are found in the Eocene beds both of Europe and America; neither have we among the many Foraminifera such characteristic fossils as Nummulites; but we have certain American genera which have seldom been found, as far as I am aware, above the Eocene. I shall shortly describe in the Transactions of this Society some few very characteristic Eocene genera of America, and one *Ceratotrochus* (*C. fenestrata*), which is both Miocene and Eocene, as it is both American and European. The commonest of our corals in the Muddy Creek is undoubtedly *Deltocyathus viola*, Woods and Duncan; and of this Professor Duncan says it has a greater resemblance, as far as shape is concerned, to the *Pleurocyathi* of the German Oligocene; but it is a true *Caryophyllia*,* and therefore not in the same sub-division of the Caryophyllian sub-family. Hitherto only one member of the genus has been found in either the Indian, Southern, or Pacific Oceans; there is a new species, *C. Australis*, whose diagnosis will shortly appear in a monograph of our living Australian corals which I am preparing for the Linnean Society of New South Wales. No other species has been found in our fossil deposits, though the individuals are very abundant, which is an anomalous fact, and one not in keeping with the evolution theory. The genus best represented in the number of species, and probably in individuals as well, is *Balanophyllia*. "These," says Professor Duncan, "give a very Falun-

* I have placed this in another genus (*Deltocyathus*) as it departs in many important details from *Caryophyllia*.

nian and Crag facies to the Australian corals as a whole, especially as there are no recent species in the seas around." But I don't think that we are quite without the recent species, as far as I can judge from an examination of many undescribed forms in the Australian museums. I believe there are undescribed species in the Sydney Museum from Port Jackson, and another, if I am not mistaken, in the Macleayan museum, from the East coast further north. Dr. Duncan adds—" Forming a large proportion of the fossil fauna, the *Balanophylliæ* stamps the deposits with a definite character as regards the depth at which they occurred, and this is rendered almost certain by the bathymetrical disposition of the genera *Caryophyllia*, *Flabellum*, *Placotrochus*, *Sphenotrochus*, and *Amphihelia*. The northernmost Faluns (Miocene) contain vast quantities of *Balanophylliæ* (not of species) a *Flabellum*, a *Sphenotrochus*, and there, as in the Australian Tertiaries, every gradation of sea depth, from the abyss to low spring tide mark, is represented by species." (*Quart. Jour. Geol. Soc.*, 1870, *p.* 310.)

With reference to this I must remark that our corals have been collected from beds widely apart, and evidently deposited under different conditions. That where *Caryophylliæ*, *Sphenotrochi*, and *Flabellum* occur we have few or no *Balanophylliæ*. There are few at Muddy Creek, and none at Table Cape in Tasmania. But we have in place of them in the latter place, remarkable species of branching or reef-forming corals; all the others enumerated being solitary, turbinate, and for the most of the genera free. Such forms as *Dendrophyllia*, *Heliastræa*, and *Thamnastræa*, make their appearance in Tasmania, all indicative, in the manner in which they are found, of a deep warmer sea than in Tasmania. Professor Duncan has called in question my opinion that the sea was also a deep one, but I think he misunderstood my meaning. These fossils, no doubt, *grow* in a sea of a few fathoms, but they did not grow where they are found, but are evidently brought from a distance. They are associated with organisms generally found at least in a moderately deep sea, and this is the origin of my opinion. The *Thamnastræa* (*T. sera*, Dunc.) is a very peculiar form of early Mesozoic alliances; in fact, it closely resembles a form from the Lower Oolitic of England (*T. Walcotti*, Duncan). It might, indeed, have been washed out of some older rocks; but there are other specimens, and no other oolitic forms with it. It is, however, always found very much worn and much older in appearance than the accompanying fossils. The *Heliastræa* (*H. Tasmaniensis*, Dunc.) is quite fresh, and unlike the other. It is of a genus of which other Tertiary species exist, but this species has remarkable affinities with an Indian cretaceous fossil (*H. cortica*, Stol.) from the Ootatoor rocks. (See *Prof. Dunc., Q. Jour. Geo. Soc.*, 1876, *p.* 343.) Both these genera had, as before observed, Tertiary representatives, but *Heliastræa* culminated in the Miocene period, while *Thamnastræa* became rare, or died out in the Eocene. I have lately discovered another Mesozoic form in *Smilotrochus*, of which I believe no other Tertiary species has been hitherto found.

Antillia lens (Dunc.) is another anomalous form, with Mesozoic alliances and a genus with no living form, except one in Batavia, and of which a specimen was lately brought down from Darnley Island by the Chevert Expedition, and is now in the Macleayan museum. The genus is well represented in the West Indian Miocene, and in the Sindhian, Travancore, and Arabian Miocene. It is not at all uncommon in the Brighton beds, but there is no other species, and it has no living or fossil representative in these latitudes now.

The general facies of our Australian Tertiary corals is therefore Lower Tertiary, between Eocene and Miocene, with strong Mesozoic alliances. If we separate the different species according to the locality in which they occur, we should find that the Eocene forms predominate in the Tasmanian, Muddy Creek, and Schnapper Point formations, while the Miocene forms are more common in the beds at Spring Creek, sixteen miles south of Geelong, and Portland Bay, Western Victoria.

With regard to the *Echini*, a very interesting paper has recently appeared on the subject from Professor Duncan (*Quarterly Journal Geological Society*, 1877, *p.* 42.) He says that this order, as represented in our rocks, "is very remarkable as a fossil fauna. The presence of such genera as *Temnechinus*, *Echinolampas*, *Pygorhynchus*, and *Eupatagus*, gives a Nummulitic (of Europe and India) facies to the fauna, whilst the Cretaceous aspect is presented by the genera *Catopygus*, *Holaster*, *Micraster*, and a *Rhyncopygus*, with the Ananchytic looking apex." He adds, "that the general facies of the whole is older than is warranted by the geological position." (p. 68.) I cannot well understand what is meant by the "geological position," for that is at present undecided. It must be remembered, on the one hand, that we have in our Australian fauna a genus closely allied to *Temnechinus (Temnopleurus toreumaticus*, Klein), and I have found a true *Temnechinus* in very recent Tertiary beds from New Guinea associated with recent fossils, notably *Peronella decagonalis*, Lesson. On the other hand, the difference between our living species and the species of the same genera which are fossil is very marked. There is a very great difference between our living *Lovenia elongata* and the fossil *L. Forbesii*. But I have strong reasons for believing that *L. Forbesii* possesses a true peripetalous fasciole, in which case it would be a *Breynia*, and very closely allied to our living *Breynia Australasiæ*, Gray. *Maretia anomala*,* Duncan, is

* Professor Duncan mentions this genus as West Indian, but this is probably a misprint for East Indian Islands.

a form which is retained in the genus in spite of its having a lateral fasciole, but this does violence to the classification to some extent. There is no such band visible on *M. planulata*, which is not known to naturalists as an Australian species, but which I find is not at all uncommon at Port Jackson and on the east coast. The species is a variable one, the specimens at Port Jackson are smaller, paler in colour, and with much more salient and conspicuous large spines, so that I think we may consider Professor Duncan's species as perhaps a variety. It was found at the mouth of the Sherbrook River in W. Victoria, very far removed from the present habitat. *Monostychia Australis* is another of the forms closely allied to the existing *Arachnoides*, of which two other species are described by Professor Duncan. The genus of *Monostychia* must be abandoned, according to the same author, because it is founded on a mistaken appreciation of the reproductive system and on the position of the periproct. With regard to this I may say that since seeing Professor Laube's monograph I have examined forty or fifty specimens of *Arachnoides placenta* from various localities. I find it a very variable species. The position of the periproct is the most uncertain feature. It is very infra-marginal and marginal. *Psammechinus Woodsii*, Laube, is said to be a form closely allied to our *Echinus magellanicus*, of which Agassiz states that he received two specimens from Australia. It is nearer to a species recently described by me from Darnley Islands *(E. Darnleyensis)*.* There are four species of *Eupatagus* described from our Tertiary beds, all differing but not very considerably from *E. Valenciennesii*—Agas., which is a common living form on the east coast, especially at Port Jackson. *Leiocidaris Australiæ* is a representative of *Dorocidaris papillata*, which is of world-wide distribution; but I am not aware that it has ever been found in Australian seas.

Altogether the facies of our *Echinodermata* is somewhat recent, and in some respects related to past periods of the earth's history. In those respects in which it relates to the past it is at least of early Tertiary affinities, with strong Mesozoic alliances. Its relation to the recent fauna, with only one or at most two exceptions, is to inhabitants of remote localities in Australia and of much warmer seas.

I shall have to deal more generally with the mollusca in treating of their alliances. I hasten in the first place to correct an erroneous impression, conveyed in my last paper read before this Society. I there stated that Australian genera, as the term is understood, were almost entirely absent. I overlooked the fact that I myself have described a new *Cominella* from the Tasmanian beds; and since then Professor Tate has just informed me

* Proc. Linnean Soc., N. S. Wales, Sept., 1877.

that he has found a *Phasianella* and an *Elenchus*. I referred to the *Thalotia*, which I said was doubtful. I think that we must still conclude that our present Australian fauna is not the fauna that we find even generically represented in our Tertiary fossilliferous formations. Naturalists have been accustomed to regard Australia and New Zealand as one province, but this gives rise to a misconception of the molluscan fauna of both localities. Several common New Zealand forms are totally absent from Australia, and New Zealand is singularly deficient in Australian forms. We have only a small *Struthiolaria*, which is rare, and on the east coast only, and we have no *Rotella*, which is a characteristic New Zealand genus. The differences would be too long to enumerate here, but they are at least sufficiently marked to prevent the two places being grouped as one province. As to species, it is quite the exception to meet with instances where they are common to both. We have far more which are common to Australia and the Philippines. But still the differences are great between those two provinces. The facies of our Lower Tertiary molluscan fauna is in a general way Philippine, but it is true only in the sense in which we may say that the facies of the Lower Miocene and Upper Eocene is Philippine. We meet with some existing forms there which represent the fossil fauna of both places, and the genera and general habit of the shells suggest many resemblances. But I repeat that this is only in a general way; for once we try to reduce this to some definite facts, we find that the resemblance is only general and will not bear the test of strict comparison. The truly Australian recent genera may be said to be *Phasianella*, *Elenchus*, *Bankivia*, *Macroschisma*, *Parmophorus*, *(Scutus)*. *Risella*, *Amphibola*, *Trigonia*, *Chamostræa*, *Anatina*, *Myodora*, *Myochama*. *Crassatella*, *Cardita*, *Circe*, *Cypricardia*, *Venus*, *(Chione)*. *Anapa*, *Mesodesma*, *Panopæa*, *Solenella*, *Spirula*. *Fasciolaria*, *Trophon*, *Pleurotoma*, including *Drillia* and *Daphnella*, *Voluta*, *Mitra*, *Ancillaria*, *Tornatella*, *Trochocochlea*, *Siphonaria*, *Cominella*, *Fusus*, *Liotia*, *Adamsia*, *Crossea*, *Siphonalia*, *Purpura*. *Triton*, and a peculiar trifoliate kind of *Murex*. None of these genera are entirely restricted to Australia, but some are only found in its neighbourhood as far as Japan or the Philippines; while one or two—such as *Solenella*, *Bankivia*, and *Trophon*—reappear at remote places. Thus, Dr. Carpenter reports a solitary *Bankivia varians* among the Mazatlan shells. *Anatina* and *Crassatella* are small characteristic genera. Both are found at the Philippines. *Phasianella* is found at the Philippines as well, and so the list might be continued. But of the above genera we have very few among our fossils. *Crassatella* is one which is common, and so is *Liotia*. *Voluta* and *Mitra* are common and varied; *Cardita* also does not seem scarce, and that common form of *Venus* which is recognized as a subgenus named *Chione* by some authors. A *Venus* very like

V. lammellata exists, but with decidedly specific differences. Our fossil *Pectens* are not at all like our recent forms, but are peculiar—one *P. foulcheri*, nobis, is spinous, *P. yahlensis*, nobis, is finely imbricated, *P. corioensis* is delicately striated, *P. coarctatus** and *P. gambierensis*, nobis, are both coarsely granular; in all of which particulars they differ much from our recent species. *P. yahlensis*, according to Professor M'Coy, so nearly resembles the well-known German Miocene species, *P. Hoffmani*, Goldf., as to be easily mistaken for it; but the valves are both alike in the German fossil, while they are different in the Australian. *Cypræa, (Aricia) gigas* is a very peculiar and large species, differing very much from any form fossil or recent, while *Trivia avellanoides* can scarcely be distinguished from *Trivia avellana* of the British Oligocene, and is very like *T. affinis* of the French Miocene and British Lower Pliocene. The genera best represented in our Lower Tertiary deposits are *Pleurotoma*, *Cerithium*, and *Turritella*. I have carefully compared all our species with a very complete series of the Vienna and French Miocene forms, but find that the resemblances are only remote. There is a far greater similarity between them and those of the Paris basin, but still it is not very close. None of our lower Tertiary *Cerithiadæ* have been described. There is a *Spondylus* (*S. gaderopoides*, M'Coy), which is exceedingly close to *S. bifrons*, Munster, of the Miocene of Westphalia. *Haliotis ovinoides*, M'Coy, and *H. Mooraboolensis*, are both forms with strong resemblances to *H. ovina* and *H. Roei*, Gray, respectively, both of North Australia.

I do not enter at any length into the question of the resemblances of our older Tertiary *Brachiopoda*. Their strong Miocene analogies have been pointed out by many authors, but not the Miocene of France or Austria so much as the Maltese Miocene, where the resemblances, in a few instances, have led to the species being mistaken for one another. The Maltese Tertiary formations have a peculiar facies of their own which merits some notice from all Australian palæontologists. They are described at some length in the *Annals of Nat. Hist.* for July, 1864, by Dr. Leith Adams, and the *Brachiopoda* in the same paper by Mr. Thos. Davidson. He says the Maltese Islands, which extend about 29 miles, all belong to one series, and are to be considered portion of an early Miocene equivalent to the Hempstead beds of England, which was regarded by Sir Chas. Lyell as Upper Eocene. The formations are sedimentary and marine, with a horizontal stratification, and are all conformable. The greatest thickness above the sea level is about 800 feet. Those who wish to study these strata,

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* As the name *P. coarctatus* was applied to a fossil figured by me which I thought was identical with a European species, I now propose the name of *P. stenos* for the same shell, as it has not been described, and is not *P. coarctatus*.

which certainly throw some light on our Tertiary beds, will find the following references useful:—"*On the Geology of the Maltese Islands, with Notes on the Fossils by Prof. E. Forbes, Proc. Geol. Soc. Lond., vol.* 4, *p.* 225." "*On Fossil Echinoderms from Malta, &c., by Thos. Wright, M.D.: Ann. Nat. Hist., Feby.* 1855, *p.* 101; also *Fossil Echinoderms of Malta, by Wright: Jour. Geol. Soc. for* 1864, *vol.* XX, *p.* 470." These deposits are very rich in fossils, and the strata are divided into five groups, each of which is distinguished by peculiar organisms. They are so like our Australian deposits that I enumerate them:—1. Coralline limestone; 2. Yellow sand; 3. Clay; 4. Calcareous sandstone; 5. Hard cherty flintstone. The *Echinodermata* are the most abundant and characteristic fossils. Judging from the figures of Wright, there are few that resemble our fossil species except *Echinolampas Deshayesii*, which is in no way distinguishable from my *Echinolampas Gambieriensis*, which I think is the one described by Laube as *E. ovulum*, and considered by him a distinct species from the Maltese form, *Pygorhynchus Vassali*, Wright, and another which is regarded as identical by Professor Duncan. Dr. Wright considered it as resembling *Catopygus fenestratus* from the upper chalk of Belgium, and differing but slightly from *Nucleolites* (*Pygorhynchus*) *subcarinatus* of the Middle Tertiaries of Bünde. Professor Duncan remarks that the genus is essentially tertiary, but Forbes described one which is probably a *Cassidulus*, from the Indian cretaceous. The numerous species have been found in Eocene and Miocene deposits of Malta, America, and Jamaica. *Brissus oblongus*, Forbes (see Wright, *Ann. Nat. Hist.*, vol. 15, 2nd series, p. 184), is not to be distinguished from our existing *Linthia Australis*, Gray. The only difference is the number of pairs of pores, and this depends upon age. There are also a few pairs of pores instead of a single row on the actinal anterior ambulacra. It would be interesting to find that some Eocene or Miocene forms of Europe which are not to be found in our contemporaneous rocks survive in the existing fauna here. There are not wanting facts which would support this view—it certainly is the case with the corals. *Linthia Australis* sometimes attains a very large size, but generally it is found of the dimensions given by Dr. Wright. The Maltese *Spatangus ocellatus*, Defranc, is extremely like our *Lovenia Forbesii*, Woods and Dunc., but they belong to different genera. I question, however, whether the mere absence of a visible fasciole is a sufficient distinction, considering how very easily when there is no depression such a mark disappears. It is very rare to see the internal fasciole on our fossil, but it seems to me that even from Wright's figures (*Journal Geological Society*, vol. 20, pl. 21, figure 1) there are evidences of such a mark. I should infer it from the atrophy of the apical pores of all the petals. I commend this to the attention of palæontologists in England who can refer to the specimens.

To sum up all the evidence which has been gathered on this subject, we may say that our Tertiary formations probably range through all the various Miocene periods which are represented by different deposits on other portions of the globe. We may certainly conclude that the whole of the central parts of South Australia, the north of Tasmania, and the Islands of Bass' Straits, were under the sea during that epoch. There is quite sufficient evidence to show that we have Tertiary rocks of a lower horizon than the Miocene. I conclude this from the small percentage of recent species, the relations of the fossils, and the general facies.

It is also evident that our fossils are with very few exceptions such as we only find at present in much warmer seas. This fact, which all palæontologists are agreed upon, joined to the discovery of certain reef-building kinds in Tasmania, has led to a most interesting discussion recently at the Geological Society of London, when the President, Dr. Duncan, suggested that it might be accounted for by supposing an alteration in the earth's axis. This was further suggested might be accounted for by a shifting of the earth's crust on a fluid and molten mass. It seems to me, however, of very little real service to science to make such speculations. They rest on such slight inferences that they are readily overturned, and really give us no insight into the question. If I might venture to offer an opinion to men so much more qualified than myself to judge, I should say that the theory is too much for the facts. If anything altered the axis of the earth, so as to place, let us say, Tasmania within the tropics, we should expect to find a tropical marine fauna as well. But do we find this? On the contrary, the species are those of a warm sea for the most part; but were we to find such a fauna in a warm sea, we should be equally puzzled to account for the presence of certain species and for the absence of others. Another remarkable peculiarity about our older fossil shells is, that they are thin and fragile, and with the exception of a few species they are anything but substantial. Now, I need hardly remind any one acquainted with the marine molluscan fauna of the tropics, how the first thing that strikes one is the solid and substantial nature of the shells, and for the most part the thickened character of the ornamentation, enamel, &c. Certainly our Lower Tertiary fauna is not a tropical or even a subtropical one. All that we can say is, that certain species which are found still living now inhabit the tropics, while others remain where they are, and generally very many of the genera are now to be found in a warmer climate. It is very remarkable to find specimens of reef-building corals; but we can hardly assert under what conditions they lived, since they are so very different from the reef-builders of the present day. I suppose it is hardly attempted to account for the reef-building corals which we find in the British coral rag (oolitic), for instance, by climatical conditions alone. It seems to me that we are too imperfectly acquainted with the circumstances which govern the migration of species at present to be able to apply even generally any reasoning to such facts as those before us. Climate alone will not account for them. Indeed, we have nothing very cogent to urge against those who might read the facts in another way, that is by saying that species which now live in warm seas were formerly inhabitants of temperate or even cold waters.

In conclusion, I may remark that throughout the whole of Australian Tertiary palæontology we find a certain peculiar character, which is often distinguished by its almost capricious variation from well-known types of the other hemisphere. I remember hearing a distinguished naturalist remark that he was astonished when he first came to Australia to find so many of the birds "wrong." That is, I suppose, that they seemed by their peculiarities to stray outside the rigid definitions of genera, and sometimes unite the characters of two or more. This certainly must arise from our having formed our systems too artificially from our limited experience. It was natural to suppose that the study of organisms in remote countries would widen our knowledge, and cause us to widen our conception of nature's plan. What we called the Australian "abnormalities" are in reality the shortcomings of our systems of natural history. Thus, we find a *Maretia* with a lateral fasciole, and certain other peculiarities in our *Echini* which would be very difficult to enumerate without entering too much into detail. In the corals the relations of the septa and costæ are most peculiar and exceptional. According to Edwards and Haime, costæ are modified or extra-mural septa. They ought, therefore, to correspond with the septa, and so they do generally. But there are exceptions—such as *Stephanophyllia* and *Micrabacia*—where they alternate with them. In *Dasmia*, one of the costæ corresponds to three septa. But in the Australian species everything is exceptional. We have alternating costæ and septa, and in *Ceratotrochus fenestratus*, mihi, we have the triple septa to one of the costa as in *Dasmia*, besides many other differences. We have also *Dendrophyllia epitheca*, that is to say with a thick epitheca, *Flabellum* with basilar radiciform appendages of *Sphenotrochus*. In the *Volutes*, of which mention has been made, we have always a swollen pullus at the apex, and this often forms the only mark of distinction. In *Voluta strophodon*, M'Coy, there is no difference appreciable from *Volutilite spinosus* and *V. depauperatus* of the Upper Eocene of Europe except the apex (See *Prod. Palæontology of Victoria, Dec. IV. p.* 25). I might extend these instances very considerably; but a very slight acquaintance with the fossils themselves will furnish abundant instances.

There can be no doubt that these observations on the fossil fauna might be much amplified, were our knowledge of the marine fauna of Australia more complete. Each day, however, adds to this knowledge, which is very different now from what it was when I first came to the Colony, twenty-three years ago, when such an estimate as I have made would have been impossible. It is to be hoped, however, that what I have thus far noted may be of use, and will give an impetus to the inquiries which are being prosecuted now on every side of Australia.

NOTE.—While these sheets were passing through the press, Prof. Tate informs me that he thinks he has found stratigraphical evidence showing the Muddy Creek beds to be above the Murray cliffs, and the latter as contemporaneous with the Mount Gambier limestones. These questions can hardly be decided without a careful survey. My paper professes to deal with the palæontological evidence only. Prof. Tate's zeal and industry in the matter gives hope of a speedy solution of many of these problems.

DISCUSSION.

The Chairman conveyed the thanks of the Society to the Rev. Mr. Woods for his very valuable paper.

Mr. WOODS said he desired to add that in making these investigations one difficulty he had experienced was that in our colonial museums there were no characteristic recent marine faunas represented. He meant to say that if he wanted, in any museum in Melbourne, Adelaide, Tasmania, or New South Wales, to find recent marine fauna as a means of comparison, he should look in vain for any such collection, and students must be without the instruction such a collection would give. He wished to make this known; and he thought that members of the Society ought to make this matter their first care. If he wanted to obtain in any colonial museum a collection of recent echini, or corals, or shells, he would be unable to find it. This was a matter which museums ought to give their best attention to. Such a collection would be a most useful acquisition.

A Synopsis of the known Species of Australian Tertiary Polyzoa.

By R. Etheridge, junr., F.G.S., of H. M. Geological Survey of Scotland, formerly Assistant Geologist, Geological Survey of Victoria.

[*Communicated by* Rev. W. B. Clarke. *Read before the Royal Society of N.S.W.*, 5 *Sept.*, 1877.]

1. *Introduction.*—I trust the following brief "Synopsis" of the Australian Tertiary Polyzoa may be of use to workers in that department, and may be the means of saving them, to some extent at least, both time and trouble in searching out the bibliography of the subject. With it must always be associated the names of the Rev. J. E. Tenison-Woods, F.G.S., and Prof. Busk, F.R.S. To the geological acumen and perseverance of the former we are indebted for one of the most complete works on the Upper Australian Tertiaries yet published, and it is through his labours as a collector that we owe our knowledge of the organisms in question.

2. *History and Bibliography.*—Tertiary Polyzoa appear to have been first collected in Australia, of which we have any definite record, by Captain Charles Sturt, during his memorable boat-voyage down the river Murray. Several forms were figured in his work, "Two Expeditions into the Interior of Southern Australia,"[1] published in 1833, obtained from the cliffs at the great north-west bend of the Murray. Unfortunately these figures were unaccompanied by descriptions of any kind, and we are left to form an opinion as to their relation with species since described, purely from general resemblance. The reference of his specimens made by Captain Sturt to species at that time known as European (at least I presume so from the names given in his list) will not, I think, stand; in fact this has already been pointed out for some of them by the Rev. J. E. Tenison-Woods.[2]

After Sturt's original discovery of fossils in the tertiary beds of the Murray, the matter appears to have dropped out of sight until systematically taken up by Mr. Woods. His first paper on the subject, so far as known to me, was published in 1859, entitled, "Remarks on a Tertiary Deposit in South Australia."[3] In

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[1] London: 2 vols. 8vo., vol. ii. pp. 253–54, pl. 3.
[2] Geological Observations in South Australia, 1862, p. 105.
[3] Trans. Phil. Institute, Victoria, 1859, vol. iii. pp. 84–94.

this communication he referred, after giving a good deal of geological information, to the occurrence of a *Cellepora*-like coral in the Mount Gambier deposit.[1] In the next year (1860) another paper by Mr. Woods was published, having been read, like the preceding one, before the Philosophical Institute of Victoria (now the Royal Society), " On the Tertiary Deposits at Portland Bay, Victoria."[2] The author here notifies the discovery of polyzoa by himself, in beds equivalent to those of Mount Gambier, at the Whaler's Bluff, Portland Bay.

The first really important contribution to the history of Australian Tertiary Polyzoa appeared as an Appendix by Prof. Busk to another paper of the Rev. Mr. Woods', " On some Tertiary Rocks in the Colony of S. Australia," published in the Quarterly Journal of the Geological Society of London.[3] In the paper itself, the country between the Glenelg River on the S.E., the Murray on the N.E., and Spencer's Gulf on the west is described, one of the chief points brought forward being the occurrence of a bed of limestone, a few feet below the surface, almost entirely made up of fragments of Polyzoa. The specimens collected from this bed in the neighbourhood of Mount Gambier were submitted by Mr. Woods to Prof. Busk, who gives in the Appendix a list of the species determined by him, amounting in all to thirty-nine or forty, distributed through fifteen or sixteen genera, four of which were new to science. "Taken as a whole," says Prof. Busk, "these fossil forms exhibit such generic and specific types as to render it probable that the formation in which they are found corresponds in point of relation to the existing state of things with the lower crag of England."[4]

In 1862, the Rev. J. E. Tenison-Woods published his " Geological Observations in S. Australia,"[5] in which he gives an interesting and instructive description of Mt. Gambier, and lists of the fossils from the bed of limestone at that locality. Of the latter there are mentioned of Polyzoa fifteen genera and thirty-seven species, but unfortunately no names beyond the generic ones are given.[6] Two species are figured, ***Retepora sp.***, and *Cellepora Gambierensis*, Busk. A table is also given, showing the identity of the species figured by Capt. Sturt from the Murray Cliffs section with those obtained by the author from the Mt. Gambier limestone. Eight species of Polyzoa are mentioned, of which five are common to the two localities.[7] More appears to have been published on this

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[1] *Loc. cit.*, p. 91.
[2] Vol. iv. pt. 2, pp. 169–172.
[3] 1860, vol. xvi, pp. 253–261.
[4] *Op. cit.*, *p.* 260.
[5] London, 1862, 8vo., pp. 18 and 404.
[6] *Loc. cit.*, p. 78.
[7] *Ibid*, p. 105.

subject in 1865 than in any one year before or since, up to the present time. We have, first, two papers by Mr. Woods, one in the Quarterly Journal, "On some Tertiary Deposits in the Colony of Victoria,"[1] and the other in the Transactions of the Royal Society of Victoria, "On some Tertiary Fossils in South Australia."[2] In the first of these a deposit of yellow and brown clays, underlying dolerite lava, around Hamilton, Victoria, is described. It contains Mollusca, Foraminifera, Corals, and Polyzoa. The latter are less common than at Mount Gambier, and appear to be of a more recent facies. In the second of the foregoing communications the author notices the resemblance of the Mount Gambier deposit to the English Lower Crag. He describes seven of Mr. Busk's previously named species, and refers to seven others. Thirteen figures are given.

The same volume of the Victorian Transactions contains a paper by Mr. H. Watts, "On Fossil Polyzoa,"[3] in which an account is given of a deposit containing Polyzoa 30 miles east of Warrnambool, extending along the sea-coast for a distance of from 6 to 7 miles, and is from 30 to 40 feet thick. A portion of this deposit, three or four pounds in weight yielded forty-six species of Polyzoa, but unfortunately no names are given. In 1865 there was also published the report by my friend and former colleague, Mr. C. S. Wilkinson, F.G.S., "On the Cape Otway District," attached to Mr. Selwyn's Geological Survey Report for 1864–65.[4] He mentions the occurrence of *Cellepora Gambierensis*, Busk, in the calcareous portion of the yellow sandy limestone forming the upper part of the Spring Creek section, near Geelong.[5] It is necessary to refer here to one of the results of the Austrian "Novara Expedition," which, although not directly connected with matters purely Australian, yet must be taken into account in all future investigations on Australian Tertiary Polyzoa. It appears that a large number of specimens of the latter were collected by the Expedition from the Tertiary Greensand of Orakei Bay, Auckland, and were described by the late Dr. Stoliczka, in one of the volumes descriptive of the results of the Expedition.[6] He describes two of the Australian Tertiary

[1] 1865, vol. xxi, pp. 389–394.

[2] Vol. vi, pp. 3–6, plate.

[3] pp. 82–84.

[4] Report of the Director of the Geol. Survey of Vict. for the period from June, 1863 to Sept., 1864, with appendices. Victoria, 1864–65, No. 44. Report on Cape Otway District, by C. S. Wilkinson, pp. 21–28. Sketch map and section.

[5] *Loc. cit.*, p. 23.

[6] Paläontologie von Neu Seeland. Beiträge zur Kenntniss der Fossilen Flora und Fauna der Provinzen Auckland und Nelson. Novara Expedition, Geologischer Theil, 1 Band. 1 Abth., No. 4. Fossile Bryozoen aus dem. Tertiären Grünsand stein der Orakei Bay, Auckland, pp. 87–158.

species as occurring in the Orakei Bay Greensand, viz., *Cellepora Gambierensis* and *Mellicerita angustiloba*, Busk, and makes many critical remarks on some of the other Australian forms, which will be referred to hereafter.

So far as my acquaintance with the present subject goes, there appears to have again been a lapse of time before any further progress was made in the study of Tertiary Polyzoa in Australia. In 1874, Mr. R. B. Smyth, F.G.S., gave, in his "First Progress Report of the (then) Geological Survey of Victoria," a list of the fossil organic remains of Victoria, drawn up by Professor M'Coy.[1] The only Tertiary Polyzoa mentioned are *Retepora Maccoyi*, R. Etheridge, from the Oligocene beds of Schnapper Point, and *Cellepora Gambierensis*, Busk, from Miocene strata.

In 1874, a short notice of one of the preceding fossils by myself was published in the Transactions of the Royal Society of Victoria,[2] "On the occurrence of a species of *Retepora* (allied to *R. Phœnicea*, Busk), in the Tertiary beds of Schnapper Point, Hobson's Bay." To the species in question I gave the name of *Retepora Maccoyi*, and I also pointed out the occurrence in the same deposit of one of the Orakei Bay forms, *Spiroparina vertebralis*, Stoliczka.

In the "Monthly notices of Papers and Proceedings of the Royal Society of Tasmania," for March, April, and May, 1875,[3] the Rev. Mr. Woods has an excellent paper "On some Tertiary Fossils from Table Cape, Tasmania," in which he describes a large series of the higher mollusca; but only one Polyzoon, the before frequently mentioned *Cellepora Gambierensis*, Busk. Its occurrence in the Table Cape beds is a point of much interest.

In 1875 Mr. R. B. Smyth issued his "Second Progress Report of the Geological Survey of Victoria." A most interesting and important discovery is here recorded, that of fossils in a ferruginous rock overlying an auriferous gravel at the Welcome Rush, near Stawell. In addition to several species of Mollusca, a single Polyzoon is mentioned and figured, *Lepralia Stawellensis*, M'Coy.[4] The deposit is considered by Mr. Smyth to be of the same age as the Flemington series near Melbourne.

In again referring to this discovery in his "Third Progress Report" for 1876, Mr. Smyth places the Stawell ferruginous bed on the horizon of the oldest gold drift (Lower Pliocene).[5]

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[1] Melbourne, 8vo., pp. 35–36.

[2] Vol. xi, pp. 13–14.

[3] pp. 13–26.

[4] pp. 21–22.

[5] pp. 48, 71, and 81. Fossils were first found here by Mr. Bernard Smith in 1872, but it is due to the researches of my friend and former colleague, Mr. Norman Taylor, that we owe the second and much more important discovery at the Welcome Rush. (See his "Report on the Stawell Gold Field,' contained in Mr. Smyth's "Progress Report," 1876, pp. 263-64.)

I now pass on to the Synoptical list of the species mentioned or described by the authors whose works I have called attention to. I trust that the references, as abbreviated, will be comprehended by all who may have occasion to refer to them. It is more than probable that when the Australian Tertiary Polyzoa are systematically worked out, certain specific determinations of various authors and their generic references will require careful revision. In the present paper, it has been more my desire to shew what is the state of our present knowledge on the subject than to critically pass in review each separate species.

The genera are arranged alphabetically in their respective sections "*Articulata*," or "*Inarticulata*," and the species in a similar manner under them. This has been done for convenience of reference.

In a recently published paper, "On some Tertiary Fossils from Table Cape,"[1] the Rev. J. E. Tenison-Woods has given some interesting details of the Tertiary beds and fossils at that locality. Amongst the latter he mentions *Cellepora Gambierensis*, Busk.

Class—POLYZOA.

Order—GYMNOLEMATA.

Sub-order—CHEILOSTOMATA.

Section Articulata.—Polyzoarium divided into distinct internodes by flexible joints.

Genus CANDA. *Lamaroux*, 1816.[2]

Obs. One well established species of this genus has been determined by Prof. Busk in the Rev. Mr. Woods' gatherings from the Mount Gambier coralline limestone, as given in the appendix to his paper "On some Tertiary Rocks in the Colony of South Australia, &c."

1. CANDA ANGULATA. *Busk.* Quart. Jour. Geol. Soc. 1860, xvi, p. 260; Woods, Trans. R. Soc. Vict., vi, p. 4; pl. 1, f. 2.

Genus ONCHOPORA. *Busk*, 1855.[3]

Obs. Of this genus, established by Prof. Busk in the Quart. Jour. Microscopical Science, again, only one species has as yet been noted from the same horizon and collection as the last. *C. angulata.*

1. ONCHOPORA PUSTULOSA. *Busk.* (MS.), *loc. cit.* p. 260, *Cellaria*,? Stoliczka. Pal. Neu Seeland, p. 149. No description of this species has as yet appeared.

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[1] Papers and Proceedings, R. Soc., Tasmania, for 1875 (published 1876), pp. 13-26.

[2] Histoire des Polpiers Coralligènes Flexibles, p. 131.

[3] Quarterly Jour. Microscopical Science, iii. p. 320; according to Stoliczka, this genus possesses the same characters as D'Orbigny's genus *Tubucellaria*. (Pal. N. Seeland, p. 145.)

2. O. VERTEBRALIS. *Stoliczka, Speroporina.* Pal. Neu Seeland, 1865, p. 106, pl. 17, f. 6 and 7; R. Etheridge, junr., Trans. R. Society, Vict., 1874, xi, p. 14. Prof. Busk considers this form to be a *Cheilostome*, and not one of the *Cyclostomata* as placed by the late F. Stoliczka, and further to be a species of his genus *Onchopora*. Tertiary greensand of Orakei Bay, New Zealand; and Oligocene beds of Schnapper Point, Hobson's Bay, Vict.

Genus SALICORNARIA. *Cuvier*, 1817.[1]

Obs. Four species of this very elegant generic type have been discovered in the Australian upper tertiary deposits. Two have been determined by Prof. Busk, and two by the Rev. Mr. Woods. They are :—

1. SALICORNARIA GRACILIS. *Busk.* Brit. Museum, Cat. Polyzoa, 1852, pt. 1, p. 17, pl. 63, f. 3, pl. 65, *bis.* f. 2; Woods, Trans. R. Soc. Vict., vi, p. 4. Coralline limestone of Mt. Gambier, S. Australia.

2. SALICORNARIA PARKERI. *Busk.* (MS.) Quart. Jour. Geol. Soc., 1860, xvi, p. 260. An undescribed species —same horizon and locality as last species.

3. S. SINUOSA. *Hassall. Farcimia.* Annals Nat. History, 1841, vi, p. 172, pl. 6, f. 1 and 2; *Salicornaria.* Busk, Monograph. Foss. Polyzoa Crag., 1859, p. 23, pl. 21, f. 5; *Glauconome rhombifera.* Sturt, Two Expeditions Interior S. Australia, 1833, ii, p. 254, pl. 3, f. 5, *Salicornaria.* Busk. Quart. Jour. Geol. Soc., 1860, xvi, p. 260; Woods, Geol. Observations, S. Australia, 1862, pl. 1, f. 5.; Trans. R. Soc. Vict., vi, p. 4, pl. 1, f. 1. More than ordinary interest is attached to this species, as it was one of the forms collected by Capt. Sturt in his memorable boat expedition down the Murray, and it figured in his interesting work. The identity of *Glauconome rhombifera*, Sturt (non *Goldfuss*) with *Salicornaria sinuosa* was pointed out by the Rev. J. E. T.-Woods, in the work in which he has so ably illustrated the geology of S. Australia. It is found in the coralline limestone of Mt. Gambier, the Murray River cliffs, the Muddy Creek beds, Hamilton, Vict., *S. tenuirostris, Busk.* Brit. Museum Cat. Polyzoa, 1852, pt. 1, p. 17, pl. 63, f. 4.; Woods, Trans. R. Soc. Vict., vi, p. 4. Mt. Gambier, S. A.

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[1] Le Règne Animal, vol. iv, p. 75.

Section Inarticulata.—Polyzarium continuous throughout.

Genus Caberea. *Lamx.*, 1816.[1]

Obs. The Mount Gambier coralline limestone has furnished Mr. Woods with one species, and it is, so far as I know, the only one yet determined from Australian beds.

1. Caberea lata. *Busk.* Brit. Museum, Cat. Polyzoa, 1852, pl. 1, p. 39, pl. 47; Woods, Quart. Jour. Geol. Soc., 1865, xxi, p. 394; Trans. R. Soc. Vict., vi, p. 5, pl. 1, f. 11.

Genus Cellepora. *O. Fabricius* 1780.[2]

Obs. This genus is numerously represented in the Australian tertiary deposits, and is particularly characteristic of the Mount Gambier beds, as both Prof. Busk and Mr. Woods have pointed out. No less than seven species have been detected there, and an eighth doubtfully so. Dr. Stoliczka applied the name *Orbitulipora*[3] to spherical flat-depressed *Celleporæ*, such as are figured from the Mount Gambier deposit by the Rev. Mr. Woods.[4] He further considers that one of his Orakei Bay species, *Celleporaria* (=*Cellepora*) *globularis*, may be found amongst the South Australian forms under a different name.

1. Cellepora costata. *Busk* (MS.), Quart. Jour. Geol. Soc., 1860, xvi, p. 261—Mt. Gambier.
2. C. echinata. *Sturt.* Two Expeditions Interior S. Australia, 1833, ii, p. 252, pl. 3, f. 4—Another of the forms detected by Capt. Sturt in his expedition. It is at present difficult to say what relation it bears to *C. echinata*, Münster[4]—probably little or none. Murray River Cliffs and Mt. Gambier.
3. C. Gambierensis. *Busk. Eschara celleporacea.* Sturt, Two Expeditions Interior S. Australia, 1833, ii, p. 253, pl. 3, f. 1.

Cellepora Gambierensis. Busk (MS.), Quart. Jour. Geol. Soc., 1860, xvi, p. 261; Woods, Geol. Observations S. Australia, 1862, pp. 74, 85, 91; Trans. R. Soc. Vict., vi, p. 4, pl. 1, f. 3, *Celleporaria.* Stoliczka, Paleontol. Neu Seeland, p. 141, pl. 20. f. 7, *Cellepora.* Woods, Monthly Notices R. Soc. Tasmania, March, May, 1875, p. 14. Of all the Australian Tertiary Polyzoa this is perhaps the most interesting form, from the quantity in which it is found, its peculiar characters, large massive form, wide geographical distribution, and

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[1] Histoire Polyp. Coral. Flexible, p. 128.
[2] Fauna Groënlandica, 1780, p. 434.
[3] Pal. Neu Seeland, 1865, pp. 121–122.
[4] Geol. Observations, S. Australia, plate, p. 73.

constant recurrence at certain horizons in the Australian tertiary series. The species was originally found in the Murray Cliff section by Sturt; named by Busk from specimens collected at Mt. Gambier by Woods; then figured by the latter in his S. Australian work; recorded from the Spring Creek section, near Geelong, by Wilkinson[1]; again from a Victorian locality by Mr. R. B. Smyth[2]; described and figured in detail for the first time by Stoliczka from the tertiary beds of Orakei Bay, New Zealand, and, lastly, again discovered in the Table Cape beds, Tasmania, by the Rev. Mr. Woods. *Cellepora Gambierensis* is said by Dr. Stoliczka to be still living on the coast of New Zealand.

4. C. HEMISPHERICA. *Busk.* Quart. Jour. Geol. Soc., 1860, xvi, p. 261; Woods, Geol. Observations, S. Australia, 1862, pl. 1 f. 3; Trans. R. Soc. Vict., vi, p. 4, pl. 1, f. 4. Capt. Sturt figured a form as *Cellepora escharoides* in his two Expeditions (vol. ii, pl. 3, f. 5) which is probably referable to this species, rather than to the *C. escharoides*, Goldfuss[3]. Murray River Cliffs and Mt. Gambier.
5. C. NUMMULARIA. *Busk.* Quart. Jour. Geol. Soc., 1860, xvi, p. 261; Woods, Geol. Observations, S. A., 1862, pl. 1, f. 1; Trans. R. Soc. Vict., vi, p. 4, t. 1, f. 5. Mount Gambier, S. A., and perhaps also at Geelong, Vict.[4]
6. CELLEPORA SPONGIOSA. *Busk.* Quart. Jour. Geol. Soc., 1860, xvi, p. 261; Woods, Geol. Observations, S.A., 1862, pt. 1, f. 2; Trans. R. Soc. Vict., vi, p. 5, pl. 1, f. 7. Mount Gambier, S. A.
7. C. TUBULOSA. *Busk.* Quart. Jour. Geol. Soc., 1860, xvi, p. 261; Woods, Trans. R. Soc. Vict., vi, p. 5, pl. 1, f. 6. Mount Gambier, S. A.

Genus CÆLESCHARA. *Busk.* 1860 (MS.)

Obs. This is a manuscript name used by Prof. Busk in the appendix to the Rev. Mr. Woods' paper "On some Tertiary Rocks in South Australia."

1. CÆLESCHARA AUSTRALIS. *Busk.* (MS.) Quart. Jour. Geol. Soc., 1860, xvi. p. 261. Mount Gambier limestone.

Genus ESCHARA. *Ray (pars)*, 1724.

Obs. As the genus *Cellepora* was exceedingly characteristic of the Mount Gambier beds, so Mr. Woods states is *Eschara* peculiarly typical of the Hamilton series in Victoria, no less

[1] Cape Otway Report, 1865, p. 23.
[2] Progress Report, Geol. Survey Vict., p. 36.
[3] Petrefacta Germaniæ, i, p. 28, t. 12, f. 3.
[4] Woods, Quart. Jour. Geol. Soc., 1865, xxi, p. 394.

than eleven different forms occurring there ;[1] and further, those of the Hamilton beds are remarkable for the singular beauty of their cells, the Mt. Gambier species on the other hand being comparatively destitute of ornament.

1. Eschara arcuata. *Busk.* (MS.) Quart. Jour. Geol. Soc., 1860, xvi, p. 261. Mt. Gambier, S. A.
2. E. bimarginata. *Busk.* (MS.), *loc. cit.* p. 261. Mount Gambier, S. A.
3. E. hastigera. *Busk.* (MS.), *loc. cit.* p. 261. Mount Gambier, S. A.
4. E. inornata. *Busk.* (MS.), *loc. cit.* p. 261. Mount Gambier, S. A.
5. E. oculata. *Busk.* (MS.), *loc. cit.* p. 261. Mount Gambier, S. A.
6. E. papillata. *Busk.* (MS.), *loc. cit.* p. 261. Mount Gambier, S. A.
7. E. piriformis. *Sturt.* Two Expeditions Interior S. A., 1833, ii. p. 253, pl. 3, f. 2 ; Woods' Geol. Observations S. Australia, 1862, p. 105. Goldfuss has described a species of *Eschara* under this name,[2] which Capt. Sturt probably took his form to be. Murray Cliffs, S. A.
8. E. simplex. *Busk.* (MS.) Quart. Journ. Geol. Soc., 1860, xvi, p. 261. Mt. Gambier, S. A.
9. Eschara, sp. ind. Woods' Geol. Observations, S. A., 1862 ; pl. 1, f. 7. Mt. Gambier, S. A.
10. Eschara, sp. ind. *Sturt.* Two Expeditions Interior S. A., 1832 ; ii, p. 253, pl. 3, f. 3. Murray Cliffs, S. A.

To the above must now be added the following *ten* species of *Eschara* described by the Rev. J. E. Tenison-Woods in 1876,[3] viz. :—

E. cavernosa. Mount Gambier.
E. porrecta. Mount Gambier.
E. clarkei. Muddy Creek.
E. verrucosa. Mount Gambier.
E. rustica. Mount Gambier.
E. elevata. (? monilifera. *Busk.*) Mount Gambier.
E. liversidgei. Mount Gambier.
E. oculata. Mount Gambier.
E. tatei.
E. Buskii. Mount Gambier.

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[1] Woods, Quart. Jour. Geol. Soc., 1865, xxi, p. 394.
[2] Pet. Germaniæ, i, p. 24, t. 8, f. 10.
[3] Journal of Roy. Soc. N. S. W., vol. x, 1877, p. 147-149.

Genus LEPRALIA. *Johnston*[1], 1838.

Obs. This very extensive genus is represented in the Australian tertiaries probably by many species, but so far as I know only four have received names.

1. LEPRALIA DOLIIFORMIS. *Busk* (MS.) Quart. Jour. Geol. Soc., 1860, xvi, p. 261. Mt. Gambier coralline limestone.
2. L. STAWELLENSIS. *M'Coy.* Smyth's Progress Report, 1875, No. 2, p. 22, f. 1. This species was discovered by Mr. Norman Taylor, in a ferruginous stratum overlying an auriferous drift at the "Welcome Rush" near Stawell, Vict., and from its geological position and associated fossils is of much importance and interest. The ferruginous deposit is placed by Mr. R. B. Smyth on the horizon of the Melbourne Flemington beds (= L. Pliocene.)
3. L. SUBCARINATA. *Busk* (MS.) Quart. Jour. Geol. Soc., 1860, xvi, p. 261. Mt. Gambier coralline limestone.
4. L. SUBMARGINATA. *Busk* (MS.), *loc. cit.* p. 261. Mount Gambier coralline limestone.

Genus LUNULITES. *Lamarck*[2], 1876.

Obs. Undetermined species of this genus occur both in the Mount Gambier limestone and Muddy Creek (Hamilton) beds, according to the Rev. Mr. Woods.

I. LUNULITES. SP. IND. (2) Woods. Quart. Jour. Geol. Soc., 1865, xxi, p. 394.

Genus MELICERITA. *Milne Edwards*, 1836.[3]

Obs. The only hitherto recorded species of *Melicerita* is of interest from its geographical distribution. It is also of interest from the limited number of species occurring in the European Tertiaries, and again as one of the commonest forms at Mt. Gambier.

MELICERITA ANGUSTILOBA. *Busk.* Quart. Jour. Geol. Soc., 1860, xvi, p. 261; Woods, Geol. Observations, S. Australia, 1862, pl. 1, f. 4; *id.* Trans. R. Soc. Vict., 1865, vi, p. 5, pl. 1, f. 8; Stoliczka, Paleontol. Neu Seeland, p. 155, pl. 20, f. 15—18. Mt. Gambier Coralline limestone, S. A.; Muddy Creek beds, Hamilton, Vict.; Tertiary greensand of Orakei Bay, New Zealand.

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[1] History Brit. Zoophytes, p. 277.
[2] Hist. Anim. sans Vertèbres, vol. ii.
[3] Annales des Sciences Naturelles, vi, p. 347.

Genus MEMBRANIPORA. *De Blainville*, 1830.[1]

Obs. Of this genus, always one of the most difficult to deal with in a fossil state, not only from the great amount of variation a species is liable to go through, but also from the worn condition in which specimens are usually found, four species have been recorded from Australian tertiary rocks.

1. MEMBRANIPORA APPRESSA. *Busk* (MS.) Quart. Jour. Geol. Soc., 1860, xvi, p. 261. Mt. Gambier limestone.
2. M. FIDENS. *Hagenow*, *Busk*. Monograph. Foss. Polyzoa Crag, 1859, p. 34, pl. 2, f. 4; Quart. Jour. Geol. Soc., 1860, xvi, p. 260; Woods, *ibid*, 1865, xxi, p. 394. Mt. Gambier limestone, S. A.
3. M. CYCLOPS. *Busk*. British Museum, Cat. Polyzoa, 1854, pt. 2, p. 61, pl. 65, f. 3. Quart. Jour. Geol. Soc., 1860, xvi, p. 261; Woods, *ibid*, 1865, xxi, p. 391. Mt. Gambier limestone, S. A.; Muddy Creek beds, Vict.
4. M. STENOSTOMA. *Busk*. British Museum, Cat. Polyzoa, 1854, pt. 2, p. 60, pl. 100, f. 1; Quart. Jour. Geol. Soc., 1860, xvi, p. 260; Woods, *ibid*, 1865, xxi, p. 394; Mt. Gambier limestone, S. A.

Genus PSILESCHARA. *Busk*. 1860 (MS.)

Obs. Another manuscript name used by Prof. Busk in the paper previously referred to.

1. PSILESCHARA PUSTULOSA. *Busk*. (MS.) Quart. Jour. Geol. Soc., 1860, xvi, p. 261. Mt. Gambier limestone.
2. P. SUBSULCATA. *Busk*. (MS.), *loc. cit.* p. 261. Mt. Gambier limestone.

Genus RETEPORA. *Imperato*, 1672.

Obs. The Australian species of this genus require strict revision. It is very difficult to say what two out of the four recorded species may turn out to be when strictly investigated, they having been identified originally by Captain Sturt with European species, which so far as can be judged from his figures they certainly do not appear to be.

1. RETEPORA DISTICHA. *Sturt*. Two Expeditions, Int. S. Australia, 1833, ii. p. 254, pl. 3, f. 6; Woods, Geol. Observations, S. Australia, 1862, p. 105. This is not *R. desticha*, Goldfuss (Petrefacta Germaniæ, i, p. 29, pl. 19, f. 15), but is more probably *Hornera Gambierensis*, Busk, or perhaps an *Idmonea*.
2. RETEPORA MACCOYI. *R. Etheridge, jun*. Trans. R. Soc. Vict., 1874, xi, p. 14. Oligocene beds of Schnapper Point, Port Phillip Bay, Vict.

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[1] Dictionnaire des Sciences Naturelles, tome Zx, p. 411.

3. R. MONILIFERA. *M'Gillivray.*[1] Trans. R. Soc. Vict., 1860, iv, pt. 2, p. 168, pl. 3; Woods, Quart. Jour. Geol. Soc., 1865, xxi, p. 394. Mt. Gambier limestone, S.A.
4. R. VIBICATA. *Sturt.* Two Expeditions Interior S. Australia, 1833, ii, p. 254, pl. 3, f. 7. *Retepora*, sp., Woods, Geol. Observations S. Australia, 1862, p. 74, fig.—. *Ret. silicata, id. ibid*, p. 105. This is not *Retepora vibicata*, Goldfuss (Petrefacta Germaniæ, i. p. 103, pl. 36, f. 18); as Capt. Sturt appears to have thought. Both the latter and the Rev. Mr. Woods figure the same species; that of the last named is considered by Dr. Stoliczka.[2] to be possibly *R. Beaniana*, King, Murray R. Cliffs and Mt. Gambier limestone, S.A.

Genus SCUTULARIA. *Busk* (MS.), 1860.

Obs. This, at present only a manuscript name, Mr. Busk informs me (by letter) is intended for the reception of certain forms not unlike *Lunulites* but with different zœcia. It was probably a free form, and may perhaps be placed in Mr. Busk's family *Selenaridæ*.

1. SCUTULARIA PRIMA. *Busk* (MS.) Quart. Jour. Geol. Soc., 1860, xvi, p. 261. Coralline limestone, Mt. Gambier, S. A.

Sub-order CYCLOSTOMATA.

Section ARTICULATA.

Genus CRISIA. *Lamouroux*, 1812.[3]

Obs. Only one species has as yet been noted from the Australian tertiaries.

1. CRISIA EBURNEA. *Linnæus.* Johnston, British Zoophytes, 1847, i, p. 283, pl. 50, f. 3 & 4; Woods, Trans. R. Soc. Vict., 1865, vi, p. 5, pl. 1, f. 12; Quart. Jour. Geol. Soc., 1865, xxi, p. 394, Busk; Brit. Museum Cat. Polyzoa, 1875, pt. 3, p. 4, pl. 2, f. 1 & 2, pl. 5, f. 1 & 2, 5–10. Mount Gambier limestone, S. A.

Section INARTICULATA.

Genus HORNERA. *Lamouroux*, 1821.[4]

Obs. This genus is divisible into two well marked sections, according as the frond is ramose or fenestrate. For the latter group a distinct name *Retihornera* has been proposed by Herr

[1] Notes on the Cheilostomatous Polyzoa of Victoria, and other parts of Australia. *Trans. Phil. Institute Vict.*, vol. iv, 1860, pt. 2, pp. 159–168, pls. 2 & 3.

[2] Pal. Neu Seeland, 1865, p. 125.

[3] Bulletin des Sciences de la Société Philomatique, &c., vol. iii, p. 183.

[4] Exposition Méthodique des Genres de l'Ordre des Polypiers, 1821, p. 41.

Kirchenpaur. The best known of the Australian tertiary species of this genus, *H. Gambierensis*, Busk, is one of the ramose forms.

1. HORNERA GAMBIERENSIS. *Busk.* Quart. Jour. Geol. Soc., 1860, xvi, p. 261; Woods. Trans. R. Soc. Vict., 1865, vi, p. 5, pl. 1, f. 10. The form figured by Capt. Sturt as *Retepora disticha* (*see ante*), is probably identical with that given by Woods as *H. Gambierensis*, although I think it has more the appearance of an *Idmonea* than *Hornera*. Mt. Gambier limestone, S. A.
2. H. RUGULOSA. *Busk.* Quart. Jour. Geol. Soc., 1860, xvi, p. 261; Woods, Trans. R. Soc. Vict., 1865, vi, p. 5, pl. 1, f. 9? Mt. Gambier limestone, S. A.

Genus IDMONEA. *Lamouroux*, 1821.[1]

Obs. Two species have been obtained from the Mount Gambier limestone.

1. IDMONEA LIGULATA.—*Busk.* (MS.) Quart. Jour. Geol. Soc., 1860; xvi, p. 261, Stoliczka, Pal. Neu Seeland, 1865, p. 114.
2. I. MILNEANA.—*D'Orbigny.* Zoologie, Voyage dans l' Amérique Mérid., p. 20, t. 9, f. 17–21. Busk, Quart. Jour. Geol. Soc., 1860, xvi, p. 261. Woods, *ibid*, 1865. xxi, p. 394; Stoliczka, Pal. Neu Seeland, 1865, p. 114. This is a living species on the coast of Tierra del Fuego, Patagonia, and other places.

Genus PUSTULOPORA. *De Blainville*, 1830.[2]

Genus ENTALOPHORA. *Lamouroux*, 1821.

Obs. Prof. Busk observes that perhaps the more correct generic term for polyzoa of this description is the second of the foregoing names, which has been adopted by Dr. Stoliczka in his description of the Orakei Bay fossils.

1. PUSTULOPORA DISTANS. *Busk.* Quar. Jour. Geol. Soc., 1860; xvi, p. 261. Mount Gambier limestone. Dr. Stoliczka remarks that this species may possibly be identical with his *Entalophora Haastiana*.[3]
2. P. UNGULATA. *Woods.* Mount Gambier.[4]
3. P. CORRUGATA. *Woods.* Mount Gambier.[4]

Genus TUBULIPORA. *Hagen.*

1. T. GAMBIERENSIS. Mount Gambier.[4]

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[1] Exposition Méthodique des Genres de l'Ordre des Polypiers, &c., Suppl. p. 80.

[2] Dictionnaire des Sciences Naturelles, 1830, p. 332.

[3] Pal. Neu Seeland, p. 103.

[4] Journal Roy. Soc. New South Wales, 1876, vol. x, p. 150.

In the following table I give a list of the species mentioned in the foregoing Synopsis which are at present living, arranged in alphabetical order.

Genus and Species.	Localities.
1. *Caberea lata.* Busk	Australia, New Zealand. Busk.
2. *Crisia eburnea.* Linn..............	European Seas.
3. *Idmonea Melneina.* D'Orb.	Tierra del Fuego, Patagonia. Busk.
4. *Membranipora cyclops.* Busk ...	New Zealand. Busk.
5. ,, *stenostoma.* Busk	Tasmania; East Falkland Islands. Busk.
6. *Retepora monilifera.* M'Gilv......	King's Island, Bass's Strait; Queenscliff, Vict.
7. ,, *Beaniana.* King...... (? *R. vibicata.* Sturt)	North Britain. Busk.
8. *Salicornaria gracilis.* Busk......	Cumberland Islands, Cape Capricorn. Busk.
9. ,, *sinuosa.* Hassal	British Seas.

NOTE.—In addition to these, the characteristic *Cellepora Gambierensis*, Busk, is said by Dr. Stoliczka (Pal. N. Seeland, 1865, p.—) to be probably still living on the coasts of S. Australia and N. Zealand. The Rev. Mr. Woods states that *Membranipora bidens*, Hagenow, is also a living species. Quart. Jour. Geol. Soc., 1865, xxi, p. 394.

2. In conclusion I give a statement showing the species common to the various localities.

a. Species common to the Mt. Gambier limestone and Murray River cliff beds.

1. *Cellepora echinata.* Sturt. (? *C. hemispheria.* Busk).
2. ,, *escharoides.* Sturt. (? *C. hemispheria.* Busk).
3. ,, *Gambierensis.* Busk.
4. *Retepora disticha.* Sturt. (? *Hornera Gambierensis.* Busk.)
5. *Retepora vibicata.* Sturt. (? *R. Beaniana.* King.)
6. *Salicornaria sinuosa.* Hassal.

b. Species common to the Mt. Gambier limestone and Hamilton beds.

1. *Cellepora nummularia.* Busk ?
2. *Mellicerita angustiloba.* Busk.
3. *Membranipora cyclops.* Busk.
4. *Salicornaria sinuosa.* Hassal.

c. Species common to the Mt. Gambier Limestone and Spring Creek beds.

1. *Cellepora Gambierensis.* Busk.
2. „ *nummularia.* Busk ?

d. Species common to the Mt. Gambier Limestone, and the Greensand of Orakei Bay, Auckland, N. Z.

1. *Cellepora Gambierensis.* Busk.
2. *Idmonea Melneina.* D'Orb.
3. *Pustulopora distans.* Busk ? (? *Entalphora Hoastiana,* Stol.)

e. Species common to the Schnapper Point beds, Victoria (*Oligocene*), and the greensand of Orakei Bay, Auckland.

1. *Onchopora* (*Spiroporina*) *vertebralis.* Stol.

Ctenacanthus, a Spine of Hybodus.

By W. J. Barkas, M.R.C.S.E.; L.R.C.P.L.

[*Read before the Royal Society of N.S.W.*, 3 *October*, 1877.]

In the Geological Magazine for April, 1874, there appeared a paper written by me entitled "Hybodus, a Coal Measure Fish." In it I attempted to prove that the fish Hybodus existed earlier in the world's history than the Jurassic Age as was stated by Professor Agassiz and others, and I supported my opinion by comparing certain teeth that had been discovered in the true Coal Measures, and which up to that time had been designated Cladodus, with engravings of teeth of Hybodus and Cladodus from the works of Agassiz, Newbery and Werthen. This direct comparison of the external characters of the teeth of the above-named fishes showed, as I think, most conclusively that a fish having teeth similar to those of the Jurassic Hybodus existed during the Coal Measure period. In the third and fourth chapters of my papers on the "Microscopical Structure of Fossil Teeth from the Northumberland True Coal Measures," which appeared in the "Monthly Review of Dental Surgery" for 1874, I gave a full account of the microscopical structure of the teeth of Hybodus from the Wealden and of the so-called Cladodus from the Carboniferous system, and exhibited engravings of the structure of Cladodus (?) from the latter formation; I also pointed out in these papers that the histological characters of the teeth of Hybodus from the Wealden differed very slightly indeed from the structure of the teeth which I consider to pertain to Hybodus (Cladodus ?) belonging to the Coal Measures. My investigations, therefore, led me to the conclusion that most of the teeth found in the true Coal Measures which had been named Cladodus did not belong to that genus at all, but to the genus Hybodus; the remainder, comparatively few in number, were undoubtedly true Cladodi; also that these Coal Measure Hybodi and Cladodi teeth possessed similar structures, just as the Hybodi teeth from the Wealden resembled the Cladodi teeth from the Mountain Limestone. When I published my researches I was not aware that any other palæontologist had discovered teeth of Hybodus in the true Coal Measures, but since then I have ascertained that Giebel, in his "Fauna der Vorwelt," describes in a very brief manner the external characters of two varieties. This I take to be a corroboration of the opinion I arrived at independently.

These three papers treated only of the fact of the teeth of Hybodus being found in the upper Coal Measures, but incidentally I mentioned that the teeth of Hybodus and Cladodus were discovered comparatively frequently associated with the spines of Ctenacanthus, and that from that and other circumstances I was of opinion that the reputed spine of Ctenacanthus was undoubtedly a spine of Hybodus.* It is with the intention of giving further proof in confirmation of the view I then casually published that I have undertaken to write this paper, and I shall (following the plan I adopted in my "Hybodus, a Coal Measure Fish") place before you the descriptions of the spines of Ctenacanthus and Hybodus as given by other palæontologists, viz., Agassiz, Münster, &c., and descriptions of the so-called spines of Ctenacanthus in the possession of Mr. T. P. Barkas, F.G.S.

After having thus referred to the external characters of these spines, I shall draw attention to their microscopical structure and point out what similarity there may be between the minute characters of an undoubted spine of Hybodus and those of a reputed spine of Ctenacanthus. In order that there might not be the slightest doubt as to the veritableness of the spine of Hybodus from which the sections for microscopical examination were to be made, I wrote to two of our greatest palæontologists, the Earl of Enniskillen and Sir Philip de Grey Egerton, for portions of an undoubted spine; they very graciously supplied me with the required specimens, and it is from them that I made my sections. With regard to the sections of the spine of Ctenacanthus being undoubted, I may state that the remains of the spines that I destroyed to make them are in Mr. T. P. Barkas' possession, and also that the sections were cut from five or six different spines, and from different portions of those spines.

The spines of the genus Hybodus, according to the late Prof. Agassiz, present the following external characteristics:—"Les rayons de ce genre, surtout ceux des espèces du Lias, se font remarquer par leur grandeur considérable. Ils ont une forme et des caractères extérieurs très-caractéristiques. Ils sont généralement *un peu arqués*,† *plus gros et plus larges vers leur base qu'à leur extrémité, et se terminent en une pointe plus ou moins*

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*Although I consider Ctenacanthus spines to pertain to Hybodus, I shall keep the original names throughout this paper, with the understanding that Ctenacanthus means Hybodus found in the Coal Measures, and that Hybodus refers to the spines obtained from the Lias, Wealden, &c.

† The italics in these quotations are my own.

amincie. La partie de leur extrémité inférieure qui était cachée dans les chairs, est assez considérable, *elle égale le plus souvent le tiers de la longueur totale;* elle est finement striée longitudinalement et ouverte en côté postérieur en forme de sillon très-évasé qui se resserre pour former une cavité intérieure assez spacieuse et qui s'étend jusque vers l'extrémité du rayon. La partie des rayons qui soutenait le bord antérieur des nageoires est *plus ou moins arrondie, légèrement comprimée latéralement*, coupée moins ou plus *carrément au bord postérieur* et arrondie au bord antérieur; toute sa surface, du moins *les côtés et le bord antérieur, sont ornés de fortes arêtes longitudinales arrondies*, plus ou moins parallèles au bord antérieur du rayon et qui alternent avec des sillons assez profonds et à peu-près de mêmes dimensions que les arêtes qui séparent. Vers le bord antérieur ces arêtes et ces sillons sont généralement plus gros, plus profonds, plus larges et plus distans que vers le bord antérieur *(sic)*, *le long duquel ils se confondent fréquemment, ainsi que* vers la pointe. Le long du bord postérieur, qui est plus ou moins plat et finement strié en long, il y a *deux rangées* plus ou moins distantes de grosses dents acérées, et arquées vers la base du rayon; vers son extrémité ces deux rangées de dents se *rapprochent de plus en plus*, et *finissent souvent* par se confondre entièrement sur la ligne médiane." In describing *Hybodus apicalis* he says:—"*le bord antérieur est aussi plus arqué que le bord postérieur, qui est presque droit, sauf la pointe qui se courbe assez subitement.*" Then again, with regard to *H. curtus*—"Le sillon postérieur de la racine est très-évasé, et la cavité intérieure assez considérable vers la base; mais elle se rétrécit rapidement vers l'extremité du rayon." In *H. leptodus*—"Les dents des bords postérieurs sont grêles et assez distantes, c'est-à-dire, plus distantes les unes des autres que les sillons longitudinaux." When describing the longitudinal ridges of *H. reticulatus* he remarks—"Ils sont au contraire souvent sinueux, et s'anastomosent de temps en temps." In *H. formosus* the grooves on the anterior surfaces of the spine are "finement granulés." According to Agassiz then, the above are the principal external characters of different spines of Hybodus. He mentions seventeen other varieties, at least he makes them species, though I think he has in this case fallen into the bad habit of hair-splitting, for many of the spines he describes are mere fragments, others are exceedingly similar and some are evidently crushed specimens; in fact to distinguish these twenty-two varieties from his drawings requires a remarkable amount of imagination.

Count Münster, in his "Beiträge zur Petre-facten-kunde," gives the following short account of *H. hexagonis*—"Der rucken und die Seiten dieses Ichthyodoruliten sind stark gefurcht; Rippen und Furchen gleich breit; die eckige Banchseite ist glatt; der Durchschnitt zeigt eine länglich sechsseitige Form. Nach einem zweiten Bruchstücke wird Ruckenstachel doppelt so gross." An evidently incomplete description of a portion close to the apex of the spine.

We have now learnt the appearances presented by the spines of this genus, from two of the greatest authorities; and the portions of the spines of Hybodus that I possess, and from which I made sections, correspond to the above descriptions.

I will now refer to the external characters of the spines of Ctenacanthus in my possession and quote the descriptions of others; we shall then be in a better position to institute comparisons between Ctenacanthus and Hybodus. Let us take Agassiz first. He says:—"Les Ctenacanthus ont d'immense rayons très-comprimés, à base large * * La partie de ces rayons cachée dans les chairs parait avoir été considérable. Au bord postérieur se voient quelques petites épines. La surface est ornée de striés longitudinales, plus rapprochées que celles des Hybodes, pectinées, c'est-à-dire, crénelées transversalement et saillantes en forme de dents qui alternent d'une série à l'autre, mais qui semblent continuer à cause de leur obliquité." In describing *C. major* he observes—"Le rayon est élégamment arqué en forme de faux * * Au bord postérieur du rayon, et vers sa pointe seulement, on remarque quelques petites épines, ou plutôt quelques rides plus saillantes en forme de peigne sur le sillon marginal * * Sa coupe transversale est ovale, arrondie du côté de la face postérieur du rayon et tranchante à son bord antérieur. La ligne de démarcation entre la partie sillonée du rayon * * et sa base lisse * * est très-oblique."

The descriptions of Ctenacanthus given by McCoy in his "British Palæozoic Fossils," and by Messrs. Newberry and Werthen in the "Geological Survey of Illinois, U. S.," are similar to the above, with the exception that the spines they mention are smaller and finer. M'Coy, however. remarks further that "the fin-defences of this genus are confined to the Devonian and Carboniferous rocks, where they seem to represent the genus Hybodus of the Mesozoic period."

In my own collection and in the cabinets of others I have had the opportunity of examining upwards of two dozen spines of Ctenacanthus, and in their external characters hardly any two agree precisely. They vary in length and breadth exceedingly, some being very large, but these are the rarest, and I have seen none so large as the *C. major* figured by Agassiz in his "Poissons Fossiles," tome 3, tab. 4, fig. 2; others are comparatively small and thin like *Hybodus dorsalis* exhibited in tab. 10, fig. 1, of the above work. They are *generally a little arched*, but are in some cases perfectly straight; in others the anterior border is curved while the posterior is straight, the apex being bent in some cases, and in others not. They are large at the base and gradually and often rapidly become narrower till they terminate in a point more or less sharp. The portion of the spine buried in the flesh is considerable enough and generally equal to the third of the total length, but it is very rare to obtain this portion of the spine entire; it is finely and longitudinally striated; the division between this portion of the spine and the ridge or exposed part is marked by a very distinct line of demarcation, which is sometimes very oblique and often curved. The posterior surface of the base of the spine is open, a very deep furrow extending deeply into the body; as this furrow proceeds upwards it becomes closed in posteriorly and forms an oval cavity, this oval character is in many cases lost, for numbers of the larger spines, having necessarily large cavities, have been crushed in by the superincumbent pressure; the cavity extends nearly to the apical extremity. The exposed portion of the spine is rounded anteriorly, more or less compressed laterally, and its posterior surface is slightly concave, the concavity being very shallow near the apex, making the surface there nearly flat. The anterior surface and sides are marked by longitudinal ridges, which are separated from each other by grooves of nearly the same dimensions as the ridges; the grooves and ridges run parallel with the anterior border, but as they approach the apex they become fewer in number by anastomoses, and in some cases when close to the extremity they disappear altogether, leaving a small surface which is minutely striated; in the large specimens the ridges proceed quite to the point. The sulci are often smooth, but occasionally they are finely granular or even longitudinally striated. The ridges, according to all palæontologists, are generally supposed to be tuberculated or crenelated, but this is evidently a mistake, for among the specimens I have observed, I have examined six in which the ridges were perfectly smooth and rounded as in Hybodus; in other cases they varied from being strongly tuberculated on the lateral and anterior surfaces of the spine to being slightly denticulated on the posterior ridges of the lateral surfaces only, the non-tuberculated ridges being smooth and rounded. The posterior surface I have said is slightly concave, and on each side are arranged from one to two rows of obtuse denticles; the intervening space is finely striated; the obtuse denticles of *H. marginalis*, shown in tab. 10, figs. 18-20 in Agassiz' 3rd volume, closely resemble them.

A careful comparison of the above descriptions of Ctenacanthus and Hybodus will show that the so-called spines of Ctenacanthus differ from the spines of Hybodus in very few particulars, in fact in two only, first, that the posterior surface of the former has sometimes four rows of teeth, which are situated on the sides of that surface instead of near the centre as is generally observed in Hybodus, but Agassiz figures in tab. 10, fig. 3, of his third tome a spine, *H. leptodus*, in which the teeth are situated like those in Ctenacanthus, however Hybodus has never four rows of denticles that I am aware of. Second, that the longitudinal ridges on the exposed portion are often tuberculated. Of course the tuberculated variety of Ctenacanthus may be considered quite a distinct species from those with smooth ridges, but I cannot accept this opinion, for the spines present every variation between the two extremes, and both varieties are found associated with the teeth of Hybodus and Cladodus and also with undoubted dermal tubercles, which were consequently designated tubercles of Ctenacanthus; finally these two varieties have exactly the same microscopical structure. For the purposes of comparison with the spines of Hybodus, I have of course chosen the most typical specimens of Ctenacanthus. No. I* is the upper portion of a spine of Ctenacanthus; on its lower part it is to be observed that there are two rows of denticles on the posterior surface, and that as they proceed upwards one row disappears. Suppose I had taken a portion of this spine near the apex and placed it side by side with the small pieces exhibited by Münster in his "Beiträge zur Petrefacten-kunde," Tafel xvi, figs. 16 and 17, one would have had some difficulty in distinguishing which was Ctenacanthus and which Hybodus. No. II is a portion near the base, it closely resembles the same portion of the spine of *Hybodus formosus* which is figured by Agassiz in his*" Poissons Fossiles"; these spines are so alike at their base that no dissimilarity is noticeable in the marking on the part that was buried in the flesh, in the line of demarcation between that portion and the spine proper, or in the smoothness of the ridges on the exposed portion. A transverse section through No. I shows the shape of the internal cavity and the slight concavity of the posterior surface; with the exception of being larger, there is little difference between this section and the section of *H. pleiodus* exhibited in "Poissons Fossiles," vol. 3, tab. 10, fig. 17. The transverse sections of Ctenacanthus given by Agassiz must not be compared with similar sections of Hybodus, because the former are very far from correct, in fact, if his drawings were true to nature they would cause Ctenacanthus to resemble Hybodus still more strongly than I have shown it to do. I have stated that all the specimens I have examined, and that were in perfect condition, were slightly concave on the posterior surface of the ridged portion of the spine, but that sometimes the surface was flat near to the apex. Now, Agassiz, in his descriptions and figures of *C. tenuistriatus* (Poiss. Foss., vol. 3, tab. 3, figs. 10, 11) makes that surface evenly convex at the lower portion, and as it proceeds towards the apex it bulges out more and more

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* Referring to specimens I have had the opportunity of examining.

at its centre. Then again, in *C. major* (tab. 4, fig. 3) the posterior surface "est ovale et arrondie." These descriptions and figures are manifestly incorrect; it may be that the specimens he examined were either crushed spines or else much buried in the matrix; if they were not, then the spines were not appurtenances of the fish he named Ctenacanthus. All the specimens I have examined have similar appearances to No. II at their base, except when the specimen has been crushed, which is almost invariably the case near the lower extremity, where there is not any cavity, but a broad, deep excavation perfectly open at the posterior part.

The microscopical structure of these spines is very little known, the only author that I am acquainted with who attempts to describe it is Agassiz; in his "Poissons Fossiles," tome 3, he gives two engravings (tab. A., figs. 8 and 9) of the structure of *Hybodus reticulatus*, they are, however, poor representations; and on page 215 he refers briefly to the general structure, but it would be impossible from that description, even with the aid of his illustrations, to recognise a section of Hybodus under the microscope. He remarks—"Ce genre ne se distingue du précédent (Asteracanthus) que par le plus grand nombre de couches concentriques qui entourent la cavité médiane et dans lesquelles on distingue également des tubes calcifères dendritiques, mais en pétit nombre. Les lisières obscures qui se trouvent entre la dentine claire dont les canaux secondaires sont entourés sont trés-larges et présentent un aspect finement pointillé. Pour toute la reste, la structure est entièrement semblable à celle des Asteracanthus." The latter spine he states is similar in structure to the spine of Gyracanthus; thus Hybodus, according to Agassiz, has some points of resemblance to Gyracanthus, though what the points are he does not say. His description of the structure of Gyracanthus is unfortunately wrong, but it has I know many points of resemblance to Ctenacanthus and therefore to Hybodus. Agassiz does not refer to the structure of Ctenacanthus. Having therefore no authority upon whom I can depend for a correct account of the minute structure of Hybodus and Ctenacanthus, I shall rely solely upon sections that I have had made in my presence. In order to prevent a great amount of repetition I will state at once that the structures of these two spines are very similar, for under the microscope it is well nigh impossible to say which is which. In preparing the sections great care is required, for if too thick nothing can be seen but the openings of the larger canals and dark tissue between the orifices, and a section of Hybodus cut thus imperfectly I confess does somewhat resemble the drawings of Agassiz; if too thin, then the calcigerous tubules, more especially the finer ones, are broken or ground away. The spine of Ctenacanthus is permeated by numerous vascular canals, which are open at the extremity of the base where they received their vascular supply; they pass up the spine parallel with its vertical axis and with each other. In the base the course of the canals is very straight, and they appear to maintain an uniform size, their average diameter being $\frac{1}{120}$th of an inch; they branch seldom, but when ramuli are given off they arise nearly at right angles to the parent trunk; the tissue between equals about two-thirds of the diameters of the canals, it is homogeneous and is not arranged round the canals in concentric laminæ; from all the canals arise calcigerous tubules which branch and anastomose very freely with each other, the ultimate branches terminating in a layer of minute calcigerous cells which divides one vascular system from another, or they pass beyond this boundary and inosculate with the terminal branches of the neighbouring system. The diameters of these tubules average $\frac{1}{3000}$th of an inch at their origin and the finer branches average $\frac{1}{15000}$ of an inch. There are no concentric layers of dense vascular tissue surrounding the central cavity near the root, but as we proceed upwards this concentric arrangement becomes observable.

In the body of the spine the canals become slightly altered in character, those near the circumference being much smaller in diameter from the deposition of tissue within them in concentric layers, and those near the centre have also decreased in size to about the 200th of an inch but they are not surrounded by lamellæ. The circumferential portion of the body has now, therefore, a superabundance of tissue over canals, but near the centre they are about equal. From all the canals calcigerous tubes arise, but those near the centre give them off very sparingly, while the vessels near the periphery do so exceedingly abundantly; the tubuli branch very freely and the ramifications anastomose frequently with each other, so much so that where the tubules are numerous, as near the external surface, they fill the tissue between the canals with a fine network. Surrounding each canal and its system of tubules is a distinct boundary composed of calcigerous cells. The tubules from the central canals present a somewhat dendritic appearance. The central cavity is surrounded by layers of tissue denser than the above two varieties of dentine; it is, however, not arranged concentrically but irregularly, and in some parts is pierced by very large canals from which arise long but fine dendritic tubules. As we approach the apex the medullary cavity becomes smaller and smaller, and all the canals are surrounded by laminæ and therefore smaller in diameter.

Such are the characters presented by sections of the spine of Ctenacanthus, and such are the characters observed when similar sections of Hybodus are examined, even the sizes of the tubules and their branches agreeing. It is extremely difficult to prepare a vertical section of a spine of Hybodus in order to see the tubular arrangement satisfactorily, on account of the hardness of the fossilized spine and of the consequent brittleness when the section is becoming transparent under the grinding process.

We have now compared the spine of Ctenacanthus with that of Hybodus both externally and internally, and to me the proof is most conclusive as to their identity, but to some the mere similarity of form, markings and structure may not be considered as sufficient evidence to settle this matter. I will therefore for their benefit bring forward further geological proof. It is now an accepted fact that the spines of Hybodus are always found in the same formations as the teeth of Hybodus, at least we have the statement of the great palæontologist Agassiz that such is the case; "car non-seulement je connais les rayons et les dents des Hybodes et j'ai la certitude qu'ils appartiennent au même genre, mais encore j'ai pu m'assurer que partout où l'on trouve des rayons de ce type, il existe aussi des dents analogues et *vice versâ.*" Now, in my paper, "Hybodus, a Coal Measure Fish," I showed that the teeth of Hybodus were found in the Coal Measures, and in the "Monthly Review of Dental Surgery" for February, 1874, I proved that these teeth of Hybodus from the Coal Measures possessed a similar structure to those obtained from the Wealden. We have therefore shown that teeth are found in the Carboniferous system resembling in every respect the teeth of Hybodus from the Wealden, &c., and that the so-called spines of Ctenacanthus cannot be distinguished from the spines of Hybodus from the Lias, Wealden, &c., either by their external form or by their minute structure. Now the spines of Ctenacanthus are principally found in the Carboniferous formations where the teeth of Hybodus and Cladodus are discovered; we have only, therefore, to bring forward any facts which will tend to show a connection between the teeth and the spines; this is very easily done, for it is acknowledged by all Coal Measure palæontologists that they are frequently obtained associated on the same slab of shale. The best specimen I have seen illustrating this association is from the cabinet of Mr. Ward, of Longton, Staffordshire; it is an undoubted specimen of Ctenacanthus with non-tuberculated ridges, and in close contact with it are thirteen teeth of Hybodus and two of Cladodus, and the whole piece of shale is covered with the so-called Ctenacanthus tubercles. Messrs. Hancock and Atthey, in a paper which they published in the "Transactions of the Northumberland and Durham Natural History Society," stated their belief that the teeth, tubercles and spine, belonged to one fish, and Mr. Thompson of Glasgow has also given the same opinion, although none of them had seen such a specimen as that in the possession of Mr. Ward.

Another proof, though not so direct, is that when the teeth and spines are found separately they are almost invariably associated with the tubercles. Whether similar tubercles have been discovered accompanying Hybodus spines or teeth in the Wealden or Lias I do not know, but even if they have never been found so associated in these formations my view would not receive any confutation, for in order that these light tubercles should be deposited in close proximity to such heavy objects as spines and teeth the water would have to be in perfect quiescence, and then again the character of the fish itself might have undergone change in this respect during the mighty ages which passed away between the Carboniferous and the Jurassic periods.

Both the spines and teeth of Hybodus from the Coal Measures have been found buried in or associated with masses of shagreen and disintegrated cartilage.

Eichwald, a noted palæontologist, after an examination of some spines found in the Carboniferous Limestone of Russia, came to the conclusion that they belonged to Hybodus and named them accordingly *H. panderi*. He also asserts, in his "Lethæa Rossica," that *H. polyprion* of Agassiz has been discovered in the same formation.

To sum up: all the deductions and descriptions drawn out by Agassiz and others with regard to Hybodus from the more recent formations can be applied with equal truth to the spines of Hybodus (Ctenacanthus) and the teeth of Hybodus (Cladodus) from the Coal Measures; the only statement requiring correction is the following from the "Poissons Fossiles":—"Les Hybodes s'étendent depuis le Grès-bigarré inclusivement jusqu'à la Craie, c'est-à-dire jusqu'aux derniers dépôts jurassiques et weldiens; ils existent même dans la Craie." This will require the substitution of "vieux grès-rouge" for "grès-bigarré," for although this paper is directed principally to the Coal Measure remains, undisputed spines of Hybodus (Ctenacanthus) are found in the Carboniferous Limestone and in the Old Red Sandstone. In these latter formations teeth of Cladodus are also discovered, but not those of Hybodus, so far as I am aware. This, however, is of no importance, because it is probable that the fish Cladodus possessed spines exactly similar to Hybodus, if Cladodus be not a true Hybodus, for the genus was founded on teeth alone. The teeth of Cladodus differ from those of Hybodus only in the facts that the secondary denticles of the former *increase* in size as they proceed from the centre denticle, and that they are *always equal* in number on each side of the central cone; while in Hybodus they *decrease* in size and may be *equal or unequal* on each side. Now, I have examined specimens of Hybodus having all the secondary denticles *large* as in Cladodus, but in which they were all the *same height* as the centre denticle and *equal* in number on each side of it. I have also seen other teeth with the secondary denticles *equal* in number, but *decreasing* in size on each side. We have therefore teeth alike in every respect, with the exception that in some the secondary denticles decrease in size as they proceed from the centre, in others they increase, and in others again in which they remain equal in height. Taking these facts into account, and knowing that the teeth of Cladodus are similar in structure to those of Hybodus,* that they are often found associated with spines, teeth, or dermal tubercles, or it may be with all at once, as in Mr. Ward's specimen, the simplest conclusion we can come to is that Cladodus is only a variety of Hybodus, but I think that the evidence proves that the teeth called Cladodus really pertain to Hybodus, but are situated probably in a different part of the mouth.

We must therefore abolish the genus Ctenacanthus, and I also think the genus Cladodus. With regard to the teeth of Cladodus, I am pleased to find that other Coal Measure palæontologists agree with my opinion that they are only varieties of Hybodus, and therefore that that genus should be abolished. If this be so, then both the teeth and spines of Hybodus extend as low down in the earth's crust as the Old Red Sandstone, rendering the fish Hybodus another of those examples that further research has proved to have existed during a protracted period, and that tends to break down the artificial barrier between Palæozoic and Mesozoic times.

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* See my paper with engravings proving this in the February and March numbers of the "Monthly Review of Dental Surgery" for 1874.

On a System of Notation adapted to explaining to Students certain Electrical Operations.

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[*Read before the Royal Society of N.S.W., 3 October, 1877.*]

FOR a number of years I have been in the habit of using in my lectures on electricity a simple kind of notation in applying the double-fluid hypothesis to the explanation of Volta's electrophorus, the electrical machine in charging a Leyden jar, and analogous operations. This notation has enabled me to present such operations to students in a more clear and definite form than by any explanations I have found in books. Of course it may be objected that, as the fluid hypothesis is not only not proved, but is in the view of many highly improbable, any ingenuity exerted in applying it to observed facts must be entirely thrown away. But the same objection may be urged, with greater or less force, to any other hypothesis; and if in teaching we are not to make use of any hypothesis until it has been elevated to the dignity of a proved theory, we must repress the imaginative faculty altogether, and adhere strictly to a demonstration of the bare facts, which would I think be dull work for both teacher and taught. Provisionally then we use the fluid hypothesis because it adapts itself readily to all the ordinary phenomena, and affords a simple means of classifying or connecting them together. De la Rive says of it:—"Although subject to strong objections, it is, in the present state of the science, a very convenient and tolerably exact manner of representing to ourselves this agent that we term electricity."

Even those who prefer Faraday's hypothesis of polarization of particles find it difficult, if not impossible, to avoid the use of language that implies the existence of electric fluids. It appears to be thought by some that this molecular hypothesis is inconsistent with, and ought to exclude the fluid hypothesis: but Faraday himself was careful to point out that there is really no incompatibility. In his *Experimental Researches* (No. 514), he says:—"I have endeavoured to establish, what all the facts seem to prove, that when electrical phenomena, as those of induction, conduction, insulation and discharge occur, they depend on and are produced by the action of *contiguous* particles of matter, * * * and I have further assumed that these particles are polarized; that each exhibits the two forces, or the force in two directions; and that they act at a distance only by acting on the *contiguous* and intermediate particles." In another place (No. 1667) he says:—"The theory of induction set forth * * * * does not assume anything new as to the nature of the electric force or forces, but only as to their distribution. The effects may depend upon the association of one electric fluid with the particles of matter, as in the theory of Franklin, Epinus, Cavendish, and Mossotti; or they may depend upon the association of two electric fluids, as in the theory of Dufay and Poisson; or they may not depend upon anything which can properly be called the electric fluid, but on vibrations or other affections of the matter in which they appear. The theory, though it professes to perform the important office of stating *how* the powers are arranged, does not, as far as I can yet perceive, supply a single experiment which can be considered as a distinguishing test of the truth of any one of these various views." With the humility that was a striking characteristic of Faraday, he said, at a meeting of the British Association at Swansea:—"There was a time when I thought I knew something about the matter; but the longer I live, and the more carefully I study the subject, the more convinced I am of my total ignorance of the nature of electricity."

In making use of hypothetical explanations I am always careful to impress upon my students their provisional nature, and the risk we run of confiding too much in them, and of attributing to them a higher value than our knowledge warrants. On this point Tyndall remarks:—"In our conceptions and reasonings regarding the forces of nature we perpetually make use of symbols which, when they possess a high representative value, we dignify with the name of theories. Thus, prompted by certain analogies, we ascribe electrical phenomena to the action of a peculiar fluid, sometimes flowing, sometimes at rest. Such conceptions have their advantages and their disadvantages; they afford peaceful lodging to the intellect for a time, but they also circumscribe it; and by and by, when the mind has grown too large for its lodging, it often finds difficulty in breaking down the walls of what has become its prison instead of its home."

The fluid hypothesis is sometimes applied in a manner that may to beginners convey erroneous impressions; as, for example, in Tyndall's Notes on Electricity, in explanation of Volta's electrophorus—"If the surface of a cake of resin be electrified, a plate of metal laid upon it will have its neutral fluid decomposed, its positive fluid being attracted and its negative repelled. On touching the metal plate its free (repelled) electricity flows to the earth; and now if the plate be raised by an insulating handle it will appear charged with positive electricity." Now when this positive electricity is given off to a conductor, would it not be natural to suppose that the plate is entirely deprived of electric fluid? To the same effect is the explanation in Ganot's Physics, translated by Atkinson—"The negative electricity of the cake," he says, "acts by induction on the natural fluid of the cover and decomposes it, attracting the positive fluid to the under surface, and repelling the negative fluid to the upper. If the upper surface be now touched with the finger, the negative electricity passes off, and the cover remains charged with positive electricity, held, however, by the negative electricity of the cake. If now the cover be raised by its insulating handle the charge diffuses itself over the surface, and if a conductor be brought near it a smart spark passes." I do not see how a beginner could very well avoid the inference that the cover is thus entirely deprived of its electric fluid.

Then as to the action of the electrical machine, Tyndall says—"When the glass plate is turned by a handle it passes between the silk rubbers and is positively electrified. The electrified glass then acts by induction upon the prime conductor, attracting the negative electricity and repelling its positive. The conductor is furnished with points from which the negative electricity streams out against the excited glass. Thus the prime conductor is charged, not by directly communicating to it positive electricity, but by robbing it of its negative, the positive remaining behind." And Ganot—"The rubbers communicate with the ground by means of a chain, and consequently as fast as the negative electricity is generated it passes off. The positive electricity of the glass acts then by induction on the conductor, attracting the negative fluid, combining with it to regenerate the natural fluid; the conductors thus lose their negative electricity and remain charged with positive fluid. The plate accordingly gives up nothing to the conductors; in fact, it only abstracts from them their negative fluid." In other books usually in the hands of students the statements are equally liable to misconstruction.

In explaining electrical excitation by the two-fluid theory, I consider it necessary to show that the total quantity of electric fluid belonging to a body is never altered, but its quality may be changed by the substitution of a portion of the one fluid for an equal portion of the other. The neutral or unelectrified condition may be assumed as consisting of the two fluids combined in equal proportions. Whenever this equal balance is in any way disturbed—that is to say, when the electric fluid of a body is all of one kind, or is more than half of one kind, the total quantity proper to the body never varying—then we have electrical excitation or charge. Take, for example, a glass tube and a silk rubber—each with its own proper measure of neutral electric fluid; when they are rubbed together the compound fluid on both bodies gets completely or partially decomposed; the whole or part of the negative or resinous electricity belonging to the glass passes over to the rubber, and an equal measure of positive or vitreous passes to the glass. Each body continues to have the same quantity of electric fluid attached to it as at first, but the quality of the fluid is changed—each body has now an excess of one fluid, and a corresponding deficiency of the other—and therefore each body is electrically excited or charged, the one positively and the other negatively.

Take now the case of the electrophorus. When the metal cover is put down on the excited cake of resin, the compound fluid of the cover is decomposed by induction, its positive portion being attracted towards the cake and its negative repelled. If the cover be touched by a conductor, a part of the repelled negative is conveyed away and an equal measure of positive takes its place, leaving the total measure unchanged; but there is now an excess of positive, and when the cover is removed from the inductive action of the cake and touched with a conductor, it gives off its excess of positive and receives an equal amount of negative, thus restoring the neutral condition of the cover. Let us see how these changes may be simply represented.

Let V be a measure of vitreous or positive electricity, and R an equal measure of resinous or negative; V + R will then represent the neutral fluid. If we take the fluid on the surface of the resinous cake to be V + R we may suppose it to be entirely decomposed by friction, and it will then become 2 R. Represent the fluid of the cover thus: $\frac{V + R}{V + R.}$ The cover being put down on the cake, the whole fluid will be decomposed by induction and we shall have $\frac{2\ R}{2\ V.}$ Touch the cover with the finger. The 2 R of the cover attracts 2 V from the finger; they combine, and the neutral fluid thus formed is instantly distributed on the contiguous surfaces, V + R going to the cover and the same to the finger. The cover will then show $\frac{V + R}{2\ V}$, V being in excess and R deficient. Remove the cover by its insulating handle and touch it—V is given off, and R received in its place, leaving the cover as at first $\frac{V + R}{V + R.}$

In Dr. Golding Bird's "Elements of Natural Philosophy", a modification of Volta's electrophorus is thus described:—"A thin pane of glass is coated on one side with tinfoil to within about two inches of the edge. Placing it with the coated side on the table, excite the other surface by friction with a piece of silk covered with amalgam; then carefully lifting the glass by one corner, place it on a badly conducting surface, as a smooth table or the cover of a book, with the uncoated side downwards. Touch the tinfoil with the finger, then carefully elevate the plate by one corner and a vivid spark will fly from the coating to any conducting body near it; replace the plate, touch it, again elevate it, and a second spark will be produced." This simple apparatus is very instructive—more instructive indeed than its designer indicates—and deserves more attention than it appears to have got. It affords an excellent illustration of induction, and of the manner in which the one fluid binds or holds the other prisoner as it were. At the same time it is rather puzzling to students, and the above notation helps to make it plain. The following experiments may be made with this electrophorus: First, lay the coated surface on a book with paste-board cover, and excite the face of the glass plate by friction; of course it becomes charged with positive electricity. Lift up the plate and bring the coated back in contact with a charged electroscope. It gives off positive electricity. Excite the face again, turn over the plate on the book, lift up book and plate together, and again touch the electroscope with the coated back. It is now found charged with negative electricity. (This experiment is not mentioned by Golding Bird.) Remove the plate from the book, and again touch the electroscope with the back; it now gives a positive charge. The great difficulty with students is to understand how the coated back gives a positive spark when away from the book, and a negative when the face of the plate is kept in contact with the book. Let us apply our notation to the successive phases.

At the outset the fluid on each side of the glass plate may be represented as V + R. After friction the face may be supposed to have 2 V. This acts by induction through the glass and tends to repel the V of the back into the book and attract R from the book. The result would be 2 R on the back, if the book were a good conductor; but the book is an imperfect conductor. (To render it so, it should be well warmed at the beginning of the experiment.) The consequence is that only a portion (say half) of the V is driven away, and its place taken by $\frac{1}{2}$ R. We then have on the back $\frac{1}{2}$ (V + R) + R. On lifting the plate away from the book, the 2 V on the face tends to repel the remaining $\frac{1}{2}$ V from the back, which is thus able to charge an electroscope positively. But, on turning the plate over on its face on the book, the 2 V on the face acts by induction on the book in preference to acting through the glass; and, being then bound or masked by 2 R on the book, it no longer has any coercing influence on the electricity of the back. But that electricity has $\frac{1}{2}$ R in excess of the normal quantity, and, if brought into contact with an electroscope, a negative charge will therefore be communicated; at the same time $\frac{1}{2}$ V is received in exchange, and the back of the plate resumes the condition represented by V + R. Finally, on lifting the plate away from the book, the 2 V of the face acts again by induction through the glass and repels V from the back, which is thus capable of giving a positive spark. As a matter of fact, this last positive charge is much stronger than that obtained when the plate after friction is raised and the back brought to an electroscope; and much stronger also than the negative charge got from the back when the plate and book are raised together. A glance at the notation shows clearly the reason of this.

Turn now to the function of the machine in charging a Leyden jar. In applying our notation we have to consider four separate parts or links in the chain of action: First, the machine consisting of glass and rubber; second, the positive prime conductor; third, the inside of the jar; and fourth, the outside of same, which for the sake of simplicity we suppose connected with the insulated rubber. On each of these parts we may represent the neutral electric fluid as R + V, and we then have—

		Leyden jar.	
Machine.	Pos. P. Cond.	Inside.	Outside.
R + V	R + V	R + V	R + V

On turning the machine the electric fluid is decomposed by friction, all the V collects upon the glass, and all the R upon the rubber. The V on the glass now acts by induction on the neutral fluid of the positive prime conductor, attracting R and repelling V; this latter acts in the same manner on the fluid inside the jar, and the repelled V inside acts through the glass and decomposes the neutral fluid outside. This first step may be represented by simply obliterating the plus signs in the above notation. But at three points, namely, between glass of machine and P.P.C., between P.P.C. and inside of jar, and between outside of jar and rubber, the electricities are separated either by a narrow space of air, or by conducting matter, and the decomposition is instantly followed by recomposition, as shown by sparks; while at the fourth point the insulating glass of the jar prevents recomposition. This state of affairs may be represented as follows:—

	Machine.	Air.	P.P.C.	Air.	Inside.	Glass	Outside.	
+	R V	+	R V	+	R V	|	R V	+ to rubber.

The neutral fluid formed at these three points must be instantly redistributed on the neighbouring surfaces, one half going one way the other half the other way. We then have—

Machine.	P.P.C.
½ (R + V) + ½ (R + V);	½ (R + V) + ½ (R + V);

Inside.	Outside.
½ (R + V) + V	R + ½ (R + V)

Every part has thus exactly the same measure of electric fluid as when we began. On the machine and P.P.C. the fluid is neutral; but on each side of the jar there is an excess of the one fluid with a corresponding deficiency of the other, and the jar is represented as half charged. Continuing to turn the machine, another cycle of decomposition, recomposition and redistribution is gone through, but now with only half the original amount of fluid. The decomposition and recomposition may be represented together in one line :—

$$+\ \tfrac{1}{2}\,R\ ;\ \overbrace{\tfrac{1}{2}\,(R+V)}^{\text{Machine.}}\ ;\ \overbrace{\tfrac{1}{2}\,V+\tfrac{1}{2}\,R}^{\text{Air.}}\ ;\ \overbrace{\tfrac{1}{2}\,(R+V)}^{\text{P.P.C.}}\ ;\ \overbrace{\tfrac{1}{2}\,V+\tfrac{1}{2}\,R}^{\text{Air.}}\ ;$$

$$\overbrace{\tfrac{1}{2}\,V+V}^{\text{Inside.}}\quad \overset{\text{Glass.}}{|}\quad \overbrace{R+\tfrac{1}{2}\,R}^{\text{Outside.}}\ ;\ \tfrac{1}{2}\,V\ \ +\text{ to rubber.}$$

and the simultaneous redistribution thus :—

$$\overbrace{\tfrac{1}{4}\,(R+V)+\tfrac{1}{2}\,(R+V)+\tfrac{1}{4}\,(R+V)}^{\text{Machine.}}\ ;\ \overbrace{\tfrac{1}{4}\,(R+V)+\tfrac{1}{2}\,(R+V)+\tfrac{1}{4}\,(R+V)}^{\text{P.P.C.}}\ ;$$

$$\overbrace{\tfrac{1}{4}\,(R+V)+\tfrac{1}{2}\,V+V}^{\text{Inside.}}\quad\Big|\quad\overbrace{R+\tfrac{1}{2}\,R+\tfrac{1}{4}\,(R+V)}^{\text{Outside.}}$$

We still have the original quantity of neutral fluid on the machine and P.P.C. ; but on each side of the jar although the quantity is unaltered the quality is more changed, the V accumulating inside and the R outside. It must be needless to represent the action in detail further. The next cycle of operations would give us inside the jar $\frac{1}{8}$ (R + V) + $\frac{1}{4}$ V + $\frac{1}{2}$ V + V, and outside R + $\frac{1}{2}$ R + $\frac{1}{4}$ R + $\frac{1}{8}$ (R − V). The series evidently tends to 2 V inside, and 2 R outside, but can never absolutely reach that result.

With this mode of representing the charging of a Leyden jar (hypothetical and artificial as it may be considered) we perceive simple reasons for two well-known facts. First, that judging by the frequency and brilliancy of the sparks the action of the machine while charging gets rapidly weaker. It is because there is less and less neutral fluid to decompose on the jar. And second, we never in practice reach a point where we can say that a jar is fully charged. No doubt a jar will generally discharge itself before saturation is reached ; but irrespective of that it would appear that a perfect and complete charge is unattainable. There will always be a residuum of negative electricity inside and of positive outside.

The discharge of a Leyden jar may be represented by the same notation, but the case is too simple to require exemplification. The two fluids being equal in amount on the two sides rush together and form neutral fluid, which is instantly redistributed in equal parts to the two surfaces, leaving the whole covered with the original amount of neutral fluid.

Notes on the Meteorology and Natural History of a Guano Island.

By W. A. Dixon, F.C.S.

[*Read before the Royal Society of N.S.W.*, 3 *October*, 1877.]

Having, during a residence on Malden Island extending over two and a half years, from October, 1866, to March, 1869, made a number of observations on various subjects, I have thought that it might interest some of the members of this Society if I placed them on record. As I have only a superficial knowledge of some of the sciences within whose domain many of the observations lie, it may be that some of them are not new; but as few men have an opportunity of passing a similar period in such a place, it seems probable that some may be, which forms my excuse for venturing to lay them before you.

Malden Island, discovered by Admiral Byron in 1825, is situated in lat. 4° 2′ S. and long. 154° 58′ W., and at that time was uninhabited, though there were signs of previous occupation. The native name of the island, according to the traditions of the inhabitants of Maniki or Humphrey's Island, was "Tera Kupatea," derived from "Tera," the sun, and "Kupatea," the only tree growing on the island, signifying that this formed the only sun-shade. They named several of the chiefs who had lived there, and asserted that the people had been washed off the island. Appearances did not warrant this assertion, however, though it seemed as if the sea had at one time made a breach over one spot, and such an occurrence may have induced the inhabitants to abandon a place possessing few attractions.

In form the island is triangular, and according to a rough survey it covers an area of 19,700 acres, of which about 9,000 is occupied by a lagoon situated considerably east of the centre. On the surface the island is of purely coral formation, the only siliceous mineral found being water-borne pieces of pumice, which in many places were sufficiently numerous, and it is surrounded by a fringing reef, extending pretty uniformly 200 feet from the beach where the depth of water suddenly increases to three or four fathoms, and thence slopes rapidly off into deep water, the rate of descent being about one in two. Immediately inside the reef the bank of the island rises, formed of broken coral and madrepores thrown up by the waves. This bank differs in construction on the different sides of the island, the north and south sides.

being alike, and east and west unlike, but all about 400 yards wide. On the north and south sides the outer portion of the bank is formed of successive ridges of madrepores and corals in large pieces forming a strip about 100 yards wide. The ridges, nine in number, are tolerably uniform in height, as are also the hollows between them in depth. The outer ridge presents a somewhat steep face towards the sea, and they all follow the coast-line with great regularity. I had an opportunity of seeing one of these ridges formed during a great tidal disturbance in December, 1868, before which the lower part of the beach was so sloping that one could walk along it without much inconvenience, but the large rollers at that time coming over the reef piled up the whole of this beach with much more material from the fissures in the reef, forming a ridge as high as the others, the sea-face being left almost perpendicular. The height of the north and south banks varied from about 9 feet at the east to 20 at the west end of the island. The bank at the east end also presented a somewhat steep face towards the sea, but it was composed of much smaller pieces, which were seldom larger than about 4 cubic inches. On the top the ridges were less marked, resembling a number of somewhat highly cambered roads running parallel to one another, and the surface was composed of small shingle mixed with sand.

At the west end the beach was composed of a wide strip of coarse coral sand, and the ridges were entirely wanting, the edge of the beach being marked by a line of bushes where the height above mean water level was 21 feet, the highest on the island. Immediately inside the ridges of black broken coral, and separated therefrom by a sharply defined line, the bank was formed of shingle, covered in most places with sand or guano, or both, with occasional scattered slabs of coral rock, and it sloped gradually down to the general level of the interior, except at the east end where the slope ended at the lagoon. This interior slope was covered with vegetation, and on it were several clumps of trees.

The interior of the island was composed of masses of coral rock *in situ*, between which were patches of guano of varying richness, and was about 3 feet above water level, showing that the island had been upheaved to that extent. Near the south side a fissure extended for some distance running east and west, partly open and partly filled in by matter deposited subsequently to its formation. The water in the open part, and in a series of small lagoons forming its continuation rose, and fell with the tide, and was inhabited by a small reddish fish about an inch in length, but did not contain any living corals, the only other living creature being a minute thin-shelled mollusc.

The lagoon is similar in shape to the island, and has no open communication with the sea, but is supplied with water through fissures in the coral rock. The immense evaporation from the surface of the lagoon in continued dry weather causes a constant influx of water, which is only influenced in rapidity by the state of the tide, almost ceasing at low-water, and flowing outwards only at low-water near spring-tides as far as I could observe. During heavy tropical rains, to which the island is at times subjected, the rain-water soaking from the higher surrounding lands washes out the lagoon as it were, and reduces the amount of salts in solution more or less below the standard of sea-water, dissolving at the same time the deposits of salt which have been formed around the shallow margin. The specific gravity of the water in the open sea I found was 1·026, and on different occasions I found that of the lagoon water to be 1·090 and 1·120, representing an evaporation of from two-thirds to three-fourths of the water, whilst on large shallow patches at the west end, where the water was only three or four inches deep, salt crystallized often to a depth of two or three inches.

This alternate evaporation and removal of the more soluble salts has caused large deposits of sulphate of calcium with more or less carbonate to be formed, especially at the west end, towards which the wind is generally blowing, and which is furthest from the fissures through which the water enters. There it covers large tracts only two or three inches above water level, the surface being bound together by a mat of vegetable matter apparently the same or similar to the peculiar marine Thallogen described by M. Aimé Girard as covering the bottom of the salt gardens of Portugal*. This forms a tremulous crust which may be walked upon, whilst underneath, the deposit is a white mud which may be readily probed to a depth of several feet. The wind occasionally removes portions of this crust and carries it with adhering deposit farther west, so that it forms a long slope, which as it rises above the water level is being gradually encroached upon by a thick-leaved plant having the appearance of a mesembrianthemum. This, collecting the dust blown from the drier portions below, forms a ridge about 18 inches high in which the mutton birds burrow holes, altering its appearance by charging it with organic matter and phosphates.

The climate of the island, although lying near the equator, and sometimes having the north-east and sometimes the south-east trades, is generally characterized by extreme dryness. I arrived on the island on the 13th of October, 1866, and on the 5th November there was a heavy rain-fall at night, which I was told was the heaviest for twelve months, although one man said that four years before there was always plenty of rain. From the quantity collected in a bucket standing outside, this rain-fall

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* Compt. Rend., LXXI, 1195.

was about 0·5 inch. I then made a rain-gauge, which was placed in the ground in an exposed situation 21 feet above sea-level, but there was no rain-fall to record from that date until the 1st September, 1867, or ten months. The rain-fall then gradually increased until in the begining of 1869 we had a continuance of heavy rains. The following record shows the quantities that fell:—

1866, Nov.	5.	0·50	
1867, Sept.	1	0·036	
	2	0·094	
	4	0·018	
	6	0·012	
	11	0·027	
	12	0·076	
Oct.	13	0·015	
	20	0·201	
	25	0·009	
Nov.	25	0·634	
Dec.	9	0·032	
	10	0·162	
Year	....	1·316	No. of wet days, 12.
1868, Jan.	7	0·408	
	18	0·003	
	26	0·141	
	28	0·136	
Feb.	17	0·002	
March	29	0·106	
April	13	0·016	
	22	0·176	
May	2	0·101	
	12	0·136	
	13	0·234	
	26	0·051	
	28	0·040	
June	7	0·104	
	9	0·008	
	13	0·003	
July	10	0·051	
	11	0·051	
	12	0·050	
	13	0·578	
	15	0·002	
	16	0·068	
	23	2·881	
	27	0·003	
	28	0·102	
	29	0·034	
Aug.	14	0·068	
	18	0·068	
	19	0·663	
	21	0·034	
	26	0·034	

1868, Sept.	3	0·003	
	10	0·102	
Oct.	4	1·681	Temp. of rain 73° F., of air 77° F., wind due S. 6 a.m.
	11	0·998	Temp. rain 77° ; air, same ; wind, E., 6 a.m.
	18	0·201	
	25	0·007	
Nov.	2	0·031	
	3	0·130	
	4	0·152	
	10	0·002	
	17	0·440	
	24	0·018	Cloudy all day, sun seldom seen ; shade 3 p.m. 93° F. ; 6 p.m. 81° F.
Dec.	1	1·724	Began to rain 11 a.m., Nov. 30 ; barometer 29·850.
	11	0·018	Wind east, strong ; temperature of rain 80°, of air 84° ; rained 19 hours.
	12	0·093	
	13	0·229	
	14	0·752	Dead calm.
	15	0·061	,,
	16	0·527	,,
	18	0·046	,,
	31	0·013	,, Sea very heavy.
For year......		13·580	Number of rainy days, 52.
1869, Jan.	13	0·527	
	16	1·004	Strong west wind ; temp. rain 78° ; air 82° ; barometer 29·85.
	17, 18	1·550	Strong west wind ; temp. rain 78° ; air 82° ; barometer lowest reaching 28·825, got up towards evening to 29·875.
	19	0·682	Very strong west wind ; temp. rain 78° F. ; air 82° F.
	20	0·558	,, ,,
	21	1·038	,, ,,
	22	0·694	,, ,,
	23	0·217	,, ,,
	25	0·740	,, ,,
	26	0·775	Wind east ,,
	27	0·372	,,
	28	0·626	4·571 in 8½ hours. ,,
	29	3·943	
Feb.	2	0·074	
	13	0·496	
	19	0·223	
	20	0·403	
	21	0·589	
	22	0·682	
	23	0·099	
	24	0·031	
	25	2·232	
March	5	0·031	
	7	0·688	

1869, March	9	0·015	
	19	1·360	Thunder and lightning; barometer usual.
	22	0·446	
	23	0·229	
		20·234	28 days rain in 3 months.

It was noticeable that during the day-time it frequently rained in heavy showers on all sides, without any falling on the island. Heavy rain clouds came up from the east, which as they came over the island disappeared, owing evidently to the immense radiation from the surface, as rain still fell both north, south, and west. This effect was much more noticeable during 1867 and the early part of 1868 than afterwards; the heavy rain-fall of July of that year caused a great growth of grass, &c., to cover large tracts that were before quite bare, which checked the radiation so that the clouds no longer disappeared, but at all times the greater part of the rain fell at night or during early morning.

The barometer that I had was an aneroid which I got from on board a ship, and except on three occasions noted above registered 29·95 inches at 9 a.m. This is about 0·11 inches higher than the usual reading within the tropics, the difference being no doubt due to the barometer itself, but as it got broken coming here I had no opportunity of comparing it.

The variations of the thermometer in the shade were extremely regular. At daybreak it stood at 80°, from which it gradually rose till between 9 and 10 a.m. when it stood at 96°, at which point it stood until shortly after sunset when it gradually fell to 80° at 10 p.m., at which temperature it stood till morning. The only exceptions to this regular routine were on the 4th October, 1868, when with wind due south and heavy rain, the thermometer recorded 77° F. at daybreak, the temperature of the rain being 73° F. On October 11th, at daybreak, 77° F., raining, wind E. On December 1st, at 11 a.m., raining, 84° F. all day; and from the 16th January, 1869 to 29th, inclusive, the thermometer never rose above 82°, there being continuous rain and no sun visible for thirteen days, with the wind due west. Hanging in the sun, and freely exposed to the wind, the unblackened thermometer gave at different times readings from 103° to 106°, and covered with one inch of soil, light grey in colour, it rose to from 125° to 135° in the afternoon. As I had only one thermometer these temperatures could not be often taken for fear of breakage.

Evaporation was not observed with regularity, but an average of eight days ending 11th December, 1868, gave 0·387 inches per day.

Wind :—In the beginning of October the wind was generally light east with calms, and the north-east trades began about the middle of the month, varying from E. to N.E. till the end of February, when light winds and calms again occurred, followed by S.E. and E. trades till October. The only exceptions to this were on October 1st, 1868, when the wind was due south. From the 14th to 31st December there was a dead calm with very heavy sea for the last three days, and from the 16th to 25th January, 1869, the wind was strong westerly. The island was not large enough to check the trade wind, so that at night there was almost always a dead calm at the west end whilst there was occasionally a barely perceptible movement from the sea.

The set of the currents round the island was altered at the same time that the wind changed from N.E. to S.E., and this change was marked by the movement of an immense mass of sand forming the west beach. In the beginning of March the sand began to accumulate on the beach and continued to do so until the beginning of October, forming a beach about 120 feet wide by 9 feet high, and a mile long. When the sun crossed the zenith of the island almost to a day this sand began to move to the south, where it was piled up for some distance along the south beach until all that the waves could reach was removed, and it was again brought back as soon as the sun crossed the zenith going north. In a great tidal disturbance in the end of December, 1868, the greater portion of this sand was washed away into deep water and disappeared.

The tide rose at springs about 2 feet, and it was high-water about 4 p.m. at the full and change of the moon, at which times there was generally a heavy swell on the west beach, and either the south or north according to whether the trades were N.E. or S.E.—the swell being on the opposite side to the wind.

The zodiacal light was nearly always to be seen, but was not noticeable for brilliancy.

The botany of the island was limited to ten species. The low ground near the small lagoons was covered by a thick-leaved species of mesembriantheum, whilst the bank was generally covered with a portulaca growing about 18 inches high. These, with the kupatea-tree, formed the principal vegetation; but there were also a small yellow-flowered malva, a marygold, three grasses, a yellow-flowered and a white-flowered plant which I am not botanist enough to identify. On the reef, turtle weed and a small coralline grew sparingly, and there was afterwards introduced on ballast stone from New Zealand a green weed which grew with great vigour and seemed likely to soon cover the whole of the reefs, growing over and killing the corals.

The soil on the banks on which these plants grew, and that luxuriantly when there was rain, gave on analysis when air-dried—

Water	6·24	or	Water	6·24
Organic matter	5·01		Organic matter	5·01
Lime	46·23		Phosphate of calcium	·50
Magnesia	2·07		Posphate of calcium	7·57
Alumina and oxide of iron	0·21		Sulphate ,,	1·93
Phosphoric anhyd.	3·84		Carbonate ,,	74·34
Sulphuric ,,	1·14		Carbonate magnesium	4·34
Carbonic ,,	35·49		Silica	·21
Silica	·21			
Chlorine and alkalies	(Traces)			100·14
	100·44			

In this analysis the phosphoric acid was separated from the ammonia precipitate by G. H. Rose's method. The matter insoluble in acid, from a considerable portion examined microscopically, was found to consist principally of minute fragments of pumice, with a few diatoms and sponge spicules. The soil on which the mesembriantheum grew was actually a poor guano, which, washed free from salt-water with which it was saturated, contained—

Water and organic matter	35·56
Phosphate of calcium	13·79
Sulphate ,, ,,	6·02
Carbonate ,, ,,	43·21
Carbonate magnesium and loss	1·42
	100·00

ANIMALS.

Of the animals inhabiting the island there were twenty-two, and five birds which were occasional visitors.

Five of these were insects. 1st. The common house-fly, which is found on all islands that are or have been inhabited, but not on uninhabited ones. 2. A small blow-fly. 3. A minute red ant. 4. A beetle, a species of dermestes. 5. A large moth, which was sometimes very rare, but after continued rain became very abundant, the whole island being covered with caterpillars. All the birds had also one or more species of parasites living on them.

There were two species of lizards; a bright-coloured one, about 6 inches long, rejoicing in the sunshine, and a dull-coloured geko, much shorter, living in dark corners.

Of quadrupeds there was only one example, a small species of rat, which was more than sufficiently numerous.

Of the birds, the five occasional visitors were—a small petrel; a dark grey duck ; a bird somewhat like a kestrel hawk, which lived on lizards; a snipe or sandpiper, and curlew. The two last were almost always on the island, either on the edge of the reef or near the small lagoons, but they did not breed there.

Of the fourteen birds that breed on the island there were three species of prians, slate-coloured, pure white, and black. Three súlus or boobies, white, black, and grey. Three puffinas or mutton birds. One crow. Two terns, or wide-awakes. The tropic bird, phaeton, and the frigate bird, *Tachepetes aquilis.* Of these birds the only one which built a nest was the grey booby, which it did either on the branches of trees or on the low marshy lands near the small lagoons, where the nests by successive additions formed small cones about 18 inches high. The frigate bird seemed at times to have a vague idea that a nest would be an improvement, and collected half a dozen twigs, but then turned tired of it and laid on the ground. The boobies frequently lay two eggs and sit on them, but I never saw more than one young one; all the other birds lay one only. The mutton birds in holes dug in soft ground or between rocks, and there the tropic bird also rears her black and white young one.

The prians lay on the edge of a rock or stone, and the egg being of exactly the same colour is only seen with difficulty; they are quickly hatched, and in ten days the young have flown.

The most numerous birds are the black wide-awake and the frigate bird, and it is to them that the deposits of guano on the island are principally due.

The wide-awake lays on the sloping bank twice a year, in October and April, under the shelter of plants of portulaca. In the end of September the flock begins to collect, flying high in the air above the spot where they intend to lay, a constant stream of birds flying to and fro between the flock and the sea. Day by day the immense flock flies lower and lower, till about the 22nd or 23rd of October they are skimming closely along the ground; up to this time there are no eggs to be found, even up to 3 o'clock of that day. The flock then evidently diminishes in number—the birds are down, an event which was looked forward to with some anxiety, and by 4 o'clock there is an egg to every square foot of surface. On my first arrival on the island the flock would in this way cover 5 acres of ground, but in 2½ years the number had been reduced to one-fifth, principally in consequence of cats which had run wild and increased with extraordinary rapidity. The bird seems only to lay one egg and hatch it, but if that is taken away, in a few days another is laid in the same place, unless the flock has been too much disturbed, when they desert all the eggs and remove to some other place and then lay again. The young ones begin to be hatched in fifteen or sixteen days and remain nearly three months on the ground, being fed by the parents principally on squid and small flying-fish.

The frigate birds lay principally on the level ground where the portulaca grows short, and they remain nearly constantly at the same spot whether laying or not. They lay in December and June one large white egg remarkable for the very small size of the yolk. Compared with a fowl's egg, I find the yolk of this bird to weigh 280 grs., the white 850 grs., whilst in the fowl's egg the yolk weighed 263 grs., the albumen 424 grs., the proportions being 1 : 3 and 1 : 1·6. At the breeding time the cocks have large scarlet pouches under their necks, which they inflate when roosting. These are about 5 inches in diameter, and to see an acre or two covered with birds, every alternate one with his pouch inflated, and contrasted with his glossy black feathers, forms a fine sight; when flying they usually allow the pouch to collapse. These birds are the terror of all others; the boobies coming home laden with fish are pursued remorselessly by them as long as they remain in the air, and sometimes taken by the wing or tail and turned upside down to make them disgorge part of their booty, which the frigate bird generally catches dexterously before it reaches the water or ground. The young of the other birds also frequently fall a prey to them when left unguarded whilst still small enough to be swallowed, and if a flock of frigate birds having callow young are disturbed, the birds in the air swoop down on one another's young, which they carry up into the air, let them drop a few yards, and again catch and swallow them. If a flock of wide-awakes has settled near a clump of trees about the time of hatching, the frigate birds roost on the branches looking out for any chicks that may be left for a moment unprotected. This bird never seems to sit on the ground except when hatching, always roosting on a twig or stone, where they remain for hours together preening themselves with their eyes shut. Immediately on the appearance of a shower of rain they soar high into the air into the shower, and frequently follow a small rain-cloud for many miles.

The puffinas are remarkable for the extreme regularity of their movements, starting at 4 a.m. for their fishing grounds with the greatest punctuality. Before that time all is quiet, when almost to a minute the air is filled with their cries, and by daybreak or shortly after they have disappeared. At 4 p.m. they begin to return and sport noisily in the air till sunset, when they retire to their holes.

The flesh of most of these birds is strong-tasted, but the pectoral muscles of the frigate and tropic birds which are never fat are very good if cooked separate from the bones, whilst the eggs of the wide-awake are excellent.

The signs of previous habitation were sufficiently numerous. There were three mareas built of coral rock slabs set on edge and filled in with loose blocks and shingle to a level surface about 2 feet above the level of the ground. One of them was about

30 feet by 12, and was surrounded at a distance of a few yards by lines of coral slabs set in the ground, about 6 inches projecting above the surface.

There were numerous kitchen heaps composed of ashes and ignited stones, which are used in the Kanaka mode of cooking. Many of these were of large size, and judging from the insignificance of the similar heaps produced by the Kanakas employed on the island must have been the accumulation of many generations, so that it seems probable that the island was inhabited by a few families for a long period. Near the kitchen heaps in several places were wells (seven in all) sunk to a depth of 2½ feet, and carefully faced with coral slabs, but I never saw any water in them, and on sinking one a foot deeper salt-water only was obtained. It was evident that fresh water had always been very scarce, as everywhere that a small hollow occurred in the rocks which would collect and retain rain-water, it was covered by one or more slabs of coral to protect the water from the sun. These hollows had in most cases become filled with guano dust, and on clearing this out I generally found the belly whorl of a cassis or dolium which had been kept there as a drinking vessel.

Opposite all the kitchen heaps along the north and south banks, and at some intermediate places, the ridges had been levelled to form pathways to the reef, and flat slabs had been laid down forming a line of stepping-stones. The cutting and stepping-stones extended over the six inner ridges, whilst the three outer ones were invariably as formed by the waves, forming a record at present unreadable of the desertion of the island.

In one spot there was a rude attempt at architecture, several coral slabs being set on edge and covered by other slabs laid horizontally, forming two dens about 4 feet cube, with entrances 18 inches wide. There had apparently been others at the same place which had fallen into disrepair.

There were numerous graves surrounded by upright coral slabs. I opened several of these, but was not successful in finding any remains in them; but another gentleman was more successful, the first grave he opened yielding a skull and tibia of a man who from the length of this bone must have been nearly 6 feet high. In the same grave were a hatchet-head with polished edge made from the shell of a tridacna; two chisel-like tools formed of the outer lip of cassis polished to an edge at one end; and a neck-pendant from the inner lip of the same shell well cut to an acuminate ovate form, and bored at the wide end for suspension by a cord. In many places there were numerous axe-heads chipped roughly out of tridacna shells. These are tolerably easily made, the shell being first broken transversely, when a blow on the fractured surface breaks out from the interior of the shell an adze-shaped piece which seems to me to be the pattern on which many of the South Sea stone adzes are formed.

The Guano and other Phosphatic Deposits occurring on Malden Island.

By W. A. Dixon, F.C.S.

[*Read before the Royal Society of N.S.W., 3 October*, 1877.]

The guano deposits on Malden Island are entirely phosphatic, and occur either on the spot where deposited by the birds, or in crevices and pockets amongst the rocks, where it seems to have been washed by water or blown by the wind, or possibly it may have been there deposited anterior to the occupation of the island by natives. The former deposits are of comparatively small extent, but are very rich in phosphoric acid, whilst the latter are very extensive, but vary much in value—much of it being too poor to bear the cost of removal.

Having left the island rather hurriedly, owing to a severe illness, I unfortunately lost a note-book containing analyses of the different deposits, phosphatic minerals, plant-ashes, &c., and have therefore to fall back on some analyses in a rough note-book, made by an expeditious method, for the purpose of ascertaining what deposits were worth working. After ignition to expel organic matter and water, the process used was, to dissolve the ash in a minimum of hydrochloric acid, precipitate tricalcic phosphate by ammonia, re-dissolve the washed precipitate, and after addition of a small quantity of tartaric acid, re-precipitate with ammonia and weigh as tricalcic phosphate—the ash being tested to ensure the absence of carbonate. This process, though not absolutely accurate, gives much better results than it is usually credited with, when fluorine and soluble silica are absent and the quantity of alumina and ferric oxide present are small.* The first were never found in any of these deposits, and the last two together never amounted to more than 0·25 per cent.†

The following analyses show the general composition of the recent guanos by this method :—

Recent Guano—Wide-awake (Tern).

Water and organic matter	10·41	14·10
Calcium phosphate	72·49	79·21
,, carbonate	9·32	4·19
,, sulphate	5·82	2·17
Magnesium carbonate, alkalies, sand, and loss	1·96	·33
	100·00	100·00

* See H. Pellet, Bull. Soc. Chim. [2] xvii, 105; and Chem. Soc. Jour. [2] xvi, 578.

† See also Fettbogen, Chem. Soc., Jour. [2] x, 1,112; and Voelker, Jour. Roy. Agri. Soc. [2] xii, 440.

Frigate Bird (*Tachepetes*) Guano (recent).

Water and organic matter	11·41	9·75
Calcium phosphate	84·34	81·91
,, carbonate	3·12	7·01
,, sulphate	·79	·98
Magnesium carbonate, alkalies, sand, and loss	·34	·35
	100·00	100·00

The organic matter present consisted principally of roots of plants, and yielded very small quantities of nitrogen. The removal of the nitrogenous organic matter appears, on this island at all events, to be principally due to the action of the heat of the sun, and not to rain, which is the cause usually assigned. Whilst the birds were on the ground, there was a considerable evolution of ammonia; but this disappeared entirely before they again laid, there being an interval of three months during which the ground was unoccupied. This occurred during my residence on the island—once when there was no rain in the interval, once when 0·263 inches fell in six showers, and once when 0·812 inches fell in seven showers—the heaviest being 0·4 inches, which fell about two or three days after the birds left the ground, and in each case the nitrogenous matter had disappeared before they returned. The guano seems not to be deposited fast enough for the recent upper layers to protect the lower.

The guanos deposited by the mutton birds (puffinas) was always poor in phosphates, as they principally inhabited ground where dust—composed of carbonate and sulphate of calcium, deposited by the evaporation of the water of the lagoon—is deposited by the wind. By their continual burrowing they also bring up to the surface portions of the same substance, which has been deposited before they took possession of the ground. The following shows the composition of some of this guano:—

Water and organic matter	21·66	26·24	26·31
Phosphate of calcium	40·90	54·36	55·74
Insoluble	...	...	·21

The old guano is found on the low ground, a little inside the encircling ridge, and the surface is about 3 feet above water level. The deposits are nearly level on the surface, but, on digging, projecting rocks are laid bare which enclose pockets of guano. The immediate surface is never of any value, being largely contaminated with calcium carbonate; and the richness in phosphates increases with the depth. When the pockets did not extend down to the water level, the bottom was lined with an indurated guano very rich in phosphates (crust guano of Voelker, *loc. cit.*) Of this I have recently obtained a specimen, of which the following is an analysis, the phosphoric acid being separated by Rose's method :—

Water	2·60
Organic matter and combined water	6·45
Phosphoric acid	43·04
Sulphuric acid	·62
Carbonic acid	(Traces)
Lime	43·45
Magnesia	3·97
Ferric oxide and alumina	(Traces)
	100·13

In this (as in most other analyses that I have made of the same material) both calcium and magnesium phosphates are present.

Where the pockets descended below the water level, on the other hand, when this was attained the material altered in appearance, from being a soft yellow-brown powder (when removed and allowed to dry) to hard grains of a chocolate-brown colour, whilst the rocks were found incrusted with a hard chocolate-brown substance interspersed with minute white specks. This incrustation from being very thin a foot above the water level, gradually increased to a thickness of five or six inches when that level was attained, whilst the coral rock beneath it was often completely disintegrated—so much so that on removing the crust it formed a milky mixture with the water. This incrustation was principally composed of calcic phosphate, magnesium phosphate being absent. It gave a slight effervescence with acid, which apparently arose entirely from the white specks. Its fracture was slightly choncoidal, it gave a yellow-brown powder, and was very hard.

The following numbers show the composition of the different layers from the surface downwards—the material being taken as dug out—so that they contain all the water, of which from 14 per cent. to 16 per cent. dried out on exposure to the air. The fields from which the different samples were obtained were about three-quarters of a mile apart :—

		1st Field.	2nd Field.
Top 6 inches of guano.	Loss on ignition	24·31	23·51
	Calcic phosphate	28·67	34·24
From 6 inches down to water-level	Loss on ignition	26·24	16·80
	Calcic phosphate	54·36	63·10
Shotty phosphate to 18 inches below W. L.	Loss on ignition	24·70	23·61
	Calcic phosphate	71·85	72·53
Incrusting stone phosphate	Loss on ignition	8·25	6.31
	Calcic phosphate	86·05	87·59

Deducting from each of these the percentage of volatile matter, to make the increase more evident, the residues would contain of calcic phosphate—

Top 6 inches	37·8 ...	44·7
From 6 inches to water level	73·5 ...	74·6
From water level to 18 inches below ...	95·2 ...	94·9
Stone phosphate	93·7 ...	93·4

I have lately tried to discover the mode of formation of the stone phosphate, but without any very satisfactory result. Tricalcic phosphate in solution in water saturated with carbonic acid, I find, does not deposit any by prolonged contact with calcium carbonate, and this result is not altered by the presence of any of the salts present in sea-water; neither does a cold saturated solution of magnesium phosphate charged with carbonic acid, shaken up with precipitated tricalcic phosphate and the clear solution digested with calcium carbonate, deposit any phosphoric acid, although in all cases calcium carbonate was found in solution. A mixture of tricalcic phosphate and dimagnesic phosphate, both in excess, treated with carbonic acid, and the filtered solution digested with calcium carbonate, the carbonic acid not being allowed to escape, deposits traces of both magnesia and phosphoric acid, but in no case did the phosphoric acid deposited amount to more than 2 per cent. of that contained in solution.

It seems probable, however, that they are formed by the action of sea-water on an indurated guano, the sulphate of calcium converting the magnesic phosphate into calcic phosphate, whilst the carbonic acid generated by the slow decomposition of organic matter removes calcium carbonate in solution.

In most places where the natural coral rock projected above the surface, it was covered by a pale bluish grey coating or skin, which although extremely thin was perfectly impervious to water, so that rain collecting in any hollows remained there until evaporated; but if this skin was broken through at the bottom of a hollow, the water rapidly percolated away. This coating was in some places hard enough to strike fire with the point of a pick; it did not effervesce with acids, and was apparently entirely composed of calcic phosphate.

Amongst the recent guano deposits any loose stones were found to be similarly incrusted with calcium phosphate, which had in many cases penetrated the stone to a considerable depth, sometimes entirely so. They were found on the surface of the guano, and not buried amongst it. Several of these stones ground up together gave the result No. 1, whilst a single stone which did not effervesce on the surface, and was sonorous when struck, gave No. 2.

	No. 1.	No. 2.
Loss on ignition	15·25	12·00
Calcium phosphate	48·50	71·15.

It is evident that the general incrustation on the surface of the rocks and on these stones was formed by the direct action of the excrement of the birds, the stones being in fact pseudomorphs, as there were abundance of similar pieces of coral shingle elsewhere, the only difference in appearance being in their colour.

Discussion.

Mr. Russell asked Mr. Dixon if he thought the inhabitants had been driven away by some great drought. It had been stated with regard to another island that there had been no rain on the island for years, but that while the crew of a vessel were there, to their utter surprise it came on to rain for three months, and the island became covered with grasses.

Mr. Dixon said that four years before the year 1866 there was abundance of rain, and one man said the whole place was like a meadow—that was in 1862. Some, however, thought that nonsense. In 1863, 1864, 1865, 1866, 1867, and 1868, there was no sign of any such thing, but in 1869 there was abundance of rain, and the place was like a meadow.

Mr. Russell: And you saw it?

Mr. Dixon: Yes. Only one man had seen the previous wet season; the others said there was never any rain at all; but I believed what was said, that there was sometimes rain, and I built a tank, and it was filled with one night's rain. I believe, however, that they have now again got into a rainy season; and when a rainy season sets in, the place is very unhealthy. It strikes me that as cats and pigs can live on the island without water, perhaps the Kanakas can also. We turned out some pigs and goats, and they wandered about the island for eleven or twelve months and lived without water. Some of the cats ran wild. The rats got so numerous that we used to kill them in thousands; in the store we killed some twenty thousand in two months.

A member said, if they were to dig down a few inches, could they get water?

Mr. Dixon said they never found any fresh water in the Kanakas' wells. The nearest inhabited island is distant about 300 miles.

Mr. Moore said the existence of the species of plants described indicated long periods of drought, but the existence of grasses seemed to be extraordinary: it proved that the seeds must retain their vitality for a long period. It was very singular that the grasses should spring up so rapidly and cover the surface.

Mr. Dixon: The place was smooth and level, like a floor; it was quite salt on the surface, and yet the seeds germinated.

Mr. Moore: There are many grasses that grow absolutely in salt water.

The Chairman: Is all the guano removed?

Mr. Dixon: No. They still keep removing it. The deposits are very uncertain and scattered.

The Chairman conveyed the thanks of the meeting to Mr. Dixon for his interesting papers.

On some Australian Tertiary Corals.

By the Rev. J. E. Tenison-Woods, F.G.S.; Hon. Mem. R.S. N.S.W., Tasmania, Adelaide Phil. Soc.; Corr. Memb. R.S. Victoria, Linn. Soc. N.S.W., &c., &c.

[*Read before the Royal Society of N.S.W., 7 November, 1877.*]

The subject of the Australian fossil corals has occupied much attention among geologists of late years. Deep-sea dredging has brought them into prominent notice, for not only have several missing links of past palæontological history been thus discovered, but our fossils have been found to possess remarkable features of their own and remarkable affinities with fossils in remote places. It was in 1865 that attention was first drawn to them by Prof. Duncan, at present holding the honorable position of President of the Royal Geological Society of London. In the year referred to he published in the *Annals of Nat. History* the results of his examination of a small parcel of corals sent by me to him, from the tertiary beds of Muddy Creek in Western Victoria. It was supposed at the time that some of them came from Mount Gambier, but this was not the case. The Mount Gambier limestones are singularly destitute of corals, though they are wonderfully rich in Polyzoa. They all came from the bed of argillaceous limestone which underlies the basalts at Muddy Creek about 5 miles from Hamilton in Western Victoria. The result of Prof. Duncan's examination was that seven or eight new species were added to science, all of which possessed features of singular interest, with the usual array of Australian "*abnormalities*" as they are called. The relations were mostly with Miocene forms, and the living species among them were Australian but tropical. Prof. Duncan's researches were followed up by a very elaborate monograph in the *Proc. of the Geological Society of London* for 1870, in which he not only gave a complete review of all the species known to him and several new ones which he added, but he exhaustively dealt with their affinities and entered largely into the whole question of Australian Tertiary geology. By this means we became acquainted with many new species and two new genera, including *Flabellum*, *Placotrochus*, *Sphenotrochus*, *Conotrochus*, *Trochocyathus*, *Deltocyathus*, *Caryophyllia*, *Palæoseris*, *Amphehelia*, and *Balanophyllia*. Subsequently I was enabled to examine the fossils of Table Cape, Tasmania, a parcel of corals from which yielded many of the Australian forms, and Prof. Duncan was enabled to add two entirely new species of genera not hitherto found, namely, *Dendrophyllia* and *Thamnastræa*. What gave especial interest to these forms were, that they were reef-builders, whereas all the other species described were small pedicellate solitary corals (with the exception of *Amphihelia*) living at moderate depths at the bottom of the ocean.

Up to this time I have always been enabled to send to the learned Professor Duncan all my collections in this particular department, and here am glad to acknowledge with what courtesy and painstaking industry he has always addressed himself to their examination. I regret that I am not now able to avail myself of his aid. But latterly I have found in various public and private museums specimens which I am unable to send away for determination, and therefore am obliged, though fully aware of my own deficiencies for such a task, to undertake their investigation and description. I think it due to science to state that I feel my insufficiency, and the great help I shall receive from what my predecessor in this matter has done, without which I would not undertake it at all.

I must here state, for the information of my readers in Australia, that this branch of Natural History, the Corals, has been very carefully worked out of late years. The great standard authority of the subject is the *Hist. Nat. des Corallaires, by Milne Edwards and Jules Haime* (3 vols. 8vo., with atlas), but the student must also receive large help from the various elaborate essays in the *Annales des Sciences Naturelles* (from 1848 upwards) by the same authors, and their monograph in the publications of the Palæontographical Society on British Fossil Corals. There is also a most complete treatise on the stony corals, by Prof. Duncan, in a late number of same Society's Monographs, which contains drawings and definitions of the various organs and terms in use. These leave but little to be desired, and with the aid of them determination of genera and species becomes a comparatively easy task. The literature of the Corals is very rich, including as it does the valuable researches of Peyssonel, Pallas, Savigny, Lamarck, and Lamouroux, and our own countryman Ellis, whose work (*Essay towards a Natural History of Corallines, London*, 1754) may still be consulted with advantage. I am glad to add that there are copies of these rare volumes in the Museum Library and in that of Mr. Macleay. It was not however until 1828 that any attempt at classification was made, founded upon the anatomy. This was commenced by Messrs. Milne Edwards and Audouin. They were the first to separate from the corals proper the more highly organized polyzoa and the much lower class of sponges. M. Curier about the same time showed the close relation between the actinæ or jelly-fish and the corals. Of late years, a great development has been given to all previous investigations by the labours of the eminent American naturalist Dana, whose work on the Zoophytes of Wilkes's United States Exploring Expeditions (1*vol. 4to., Philadelphia*, 1846; *atlas fol.*, 1849) forms an epoch in the science. It may be as well to mention, for the information of students, that many important extracts from this work are given in *Silliman's American Journal of Sciences.*

My object in referring to the history of the classification of this order, is for the purpose of pointing out the modifications which an extended knowledge of Australian corals is likely to introduce. The complete work of Messrs. M. Edwards and Haime forms now the basis of the received systems in arranging the genera and families of corals; and though it is really a wonderful monument to the industry and sagacity—I may add genius—of the authors, yet I think most naturalists feel how artificial and arbitrary the system is. This must be the case with all systems, and in the corals, where we have so little to go upon—so few features upon which to erect generic and specific differences—it must be always felt. The difficulty that occurs to me is in determining the presence or absence of organs upon which generic distinctions are made to rest. Thus, in the *Turbinolidæ*, we have sub-family distinctions built on the presence or absence of pali, and this again made of generic value by their number, the presence or absence of a columella, its form, the costæ, &c. In the next group we have the first great divisions made upon the presence or absence of an epitheca, then comes the form of the columella, the adherence, &c. Now, in some of these particulars the Tertiary corals of Australia, and some of the recent forms which I am describing, unite the characters of two or three genera (*Conosmilia* &c.), or show gradations in structure which make the line of divisions exceedingly difficult to draw. Then again, we find peculiarities of structure which belong to a certain genus, though not essentially forming a basis for classification, reappearing in other genera which are remote in our present system. Take, for instance, the costal features. In the *Turbinolidæ* we find a very peculiar structure in five or six species. There are only three cycles of septa, while on the outside there is a very regular development of costæ, exactly like modified septa, only that there is one cycle more than the septa of the calice, and consequently we have a rib or septum on the outside without any septum on the inside to correspond with it. This will appear the more extraordinary if we call to mind what is the doctrine with regard to the costæ, and I must be pardoned for making an extract from Messrs M. E. and H.'s work (*Nat. Hist. des Cor.*, vol. 1, p. 58). "The *wall* not only gives origin to centripetal prolongations which we call septa, but bears also in most cases projections or laminæ analogous to the septa, which develop themselves in a contrary direction, and which we call costæ. These parts are susceptible of the same modifications as the septa, and are in fact only the exterior continuation of them, which is easily seen by examining the *Turbinolidæ*, *Phyllangia americana*, *Heliastræa Forskaliana*, and many other corals simple and compound. All that has been said of the septa, therefore, is true of the costæ as to their relative positions and modes of multiplication. Nevertheless, in certain rare cases, *Stephanophyllia* and *Micrabacia*, the costæ alternate with the external edge of the septa as if the two leaves which compose the edge of these were divided exteriorly from one another to unite with the external leaf of the neighbouring septum. On the other hand, in *Dasmia* one single rib corresponds with three septa. But these facts are exceptional, and nearly always the costæ are only distinguishable from the septa by their position outside the wall."

Now in our Australian corals we find that a very large proportion form an exception to this rule. The costæ do not correspond with the septa, but exceed them in number. If this took place in one genus alone, as it does in *Turbinolidæ*, we might not wonder so much, but it appears in remote genera. Thus we have this feature manifested in a marked manner in our living *Conocyathus sulcatus*, and, as I shall show in a species now to be described, it occurs in another species, and in a *Ceratotrochus*. In this case it seems as if the coral animal had its support on the outside. The existence of the septa is intimately connected with tentacles of the animal, and their number coincides exactly with those appendages. It is not known, or has it I believe been studied, what relation the costæ bear to the living animal. Fortunately there is one form yet surviving where the peculiar structure to which I refer can be seen, and naturalists of Sydney may make it well worth their while to ascertain the anatomical structure of *Conocyathus sulcatus*, which is so common at the mouth of the harbour.

I cannot however help raising the question as to the importance of the costæ in the matter of classification. It seems to me that where costæ predominate over the cycla, that in itself is a natural feature in the *Turbinolidæ* which should override minor details of the columella and so forth. We should thus group together corals whose living habits would probably be found to correspond, and we should not see, as we do now, corals which are closely united in one conspicuous feature distributed through three or four different genera. Distinctions founded on the columella and pali are most unsatisfactory: in very many cases it is impossible to distinguish between pali and a fasciculate columella; in others it depends much upon our fancy whether we describe the coral as without pali but with deeply lobed septa, or with pali attached to the septa. I make these remarks with the utmost diffidence, and not attempting to cause any confusion by creating new divisions, only let it be borne in mind that they are of importance, when we remember how badly preserved and how worn fossils often are from which new species and genera are created. A little wearing down may make a world of difference, when the classification rests on slight details. This department of Natural History still awaits its Linnæus to found a system that all would accept. We have not it is true those definite organs with ascertained functions that botanists possess, and probably we shall not have until the living animals are better understood. For most of our corals we must resign all hope of any further study than that which the stony portion will furnish, as the majority have flourished as past beauties of the earth's history, and are only known now as fossils. But light, and much light will come from those which still live, and probably for this we must wait. In the meantime I have drawn attention to these points, that abler and more learned naturalists may follow up.

I now proceed to describe the new species which I have to bring under the notice of the Society. They are all from Muddy Creek, near Hamilton, Western Victoria. I made a visit to that locality in December of last year, but was unfortunately taken ill while at the hospitable station of Mr. S. P. Winter of the Wannon, and so was obliged to content myself with two small boxes of clay from the edge of the creek which Mr. Winter's brother brought to me. These have been most industriously searched and sorted by Mr. Ramsay, the learned and zealous Curator of the Museum, and they have yielded many novelties. The corals were few, except the well known so called *Caryophyllia viola*, Duncan, which was very abundant, and which with a few specimens of a new species were the only *Caryophyllaceæ* present. The other genera were *Conocyathus*, *Sphenotrochus*, *Smilotrochus*, and *Conosmilia*, all of new and remarkable forms. I have been obliged to place in another genus, Prof. Duncan's *Caryophyllia*, and some other species since discovered, for reasons which will appear.

MADREPORARIA APOROSA. *Fam.* TURBINOLIDÆ.

Genus CERATOTROCHUS. *Edw. & Haime*, 1848.

Corallum, simple, free in adult state. Columella highly developed and fascicular; septa large and exsert; wall without any epitheca, presenting costæ which are distinct to the base, the principal being ornamented. Fossil only and tertiary—Miocene of Italy, Pliocene of Tuscany, Eocene of India. This genus was erected for species, all of which are highly ornamented with spines and crests, which is imperfectly represented in a worn specimen of doubtful character, the diagnosis of which I reserve for examples in better preservation.

Genus Conocyathus. *D'Orb.*, 1849.

Corallum, simple, trochoid, straight, free, without trace of adherence, septa exsert, very granular, costæ prominent, no columella, pali before penultimate cycle.

We have only had one fossil species of this genus in the Miocene of Europe, but which has lately been found living at Port Jackson. I believe it to be distinct, and this opinion is strengthened by the curious discovery of two other species in our Miocene deposits.

Conocyathus cyclocostatus, n. s.—Corallum, cuneiform, very much compressed at the base, which is roundly or bluntly pointed and without trace of adherence. Costæ numerous, forming four cycla closely set, rounded but scarcely projecting, and without trace of ornament, the secondary ones beginning at the base and being with the first thicker at their origin, becoming thin higher up. Tertiary costæ begin also a short distance from the base, but those of the fourth order at about a third, and the fifth near the edge of the calice; intercostal spaces narrower than the costæ, not deep, and between the higher orders furnished with a single series of faint pits, calice broadly elliptical. There is no calicular fossa, as the six stout pali unite in the centre at the summit of the corallum; septa in six systems of three cycla, all equal, exsert, reaching to the pali but slightly united with them; the primaries very flexuous at the inner edge and all highly granular; pali very conspicuous, forming six very flexuous large irregular rounded lobes. There are no septa to correspond with the fourth cycle of costæ, but the wall bends outward from each septum so as to form the rib. In very young specimens the first order of the fourth cycle of costæ is not visible, in which case the wall bends outwards the fourth. Alt., 6; maj. axis of calice, 3; min., 2 millim. Not very common.

Conocyathus fenestratus. n. s. Corallum, conical, the transverse section being perfectly circular. Costæ in three cycla, primaries undivided to the base, prominent, very granular and subspinous; second and third orders dividing near the base, intercostal spaces deep, marked with a regular series of deep pits, by transverse processes from the costæ sometimes reaching from side to side; septa in two cycla of six systems, exsert granular, primary and secondary equal, two only continuous with the exterior costæ, pali small, papillary, inconspicuous. Alt. 7, min.; 3 millim. Very rare.

Genus Placotrochus. *Ed. & Haime*, 1848.

Corallum, simple, free, but often with traces of adherence, straight and compressed, calice elliptical, with a straight lamellar columella, crenulate, extended in the direction of the major axis; septa very slightly exsert, either smooth, papillose, or granulous, costæ covered with a thin pellicular epitheca.

PLACOTROCHUS ELEGANS.—Corallum, minute, broadly wedge-shaped, laterally compressed, elliptical, major axis of summit not much exceeding the base, while the minor is nearly equal throughout; base convex, with a salient angle almost tubercular at each side; sides regularly convex, white, smooth, and shining; costæ corresponding to the septa; the primaries and secondaries of equal width, broad and smooth, ending in a broad point at the calice and continuing to the base, only slightly narrowing; tertiaries inserted between, arising about a third from the base, narrow and ending in a point, giving the calicular margin a regularly serrated edge with large and small teeth alternating. Calicular fossa narrow and deep; septa of three cycla in six systems, slightly exsert, very granular, primaries and secondaries equal, with a tortuous entire edge which stops short two-thirds from the centre, leaving a deep fossa in which the thin straight columella is very conspicuous, though it does not rise to the level of the septa. Alt., 3; maj. axis, 3, min., $1\frac{1}{2}$; diam. of base, 2 millim. Rare. (*Plate I, fig.* 1 *and fig.* 1*a.*)

Genus SPHENOTROCHUS. *Mil. Ed. & H.*, 1848.

Corallum, simple, free, without trace of adherence, straight, and cuneiform; columella and septa like *Placotrochus; no epitheca;* costæ generally distinct and simple, granular, or crisped.

SPHENOTROCHUS VARIOLARIS, N.S. Corallum, wedge-shaped, short, very much compressed inferiorly, and the base has two obtusely angled shallow notches dividing it into three equal parts. The section of the summit is elliptical, the major axis being more than twice the diameter of the minor. There are no costæ, but instead the whole surface has a finely spongy texture of irregular papillæ and pores. The calice is deep, and lower at both ends. Septa in six systems of three cycla, the primaries and secondaries smaller than the tertiaries and the systems at the ends incomplete. Columella finely laminar and very distinct; the primaries and some of the secondaries uniting with it simply. All the laminæ granular, and the granules arranged at the exsert rounded edges of the primaries, in radiating lines. Alt., 9; maj. axis, 7; min., 3. Not very common.

This fossil derives special interest from the fact that it still exists on the east coast, some fine specimens having been dredged by Mr. Macleay off Port Stephens at a depth of 70 fathoms. M. Milne Edwards remarks that the Sphenotrochi whose costæ are crisped or papillary are peculiar to the Eocene formation, while of the species which have smooth costæ one belongs to the present period, three to the Miocene, and only one in the older beds. This species has the costæ distinct and papillary in the young state, but as it gets older the papillæ get worn off, and become pitted, depressed, or like worm-eaten holes. (*Plate II, fig.* 4.)

The alliances of this species are therefore Eocene or older tertiary, and had it not been found living would have tended to swell the evidence in favour of the greater age of the deposits to which it belongs,—a kind of evidence, however, which this instance shows must be received with great caution, and not at best possessing much weight.

Sphenotrochus variolaris is remotely allied to *S. australis*, Dunc., of Muddy Creek and Geelong, but differing in the absence of costæ and the form of the base. The arrangement of the septa is near to *S. australis*, in very many peculiarities, but the base is very different. The costæ and twelve of the septa unite with the columella, but in *S. variolaris* only ten. In the young specimens the exterior is quite covered with fine papillary projections, and there is no laminary columella, but only a loose reticulated mass. From this we must conclude that the columella is not essential or does not rise from the base.

Genus SMILOTROCHUS. Milne Edward and Haime, 1851. Corallum, simple, straight, cuneiform, free and without a trace of adherence. No columella, septa finely granular, slightly exsert and touching by their inner edge. Wall naked, with simple costæ distinct to the base. (*Plate II, fig.* 2 *and fig.* 2*a.*)

All the specimens known to Edwd. and H. belong to the Cretaceous formation; and the discovery of the present form, though slightly aberrant from the type, is one more link which binds our tertiary beds to the upper secondary of Europe. The differences in this species are, that the internal edges of the septa are not united, and there are fewer cycles than the Mesozoic forms.

SMILOTROCHUS VACUUS, N.S. Corallum, very small, spear-shaped, very much compressed at the base and finely pointed, presenting at each side of the centre an elongated swollen tuberosity which tapers off slightly above, but is produced into a very finely pointed margin at each side of the base. Costæ corresponding to the septa, fine, straight, separated at the calicular margin, becoming fainter below, disappearing about the centre, and finally reappearing at the base. Calice shallow, narrowly elliptical, rounded and depressed at the ends. Septa in six systems of four cycla, but those of the 4th and 5th orders wanting in the two central systems, granular, not much exsert, rather thick, the three first nearly equal, not united at their inner edge, and the place of the columella represented by a conspicuous central vacuity. Alt., 5; maj. axis, 3; min., 1½ millim. Very rare.

Sub. Fam. CARYOPHYLLINÆ.

1*st Group.* TROCHOCYATHACEÆ (many circles of pali).

Genus DELTOCYATHUS. *Mil. Ed. & H.*, 1848.

Corallum, simple, conical, free, no trace of adherence, calice nearly circular, and shallow, columella ending in a rounded mul-

tipartite surface. Septa straight, large, exsert, and granular, and the higher orders generally well developed. Pali highly developed, unequal, penultimate largest and turned towards antepenultimate, so as to form chevrons or deltas. Costæ *highly developed*, distinct to the base, with many granulations.

I separate these corals from *Caryophyllia* because that genus was erected for adherent simple corals with only rudimentary costæ, which were never tubercular, crested, or spinous. The Australian species identified with Caryophyllia all depart from that type, so that I consider a different genus is necessary for their reception. It will include the present species, and one to be described by me shortly in the Linn. Soc. N.S.W. Proceedings, and *Caryophyllia viola*, Duncan and Woods. It must be observed that adherence or non-adherence are held of themselves to be of generic value, and form the essential differences between *Smilotrochus* and *Desmophyllum;* the form of the base also is a distinguishing character between *Platytrochus* and *Ceratotrochus*. When Prof. Duncan described his *Caryophyllia viola* he had only very few specimens, and these, from his descriptions and from the state in which they left my hands, I conclude were worn and deprived of some of their characteristics. Since then I have paid great attention to this fossil, and have now before me twenty-six well preserved specimens, so that I am enabled to correct his diagnosis in some important respects, as will appear from the following details.

Deltocyathus viola (*Turbinolia viola*, nobis, MS., 1860; *Caryophyllia viola*, Duncan, *Ann. Nat. Hist.*, 1865). Corallum, in the form of a somewhat laterally compressed cone; the angle being about 50, and the sides very slightly convex towards the middle, and the apex obtuse. The calice is shallow and elliptical, the major and minor axis being as 7½ to 5½. The septa are somewhat delicate; the three first orders exsert and rounded, the primaries the longest, all having lateral spiny granules in radiate lines. There are four cycla in six systems; the first and second are equal in thickness, the first reaching the columella: the *second reaching about two-thirds of the way; the tertiaries, thinner and approaching one another so as to join the pali in front of the secondaries; the fourth and fifth orders are thin, with very wavy margins, and only reaching about a third of the distance from the margin.* Pali, thin rounded lobes in front of the *three first orders, and very granular. The primaries tall and thin, the tertiaries bending or inclining so as to meet or nearly* meet in front of the secondaries, which *thus exclude their pali. Secondary opposite pali often uniting in short bilobate papillæ right in the centre of the calice.* In worn specimens the pali seem like one rounded broad lobe in front of the secondaries only. Columella *thick, solid,* and ending in two or three neat rounded compact lobes. Costæ visible to the base, rounded, *straight, sharp, and roughly granular ;* in four cycla, and corresponding to the septa, primaries, and secondaries, arising from the base ; tertiaries almost immediately above ; fourth and fifth orders, a fourth of the height from the base. Intercostal grooves rather wider than costæ, and showing at the edge a very thin wall. Alt., 10 to 12 ; maj. diam., $7\frac{1}{2}$ to 9 ; min., $5\frac{1}{2}$ to 7 millim. In young specimens (alt., 4 millim) the columella is not distinguishable, and the pali are rudimentary like twisted laminæ before the first three orders. The *Italics* indicate where my diagnosis differs from Prof. Duncan's. (*Plate II, fig.* 3.)

DELTOCYATHUS EXCISUS (*Sphenotrochus excisus,* Duncan, Quart. Jour. Geol. Soc., 1870, p. 298). Corallum, somewhat large, high, cuneiform, much compressed inferiorly and narrowed, base with a curved notch, the sides being prolonged into acute short points ; summit broadly elliptical ; costæ few, broad, flat, finely granular, persistent from edge of calice to the base, and regularly alternating with the septa ; intercostal spaces regularly subspinously granular. Septa usually in six systems of three cycla, but specimens with one system aborted as in the figure not uncommon ; primaries and secondaries equal, very much exsert, and ascending in high rounded crests above the edge of the calice, covered with short, stout spines ; tertiaries projecting about half as much as the others, and reaching half way to the columella, all the septa very thick at their origin. Pali moderately broad and high, but not so high as the septa, to which they are united lower down to the 1st and 2nd cycle only. Columella, not distinguishable from the pali in the centre. Calicular fossa, shallow. Alt., 10 ; maj. axis of calice, $5\frac{1}{2}$; min. axis, 4 ; height of exsert septa above edge, 2 ; length of base, 2 millim. Common. The type specimen of this species was sent to England by me in 1864 to Prof. Duncan ; but it was unfortunately young and imperfect, and was more like a *Sphenotrochus* than a *Deltocyathus*, as there were only very faint indications of pali, and the columella was of a doubtful character. It was regarded as a *Sphenotrochus* by the learned Professor, who gave the following diagnosis—*Quart. Jour. Geol. Soc., loc. cit.* "*Sphenotrochus excisus.* The coral is much compressed, especially inferiorly, where two lateral processes give a notched or emarginate appearance to the base. Superiorly the relation of the long to the short axis is as 2 to 1. The coral is short and broad, the base is nearly as wide as the calice is long. The costæ are large and plain and are separated by well marked lines ; the costæ of the appendices are the largest, they pass upwards to the calice, and are all more or less wavy, the centre widening out near the calicular margin. The calice is shallow and elliptical. The columella is not long, and from being joined to the primary and secondary septa by processes which are rounded above is confused in appearance. The septa are in six systems of three cycles, they are wider at the wall than elsewhere and granular, and those of the third cycle are much smaller than the others. All the septa correspond to the depressions between the costæ. Alt., $\frac{1}{4}$ inch; tot., $\frac{3}{10}$ inch. Hamilton, Victoria." Prof. Duncan gives one admirable figure of the fossil, but as the specimen is young the septa and pali were not developed. I have figured an abnormal specimen with only five systems, owing to a deformity on the side of the corallum which is not shown in the figure. The septa also are more exsert in this instance than usual and the base narrower, but it is the same species. (*Plate I, fig.* 3*a*, *and plate II, fig.* 1.)

Family ASTRÆIDÆ. *Sub-family* EUSMILINÆ. *Division* TROCHOSMILIACEÆ.

Genus CONOSMILIA. *Duncan,* 1870.

Coral, simple, pedicellate, conical. Columella formed of one or more twisted laminæ which extend from the base upwards. Endotheca scantily developed. Septa apparently with simple margins, and variable in regard to the number of the primary.

This very remarkable genus was erected by Professor Duncan for some Australian Tertiary corals of very abnormal form. They are simple, with pellicular epitheca having a peculiar zigzag or "herring-bone" ornamentation, an essential twisted columella with endotheeal dissepiments and plain septa, sometimes in six and sometimes in eight systems. These irregular septal arrangements occur in some genera of the Lower Greensand and Oolitic periods. The species I have to bring under notice has only two cycles in six systems.

CONOSMILIA BICYCLA, N.S. Coral, small, curved, slightly tapering, tall, pedicellate, base half the size of calice, costæ only traceable by the faint line which separates them, "herring-bone" pattern scarcely discernible. Columella large and strong, and is formed of one twisted lamella, and does not occupy much space. Septa arising between the costæ and are in six systems of two cycla; the primary reach the columella and are attached to it by processes, and are very wavy, uneven, and of equal thickness throughout. The secondary are very small, not reaching a fourth of the distance to the columella, curved and twisted. All are sparely studded with long spiniform granules. Endotheca sparely developed. Wall very thin, calice nearly circular. Alt., 12; diam. base, $2\frac{1}{2}$; diam. calice, 3 millim. Rare.

The following is a synopsis of the species already known :—

Systems 8, cycles 3:

Pedicel large, costæ prominent and granular. *C. elegans.*

Pedicel small, costæ faint, calice elliptical. *C. anomala.*

Pedicel very small, costæ very faint-marked with prominent rings of growth. *C. lituolus.*

Systems 6, cycles 3:

Costæ very broad and flat, with wavy lines. *C. striata.*

Systems 6, cycles 2:

Costæ faint, coral curved and horn-shaped. *C. bicycla.*

The following is a list of all the known Australian Tertiary Corals corrected in accordance with the present paper:—

Conocyathus cyclocostatus. Tenison-Woods.
Conocyathus fenestratus. „
Trochocyathus meridionalis. Duncan.
„ *victoriæ.* „
Deltocyathus viola. T. Woods and Duncan.
„ *italicus.* M. Ed. and Haime.
„ *excisus.* Duncan.
Sphenotrochus variolaris. Tenison-Woods.
„ *australis.* Duncan.
Conotrochus McCoyi. „
„ *typus.* Sequenza.
Smilotrochus vacuus. Tenison-Woods.
Flabellum candeanum. M. Ed. and H.
„ *distinctum.* „
„ *victoriæ.* Duncan.
„ *gambierense.* „
„ *Duncani.* Tenison-Woods.
Placotrochus elongatus. Duncan.
„ *deltoideus.* „
Amphihelia incrustans. „
Heliastræa tasmaniensis. „
Thamnastræa sera. „
Palæoseris Woodsi. „
Cycloseris tenuis. „
Conosmilia elegans. „
„ *lituolus.* „
„ *anomala.* „
„ *striata.* „
„ *bicycla.* Tenison-Woods.
Balanophyllia campanulata. Duncan.
„ *seminuda.* „
„ *armata.* „
„ *tubuliformis.* „
„ *fragilis.* „
„ *australiensis.* „
„ *Selwyni.* „
„ *cylindrica* (variety) „
„ *Ulrichi* „
Dendrophyllia epithecata „
„ *Duncani.* Tenison-Woods.

The results of the observations contained in the foregoing paper are :—

1. That we have no *Caryophyllia* living or fossil in the Australian seas or rocks.

2. That we have three well marked and peculiar forms of *Deltocyathus*.

3. That we have two species of *Sphenotrochus*, one of which is still existing.

4. That we have two fossil analogues of our living *Conocyathus sulcatus*, which latter is supposed to be identical with a European Miocene form.

5. That we have a fossil form of the Cretaceous genus *Smilotrochus* in our Miocene rocks.

6. Also a new species of *Conosmilia* with only two cycles.

I may add also that, in a monograph I am preparing of our Australian living corals, I shall have occasion to describe two new species of *Deltocyathus*, one very similar to *D. viola*, and several species of *Paracyathus*, *Balanophyllia*, *Eupsammia*, *&c.*

Explanation of Plates.

Plate I.

Fig. 1.—*Placotrochus elegans.*
Fig. 1*a*.—Ditto, calice.
Fig. 2.—*Conocyathus cyclocostata.*
Fig. 2*a*.—Ditto, calice.
Fig. 3.—*Deltocyathus excisus.*
Fig. 3*a*.—Ditto, calice, with only five systems and distorted pali.

Plate II.

Fig. 1.—Normal calice of *Deltocyathus excisus.*
Fig. 2.—*Smilotrochus vacuus.*
Fig. 2*a*.—Ditto, calice.
Fig. 3.—Calice of *Deltocyathus viola.*
Fig. 4.—*Sphenotrochus variolaris.*
Fig. 4*a*.—Ditto, calice.
Fig. 4*b*.—Ditto, young calice.

Note.—The figure of *Conocyathus fenestratus* is unavoidably held over for a future paper.

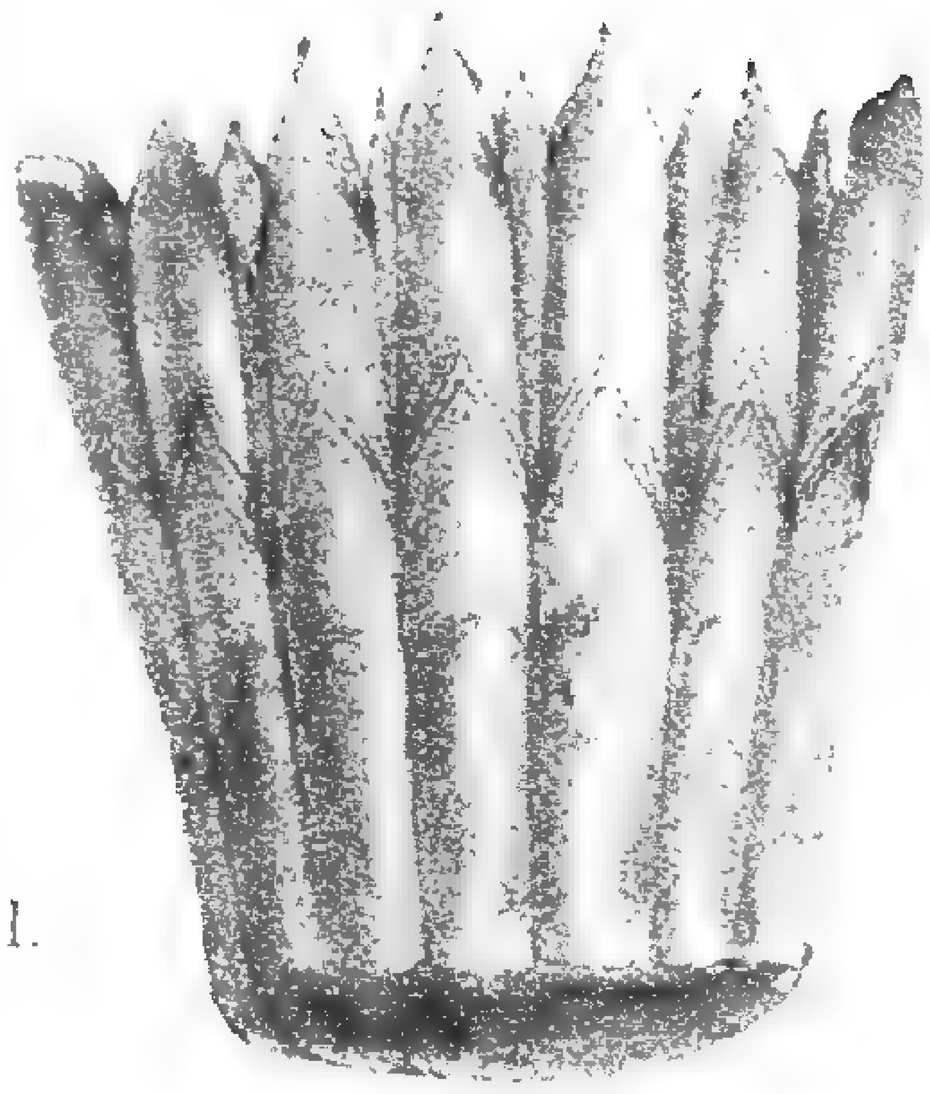

Fig. I.

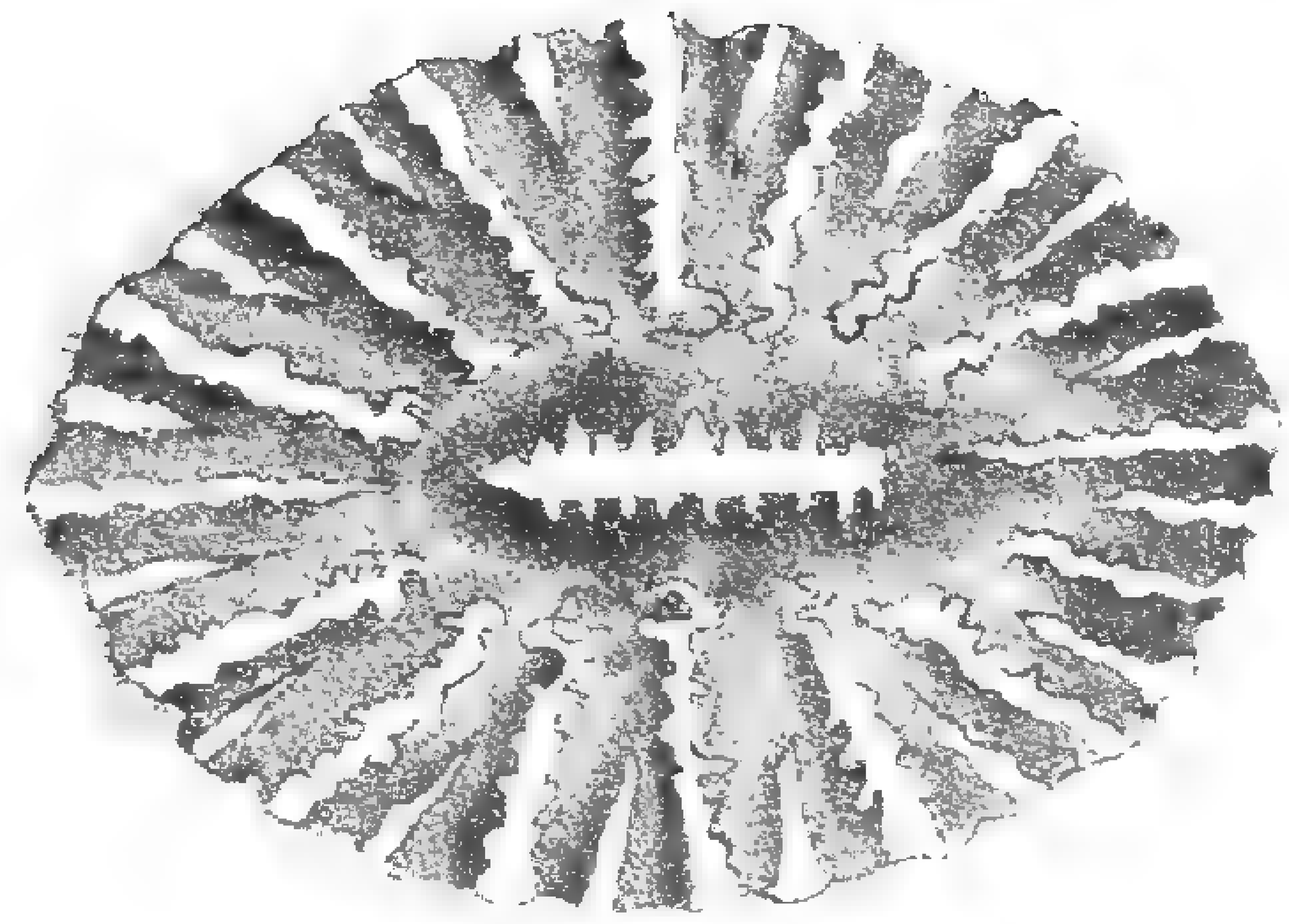

Fig. Ia

Fig. II

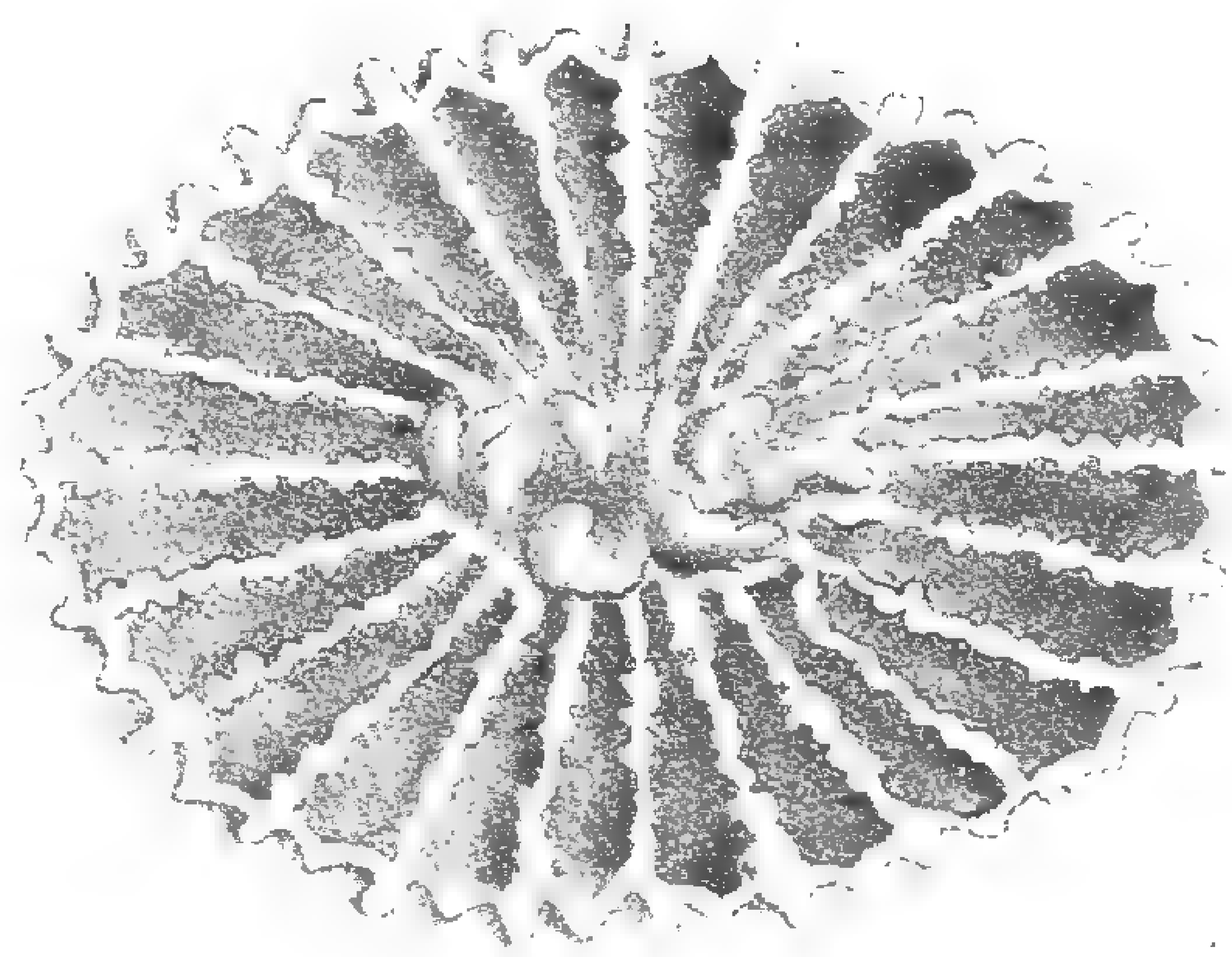

Fig. IIa.

Fig. III

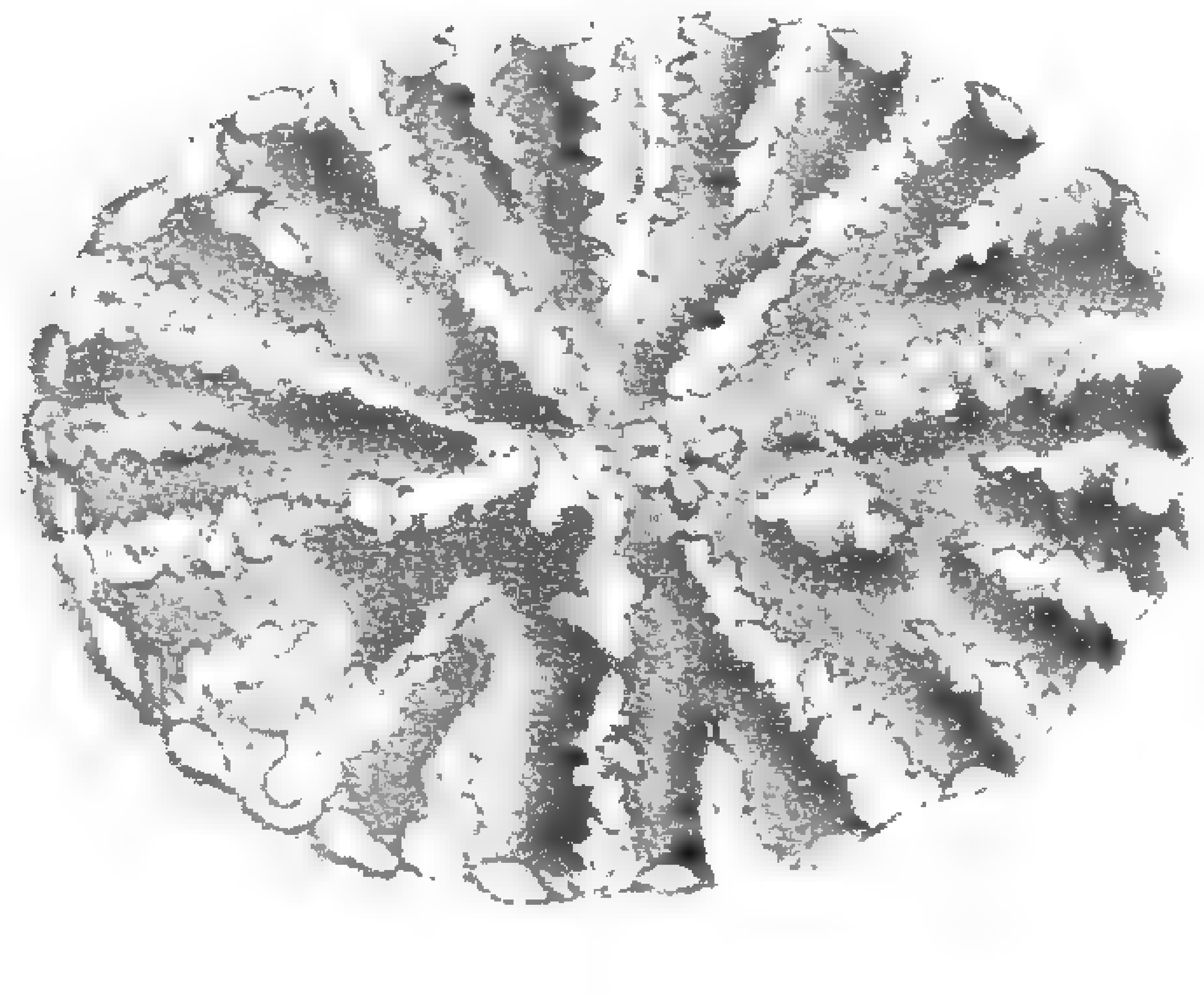

Fig. IIIa

J. E. TENISON WOODS, DELT.

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I. Placotrochus elegans
Ia. Calice
II. Conocyathus cyclocostatus
IIa. Do. Calice

III. Deltocyathus excisus
IIIa. Do. Calice with only five systems & aborted pali

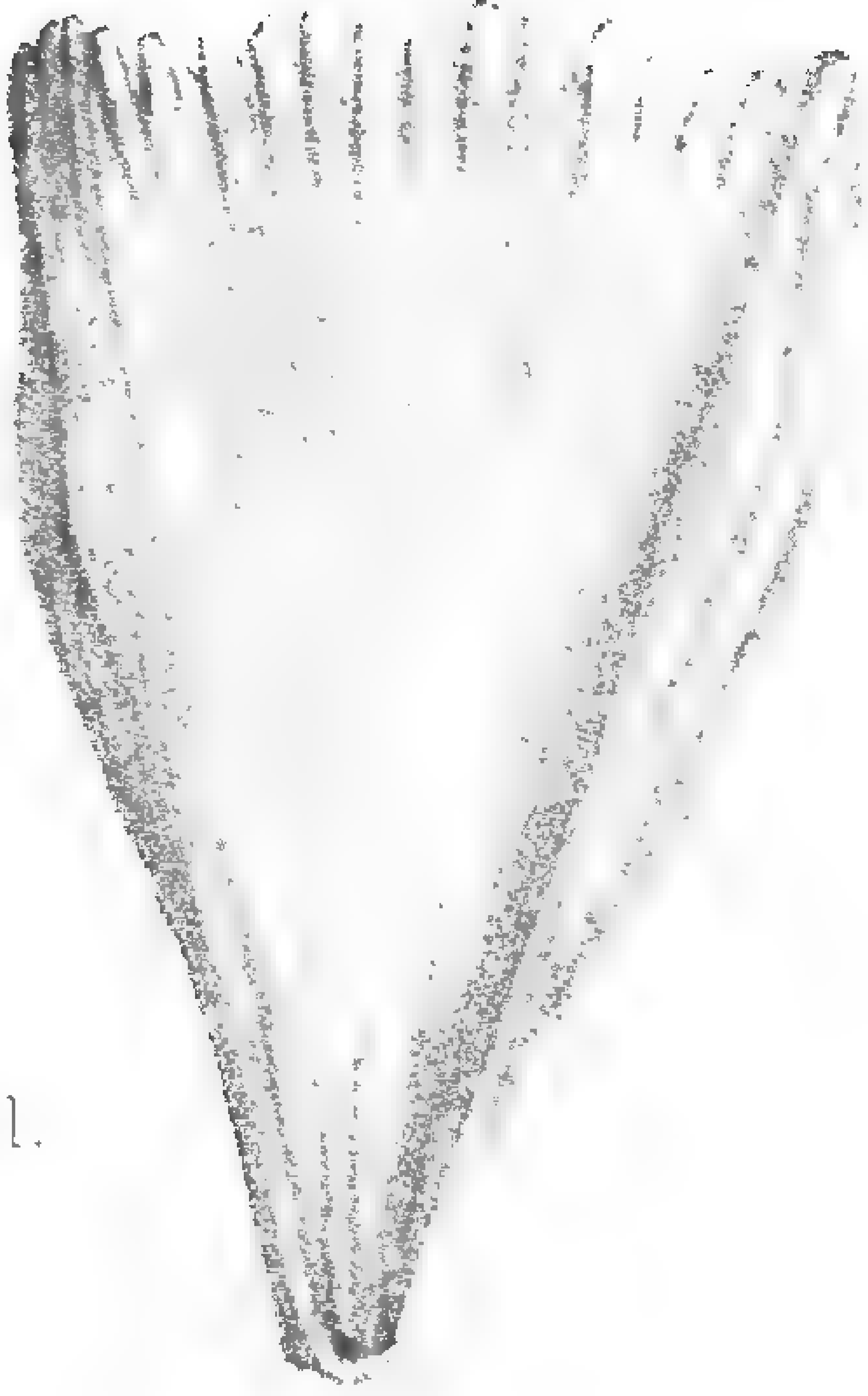

Fig. II.

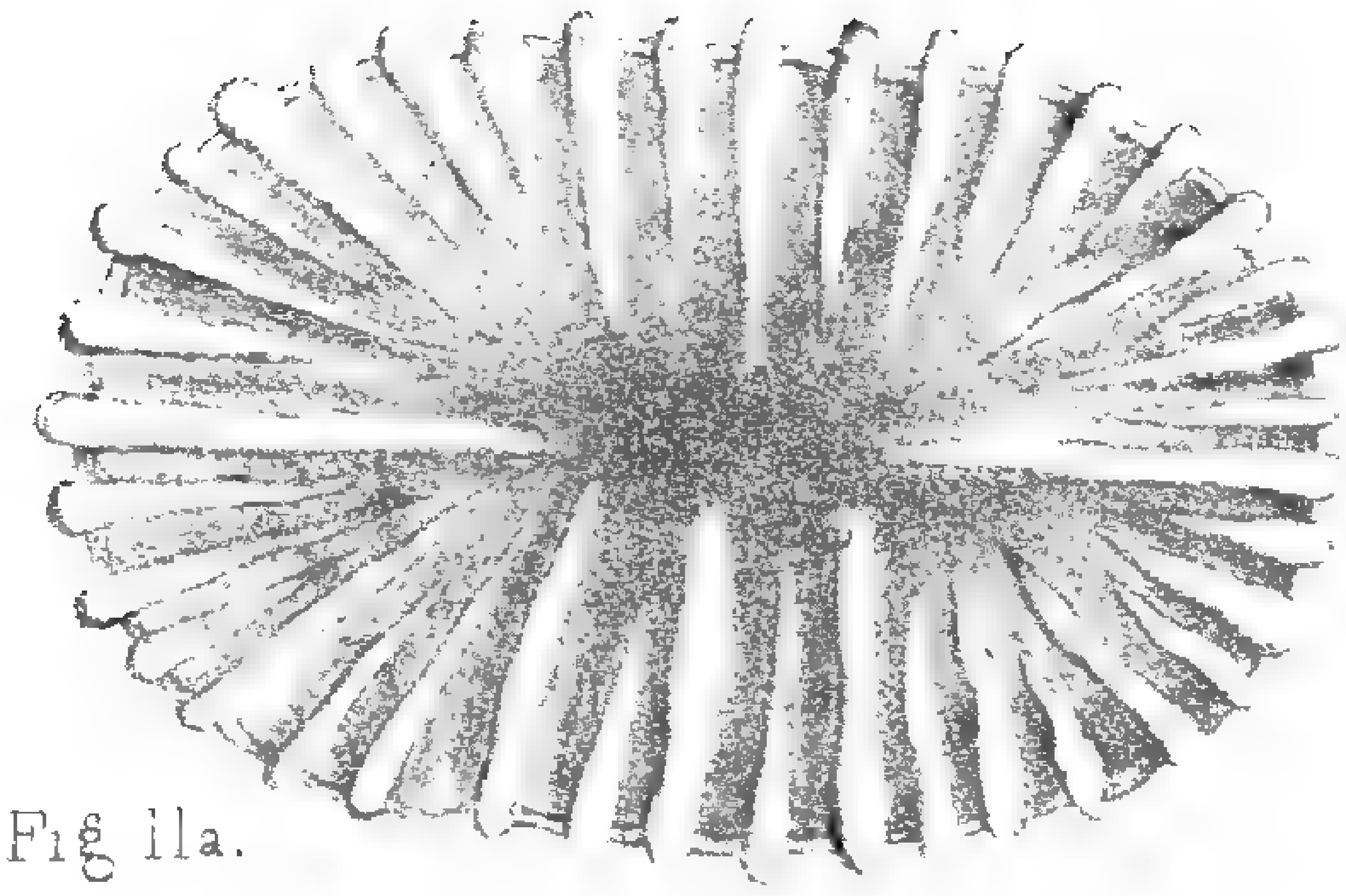

Fig. IIa.

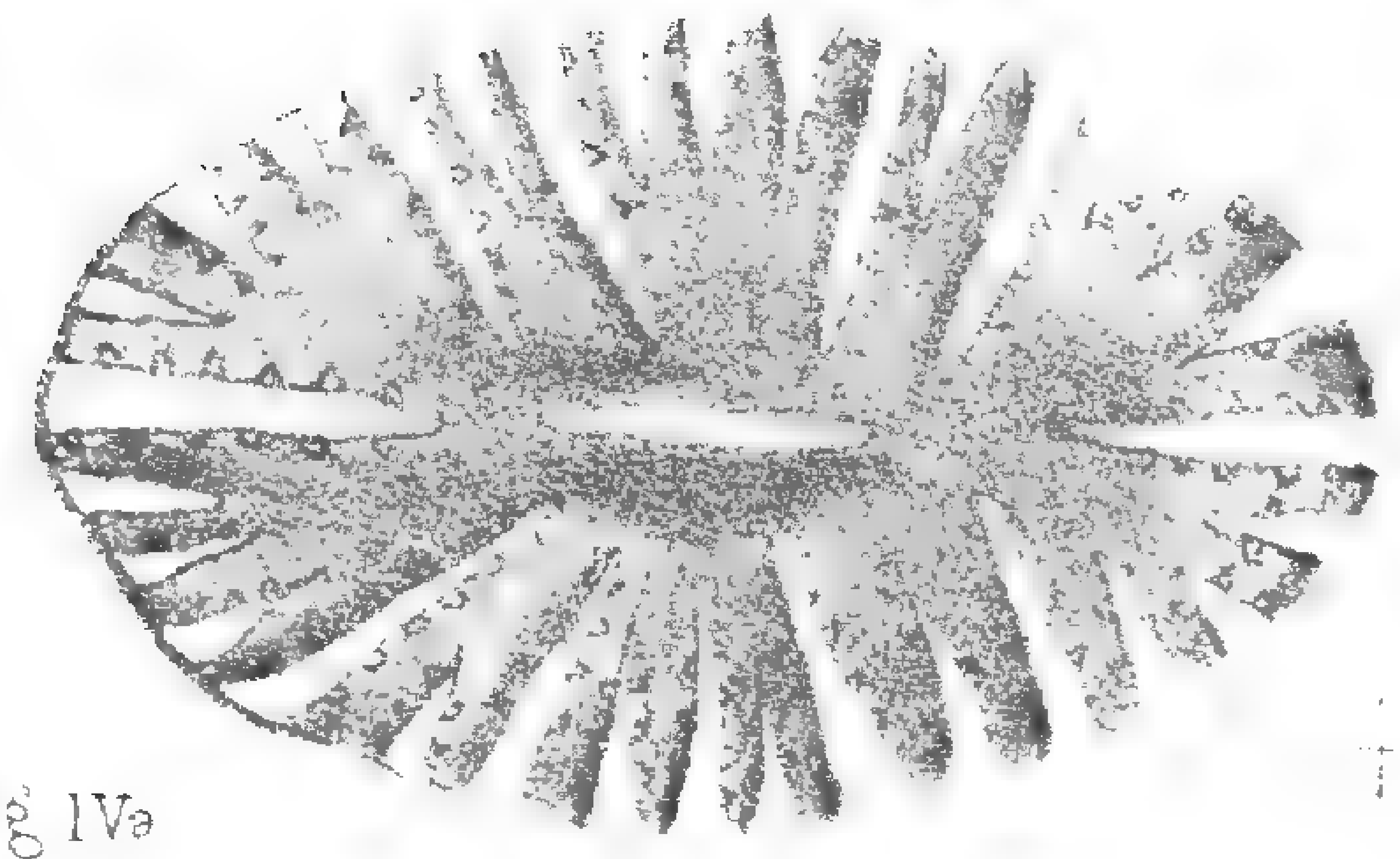

Fig. IVa

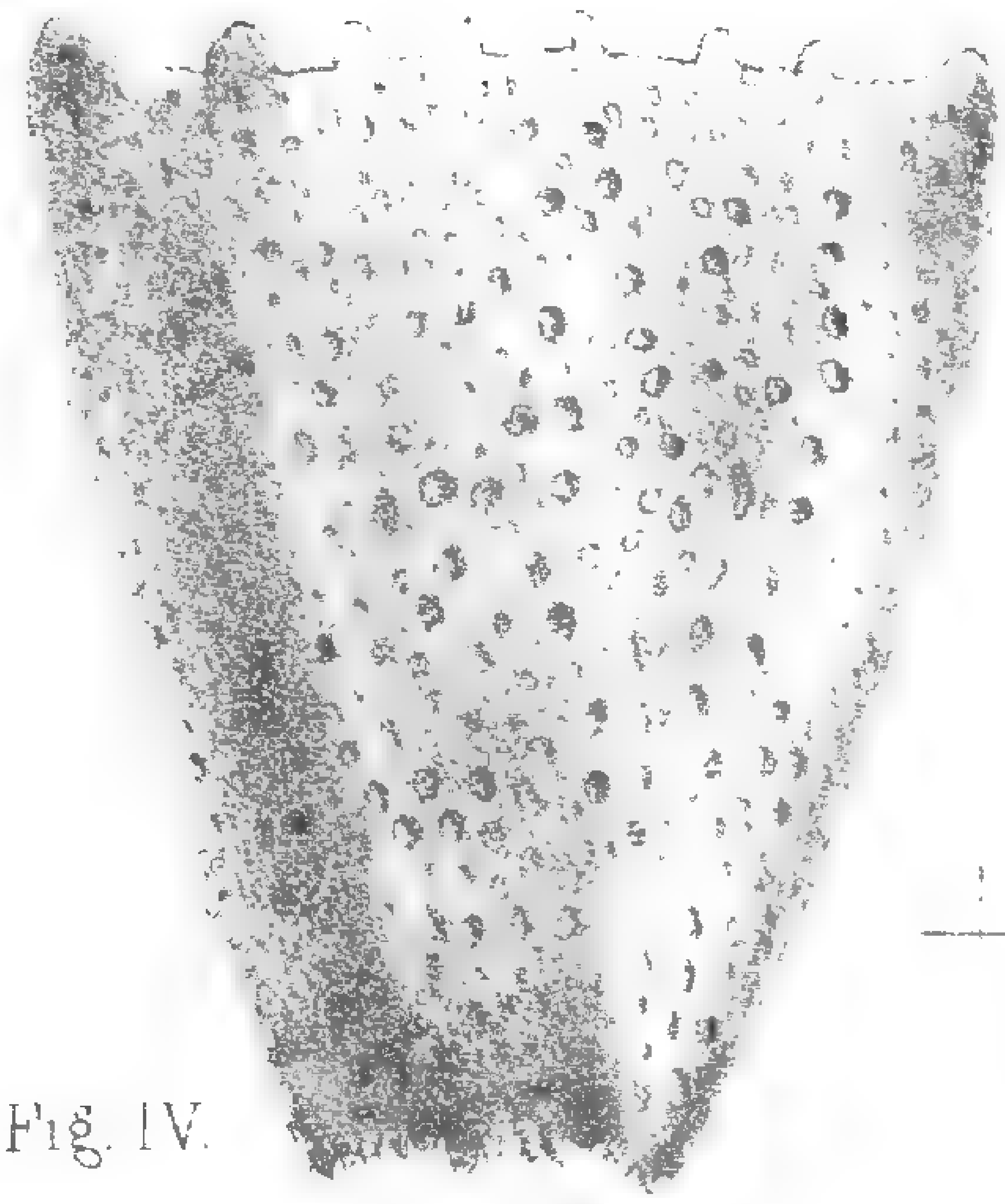

Fig. IV.

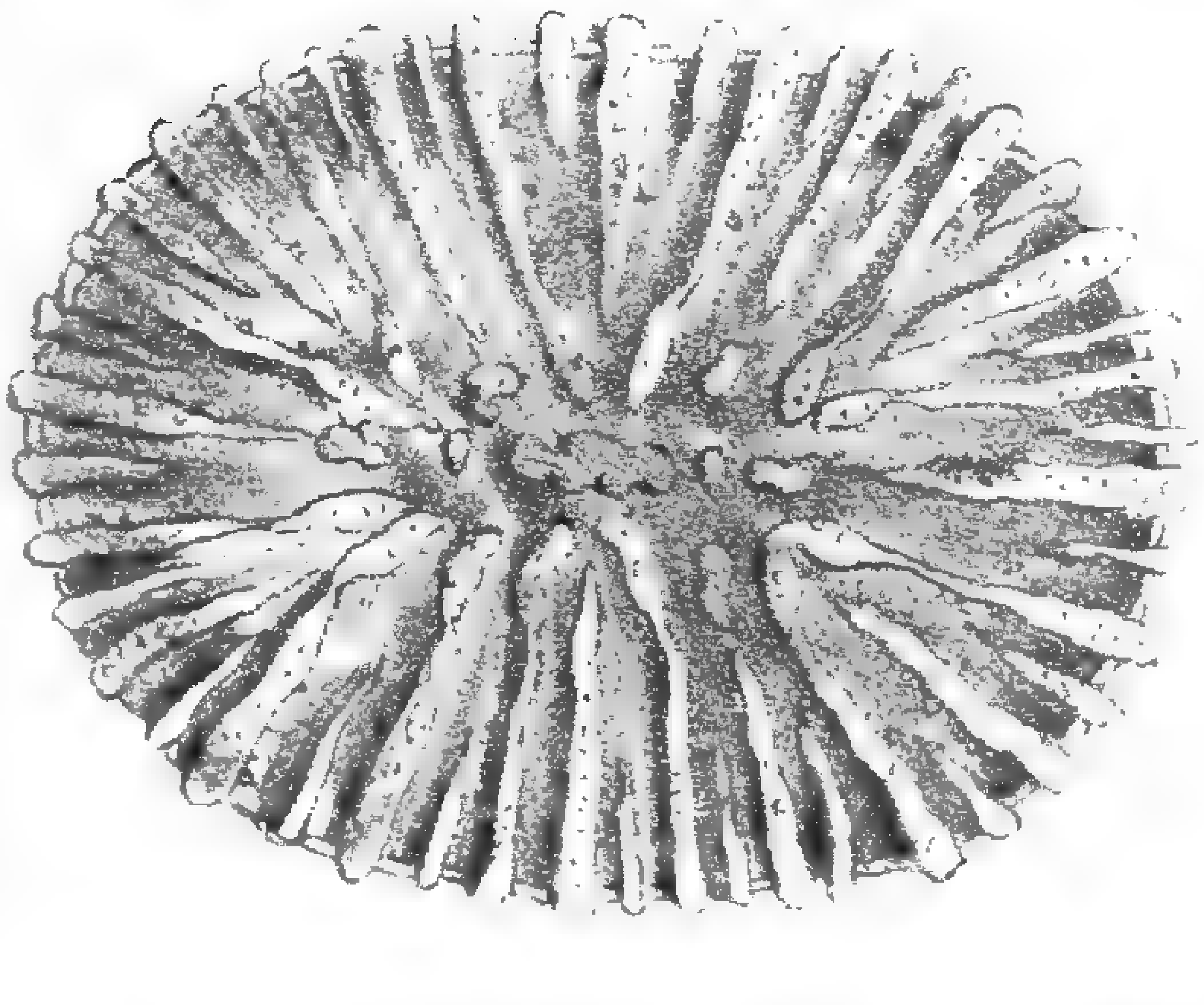

Fig. III

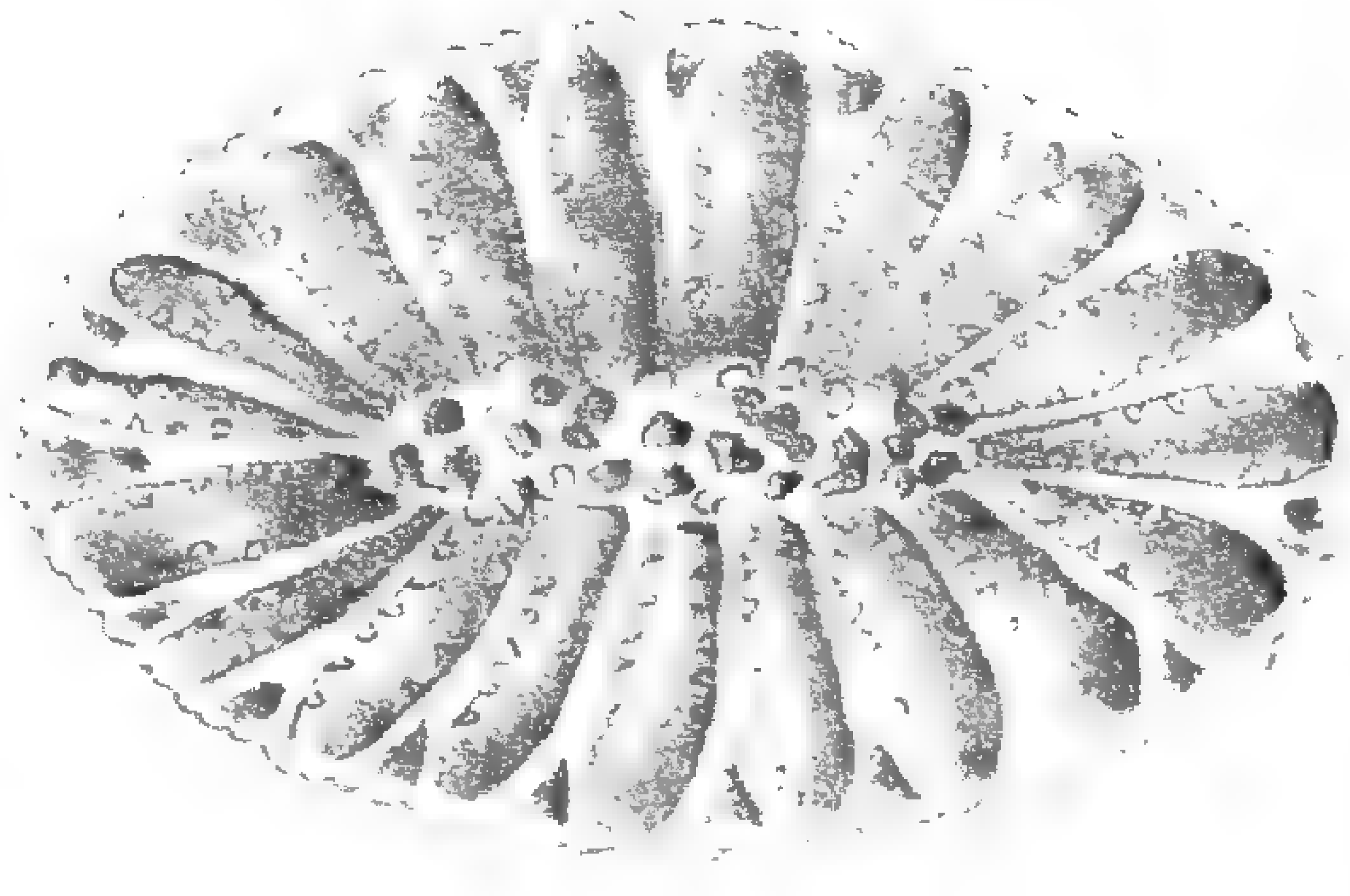

Fig. IVb

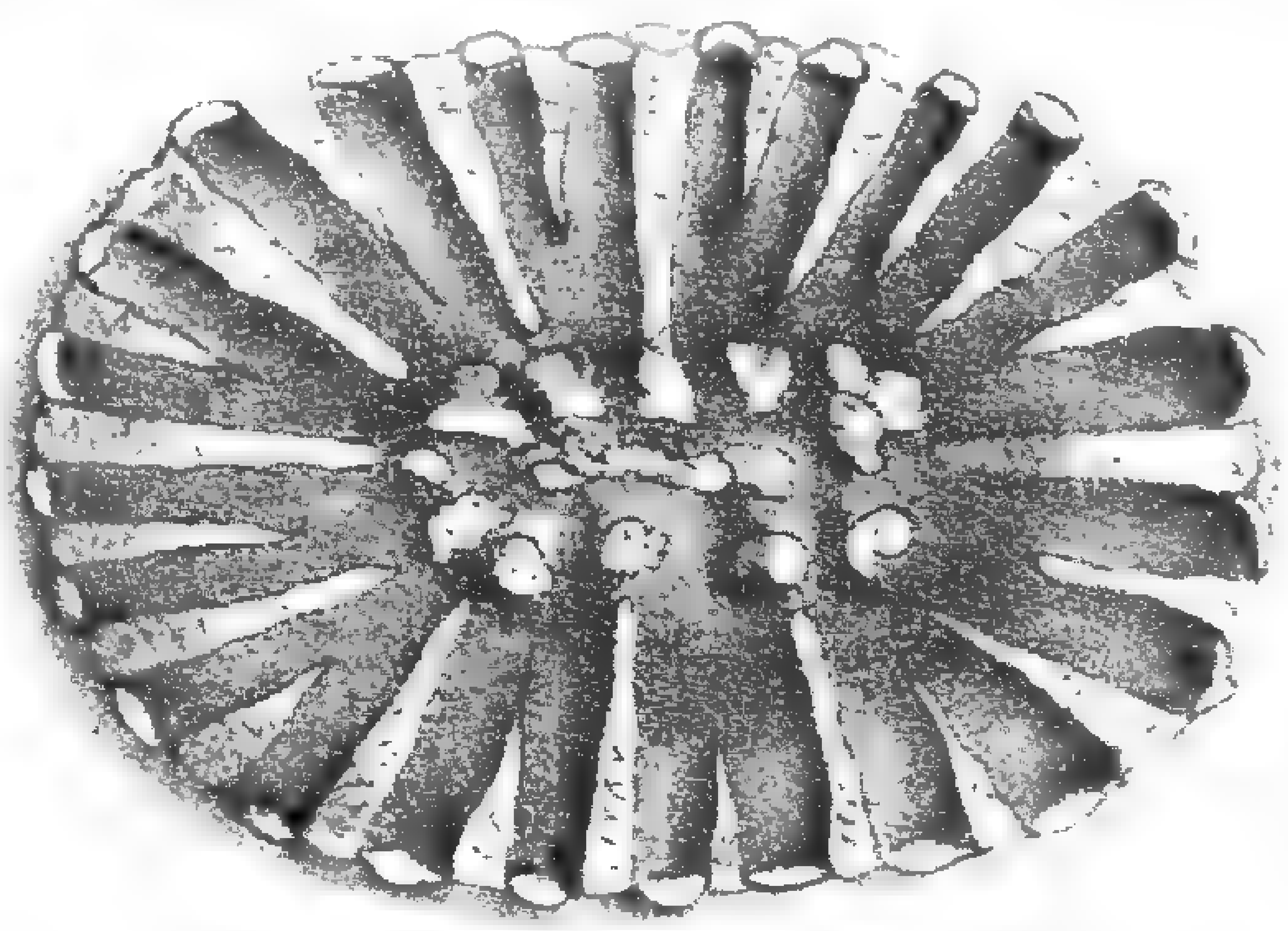

Fig.

J. E. TENISON-WOODS, DELT.

S. T. LEIGH & Co. LITH: SYDNEY

I. Normal Calice of D. excisus
II. Smilotrochus vacuus
IIa. Calice
III. Calice of Deltocyathus viola

IV. Sphenotrochus variolaris
IVa. Do Do. Calice
IVb Young Calice

On a new and remarkable Variable Star in the Constellation Ara.

By JOHN TEBBUTT, F.R.A.S., &c.

[*Read before the Royal Society of N.S.W., 5 December,* 1877.]

THE members of the Royal Society have doubtless observed a notice from me in the daily newspapers of the discovery of a new and remarkable variable star in the constellation Ara. My object now is to lay before the Society the detailed observations which have led to the discovery of the star's variable character. They will, I think, be interesting to the members, and at the same time show, as has been done before in the history of astronomical science, that a record is sometimes found to possess another and more important use than that for which it was originally intended. It will be remembered by the members of the old Philosophical Society that in October and November, 1862, I read before them two papers containing the results of my rough observations of the comet which was then visible in our southern sky. The papers were afterwards published in their Transactions for 1862–5. The observations of the comet were made with a ring-micrometer on my old refractor of $3\frac{1}{4}$ inches aperture and 48 inches focal length, the telescope itself being mounted on an ordinary tripod stand under the verandah of my present residence, and without divided circles of any kind. The time-keeper employed was a good common clock with seconds pendulum. The method which I adopted for determining the positions, and thus identifying the small stars compared with the comet, was the following:—After observing several transits of the comet and star of comparison across the ring, I compared the latter by means of the ring with some conspicuous star nearly on the same parallel of declination and visible to the naked eye. Where the stars differed considerably in declination and could not be embraced by the ring, I observed the transits across the field of view of the telescope. Sometimes I had to wait for an hour or more before such a bright star could be found to transit the field, the telescope of course remaining undisturbed in the interval. The bright star was then identified by a chart, and verified by observations made with a good sextant reading by a vernier to ten seconds of arc. Every precaution was taken in each case to ensure the correctness of the identification of the comparison stars, with what effect will best be seen from an examination of the comet observations published in the pages of the "Royal Astronomical Society's Monthly Notices," and the "Astronomische Nachrichten." On some occasions a series of stars of the 6th and 7th magnitude were observed with the comparison stars, in order thereafter to set the identity of the latter beyond all doubt. Having now stated the general plan pursued by me for the identification of the comparison stars, I will proceed to explain its connection with the subject of the present paper.

The evening of October 4th, 1862, being beautifully clear, I obtained six observations of the comet with the ring. The first three comparisons were made with two stars designated in my journal as A and B. A was of the 7th magnitude and B of the $6\frac{1}{2}$; the former preceded the comet in right ascension and the latter followed it. The fourth comparison was made with another star C of the 8th magnitude preceding the comet and B following it. The fifth comparison was made with A, and the sixth with C. A reduction of the transits in which A and B were both observed gave the following results for differences of right ascension of the two stars, B being east of A:—

		m. s.
1st comparison	.... B—A =	+ 6 37·84
2nd "	.... B—A =	+ 6 37·83
3rd "	.... B—A =	+ 6 38·58
	Mean =	+ 6 38·08

It was impossible to determine with accuracy the difference of north polar distance as B passed very near the centre of the ring, but it was estimated to be about 8′, B being south of A. Shortly after the completion of the six comparisons above mentioned a single comparison across the field of view was obtained of the comet, the star B, another star D of the $6\frac{1}{2}$ magnitude, and a star of the 5th magnitude visible to the naked eye, which latter being the brighter of two stars about a degree apart, I at first took to be Sigma Aræ. This 5th magnitude star I will for convenience designate V. A reduction of this comparison gave the following results for difference of right ascension and north polar distance of the stars, V having passed through the centre of the ring and the field:—

	R.A. m. s.	N.P.D. ′
B—V =	— 57 8·36	— 18
D—V =	— 55 55·67	+ 25

B and D having crossed at a great distance from the centre of the field, their relative positions were determined with tolerable accuracy as follows:—

D—B, in R.A. = + 1m. 12s.·69 D—B, in N.P.D. = + 43′ 11″

I may state that the value adopted for the semi-diameter of the field of view was 26′ 19″. It was remarked this evening that a small round nebula appeared north of the star V, both of which objects could be embraced in the same field of view. The following evening, the 5th, was also very clear, and I compared B and another star E of the 6 or 6½ magnitude with the bright star V across the field of the telescope, with the following results :—

			m. s.		′
1st comp....	B—V in R.A.	=	— 57 5·36	B—V in N.P.D.	= — 15
2nd „	B—V „ „	=	— 57 1·85	B—V „ „	= — 21
1st „	E—V „ „	=	— 12 16·51	E—V „ „	= + 24

In the first comparison V crossed very near the centre of the field, and in the second B passed very near it, but as both B and E crossed at a good distance from the centre in the first comparison their relative position was pretty well determined as follows :—

E—B, in R.A. = + 44 48·85 (m. s.) E—B, in N.P.D. = + 38 48 (′ ″)

It is remarked that the star E was "the following and brighter star of two about three minutes of arc apart, its companion being about the 7½ magnitude." On the evening of the 6th, which was also beautifully clear, I observed a transit of B and V, which latter according to a remark of this date was "a degree or two south of Theta Scorpii," and was still regarded by me as Sigma Aræ. This comparison was made with the ring-micrometer, and as both objects crossed it very far from its centre the result for north polar distance was satisfactory. The following is the result :—

B—V, in R.A. = — 57. 7·11 (m. s.) B—V, in N.P.D. = — 16 10 (′ ″)

On this evening there is a rough sketch of the comet and stars included in the same field of view with it. B is embraced in this sketch. On the evening of the 9th I for the first time observed with the sextant the star V, which I had erroneously supposed to be Sigma Aræ, but which, as my remarks for that date state, "was really about a degree north-east of that star and somewhat more conspicuous to the naked eye." I give the sextant observations as recorded, with the exception that the clock times are corrected to Windsor mean time :—

h. m.			° ′ ″
At 7 6½	....	Index error... ...	— 0 1 0
„ 7 9½	Read-off distance from	Theta Scorpii ...	2 27 40
„ 7 12½	„ „ „ „	Theta Scorpii ...	2 30 0 (better).
„ 7 19½	„ „ „ „	Altair	61 49 50
„ 7 25½	„ „ „ „	Antares............	23 36 40
„ 7 32½	„ „ „ „	Epsilon Sagittarii	14 2 40
„ 7 35½	....	Index error	— 0 1 0

Immediately afterwards a single comparison of B and V across the ring was observed with the following result, which was likewise good for the determination of the difference of north polar distance :—

m. s.	′ ″
B—V, in R.A. = — 57 2·85	B—V, in N.P.D. = — 17 36

Adopting the sextant distances from Altair and Antares, taking the apparent positions of these stars for October 9th, 1862, from the "Nautical Almanac," and employing mean refraction for temperature 50°, and pressure 29·6 in. in the reduction, I get the following for the apparent place of the star V. :—

h. m. s.	° ′ ″
App. R.A. = 17 29 6·60	App. N.P.D. = 135 23 42·8

which reduced to the mean place for 1862·0 with the help of the independent constants on page 331 of the Almanac becomes—

h. m. s.	° ′ ″
R.A. = 17 29 2·51	N.P.D = 135 23 33·8

Employing now the two sextant distances from Theta Scorpii and Epsilon Sagittarii as a test, I find they both establish within a few seconds of arc the correctness of the position deduced from the measurements from Altair and Antares; so there cannot be the slightest doubt that the position of the star V was fixed within a minute of arc on the evening of October 9th, 1862. If now we adopt the mean of the differences of apparent right ascension and north polar distance of B and V as determined on the 6th and 9th with the ring, we get the mean position of B for 1862·0 as follows :—

	h. m. s.		° ′ ″
App. R.A. of V	= 17 29 6·6	App. N.P.D. of V	= 135 23 43
Diff. of App. R.A. of stars	= — 57 5·0	Diff. of App. N.P.D. of stars	= — 16 53
Reduction of B to 1862·0	= — 0 3·6	....	— 0 12
Mean R.A. of B for 1862·0	= 16 31 58·0	Mean N.P.D. of B for 1862·0	= 135 6 38

Again, adopting 6m. 38·1s. W. and 8′ N. as the position of A with reference to B, we get for the position of A = R.A. = 16h. 25m. 19·9s., N.P.D. = 134° 58′ 38″. It will be at once seen that the stars A and B are identical with Nos. 5754 and 5799 respectively of the Brisbane Catalogue, whose mean places brought up to 1862·0 by means of the precession in the catalogue are,—

	h. m. s.	° ′ ″
No. 5754 R.A.	= 16 25 11·07	N.P.D. = 134 56 58
„ 5799 „	= 16 31 49·07	„ = 135 5 33

It must be understood that the discrepancies between the observed and tabular right ascensions are in a great measure the combined result of errors in the sextant observations of V, and the imperfect going of the clock for so long an interval as fifty-seven minutes. Assuming now the observed position of E with reference to B as the approximate difference of the stars' mean places, we get for the mean place of E for 1862·0 thus:—

	h. m. s.		° ′ ″
Mean R.A. of B 1862·0	= 16 31 58·0	Mean N.P.D. of B 1862·0	=135 6 38
Diff. R.A. of stars	= + 44 48·9	Diff. N.P.D. of stars	= + 38 48
Mean R.A. of E 1862·0	= 17 16 46·9	Mean N.P.D. of E 1862·0	=135 45 26

which agrees pretty well with the position of Lacaille 7267, as brought up from that catalogue by means of precession alone as follows:—

R.A. = 17h. 16m. 37·5s. N.P.D. = 135° 43′ 37″.

We have thus cumulative evidence of the accuracy of the determination with the sextant of the position of V. On consulting the Catalogue of the British Association, and especially the very exhaustive one of Lacaille, I was much surprised to find that this star V, being one so conspicuous to the naked eye and certainly not less than the 5th magnitude, had not been recorded. After the publication of my comet observations in the beginning of 1863, I thought no more of the subject till a few days ago. While engaged in searching for the most accurate determinations of the places of the comparison stars observed with the Comet III, 1862, with a view to the ultimate publication of my collected astronomical results, I in due course came to my old work for October 4th, 1862. Since the year 1862, my library had been enriched by many presents from the astronomical institutions of Europe, America, and the Colonies, and among these volumes are to be found several valuable star-catalogues. The excellent U. S. Naval Observatory Catalogue of 10,658 stars, and the Transit and Mural Circle Zones of that establishment, furnished me with many of the places of the stars observed with Comet III, 1862; but neither in these nor in the valuable Sydney and Melbourne catalogues could I find the star designated V. My curiosity was aroused, and accordingly on the 13th instant I turned the 4½-inch equatorial to the spot occupied by the star in question, when to my surprise there was no object to be seen in the field of view except stars of the 10th magnitude downwards. It immediately occurred to me that the star V was a variable one of a remarkable class, and had diminished since 1862 so as to be hardly visible in the telescope. Adopting the mean place of V for 1862·0 as before derived in this paper, and + 4·415s. and + 2·69″ as its annual precession in R.A. and N.P.D., I obtained the mean place for 1878·0 as follows.—R.A. = 17h. 30m. 13·15s., N.P.D. = 135° 24′ 16·8″. A careful examination of this position on the evenings of the 13th, 14th, and 17th instant showed that the only star in or very near it was a very faint one of the 11th magnitude. With the hour-circle of the equatorial clamped, I observed the transit of this faint star, Theta Scorpii, and Sigma Aræ, the differences of north polar distance being inferred from the readings of the declination circle. The following is the mean result of three comparisons for the position of the faint star:—R.A. = 17h. 30m. 21s., N.P.D. = 135° 23′. Owing to the bright moonlight and the rather low altitude the faint star was observed with much difficulty. The place thus determined agrees pretty well with that of V obtained from the sextant observations of October 9th, 1862. Taking therefore into account all the circumstances recorded in this paper, I am forced to the conclusion that the faint star observed on the 13th, 14th, and 17th instant is identical with the bright star V of October, 1862. There are, however, several faint stars within a few minutes of arc of its position, but considering that the place of the star just given cannot be more than a minute of arc in error, I think none of these faint stars can have a claim to be regarded as identical with V. Now that the moonlight is so strong, in conjunction with the low altitude of the stars, it is extremely difficult to observe even with a dark field; but I hope, as soon as the moon's absence will permit, to fix accurately the position of all the small stars in the field of view adopting the variable as the centre. I have communicated the discovery to the Government Astronomers at Sydney and Melbourne, with the request that they will confirm my present estimate of the magnitude of the variable. Such independent observations will be of value should another outburst of the star's light take place in future years. I may state that the nebula seen in the same field of view with the star on October 4th, 1862, is doubtless No. 3690 of Sir J. Herschel's Cape Catalogue for 1830. In conclusion, I think the star bids fair to occupy an important place among the stars of its class. Sir John Herschel, in his *Outlines of Astronomy*, edition 1851, p. 563, says:—"It is worthy of especial notice, that all the stars of this kind on record, of which the places are distinctly indicated, have occurred, *without exception*, in or close upon the borders of the Milky Way, and that only within the following semi-circle, the preceding having offered no example of the kind." A brief inspection will show that the present variable offers another example in proof of that eminent astronomer's statement.

The Observatory, Windsor,
November 22nd, 1877.

On a Dental peculiarity of the Lepidosteidæ.

By W. J. Barkas, L.R.C.P.L., M.R.C.S.E.

[*Read before the Royal Society of N.S.W., 5 December, 1877.*]

I am induced to make some remarks on this family of fossil fishes, as I have noticed in the twentieth volume of the Quarterly Journal of the Geological Society of England a brief notice of some fossil fishes obtained from the carboniferous strata of Wianamatta, Cockatoo Island, and Newcastle, that the Rev. W. B. Clarke had forwarded to England for examination. The author of the paper stated, "that after the closest scrutiny I have been unable to detect any difference between this fish and the genus Palæoniscus, save only in the position of the dorsal fin, which is more advanced than in any species of Palæoniscus with which I am acquainted. It is placed at nearly the centre of the back, as in the genus Pholidophorus, instead of more or less behind this point, as in the Palæonisci. The tail (if the detached fragment belongs as is stated to the specimen) is a true heterocercal form undistinguishable from that of Palæoniscus. The position of the dorsal fin, although not a feature of generic importance unassociated with other discrepancies, gives nevertheless a specific character to the fish, and I propose to name it *Palæoniscus antipodeus*. The result, then, of the examination of these specimens (in so far as materials so imperfect and scanty can be said to lead to any result), is the supposition that they give indications of four genera of fossil fishes—one allied to Pygopterus (*Urosthenes Dana*), one allied to Acrolepis (*Myriolepis*), one allied to Platysomus (*Cleithrolepis*), one indistinguishable from Palæoniscus, Agassiz." In the above extract there are three known genera of the Lepidosteidæ named:—Palæoniscus, Pygopterus, and Acrolepis, so if Urosthenes and Myriolepis are truly allies of Pygopterus and Acrolepis respectively, we have, then, three genera, Palæoniscus, Urosthenes, and Myriolepis, representing this family that have been obtained from the coal strata of the Colony of New South Wales. Unfortunately I have never seen these specimens, nor have I been able to meet with any detailed account of them. It will be noticed that in the abstract I have quoted above, there is no description of Urosthenes nor of Myriolepis, and the only details of the character of the Palæoniscus mentioned are the position of the dorsal fin and the heterocercal nature of the tail. Considering that the author of the paper speaks with a great deal of authority, we will take it for granted that he was well enough acquainted with the external characteristics of Palæoniscus, Pygopterus, and Acrolepis, to be able to determine that these fossil remains belonged to one or other of these genera or were close allies.

Up till the period of the publication of Professor Huxley's classification of fossil fishes there was great difficulty in arranging them, not because there was no master mind to reduce the chaos, but because the remains of the fishes were either too scanty or too securely hidden in private cabinets. Even Huxley's synopsis is not without flaw; still it is the best at present before palæontologists. He divided the class of fossil fishes into Plagiostomes and Ganoids. The order Ganoidei he further subdivided into families, of which the first on the list is the Lepidosteidæ. This family he again bisected into the Lepidosteini and the Lepidostini, the former being distinguished by having the maxilla formed of more than one bone, and its branchiostegal rays few and unenamelled; the latter by the maxilla consisting of one bone and having numerous enamelled branchiostegal rays, the anterior rays possessing the form of broad plates. The general characters of the Lepidosteidæ are:—a heterocercal tail, rhomboidal scales, branchiostegal rays, a pre-operculum, an inter-operculum, and non-lobate paired fins. Of the fossil fishes bearing these general distinguishing points, the following have been named:—Palæoniscus, Pygopterus, Acrolepis, Gyrolepis, Cycloptychius, Urosthenes, Myriolepis, Lepidotus, Aspidorhynchus, Oxygnathus, Semionotus, Dapedius, Æchmodus, Tetragonolepis, Caturus, Ditaxiodus, Pomognathus, Saurichthys; there may be others, but these are all that I am at present able to recall or learn from others. Some of these were formerly classed by Agassiz and Professor Owen as sauroids, viz., Saurichthys, Pygopterus, Acrolepis, Caturus, Ditaxiodus, and Pomognathus. With the first five of the above list of genera I am best acquainted, as in preparing my papers on the "Microscopical Structure of Fossil Teeth from the Northumberland True Coal Measures," for the Monthly Review of Dental Surgery, I had to study them very closely. My attention was drawn to the teeth of these five genera by a paper published in the third volume of the "Transactions of the Northumberland and Durham Natural History Society," in which Messrs. Hancock and Atthey pointed out that the teeth of Palæoniscus, Pygopterus, Acrolepis, Gyrolepis, and Cycloptychius, were tipped in a very peculiar fashion by a piece of enamel or ganoine. On examining them for myself I found that they were so constituted, and I was curious to learn whether this was a characteristic present in all the genera pertaining to the Lepidosteidæ. No one appears to have inferred that the teeth of all the genera of this family might be thus tipped with enamel; I consequently drew the attention of Wm. Davies, Esq., of the British Museum, to the probability of such being the case, and asked him to examine the specimens under his supervision. In due time I had the pleasure of receiving the following information:—"The teeth of Aspidorhynchus and Oxygnathus are undoubtedly tipped with enamel, of Semionotus there is no specimen which shows teeth in the collection. The marginal teeth of Lepidotus and Dapedius are also tipped with enamel, but are not so sharply pointed as the teeth of Pygopterus, &c. I cannot say with certainty, from examples in the collection, that the teeth of Æchmodus and Tetragonolepis are thus tipped, but that the summits are covered with enamel is certain." From the writings of Professors Owen and Agassiz, I learn that Saurichthys is also tipped with enamel. Of the eighteen genera that I have named as pertaining to the Lepidosteidæ, we find that ten are certainly tipped; two are enamelled on the summit, but it has not been ascertained whether the ganoine is arranged as a tip; six of which the teeth are not known, and in these are included the Australian Urosthenes and Myriolepis. I have tried to obtain specimens of the last six genera that showed teeth, but have been unsuccessful, and I cannot learn from others that the teeth have ever been seen; however, twelve out of the eighteen are known to have enamel on the summits of their teeth; it is, therefore, probable that all the other members of the family are so characterized, and I am strongly of the impression that any fish at present placed among the Lepidosteidæ that has not its teeth tipped has been wrongly classified, and pertains to some other family of Ganoids.*

Having pointed out how general this peculiarity is in the known Lepidosteidæ, I shall now draw attention more particularly to the teeth themselves, and I shall take the teeth of Palæoniscus and Pygopterus as typical examples, not only because they are truly typical, but also because Palæoniscus and an ally of Pygopterus (Urosthenes) are said to be present in the coal-bearing strata of New South Wales. The teeth are arranged along the alveolar borders of the maxilla and mandible in two rows which

* By the November mail I received a number of recent papers by Professor Traquair on fossil fishes, and I notice that he has founded some new genera; that are close allies of Palæoniscus and Pygopterus, viz., Cheirolepis, Elonichthys, Gonatodus, and Nematoptychius. The last named he mentions as having tipped teeth, but he either is not acquainted with the structure of the teeth of the first three genera, or he has forgotten to detail this peculiarity if present.

Since my paper was written, I have recalled to my memory another fossil fish belonging to this family, viz., Amblypterus, but whether its teeth are tipped I know not.

Among fishes that are now in existence, there are only two that to my knowledge possess tipped teeth, and they are Lepidosteus and Polypterus.

run parallel with the long axis of the jaw and with each other. The internal row of teeth are large (comparatively speaking) and placed at distinct intervals of about equal distance. The outer row is formed of a great number of very minute teeth (in some species they are almost invisible to the naked eye), generally much crowded together, and often very irregular in their order; they are so numerous that the usual expression regarding them is that they are "*en brosse*." Both the laniary and minute teeth are conical, with very sharp apices, the latter being generally straight but occasionally curved; the former are, in the two genera I have taken as typical, always curved in a direction usually inwards but often with a tendency forwards. The apices of these teeth are tipped with a thick "cap" of enamel, which is smooth and glistening on its external surface. On making a vertical section of one of these teeth, the peculiarity of the arrangement of the enamel is shown more perfectly. The tooth is composed of dentine enclosing a pulp cavity; as the dentine approaches the apex it rapidly attenuates to a sharp point, and upon this is fitted the "cap" of enamel, or ganoine as fish enamel is usually termed, which is also acutely pointed. The tip of ganoine, therefore, appears like an inverted V closely adjusted to the aciculated apex of the dentine. The structure of this "tip" I detailed and figured in chapter XIV of my series of papers on the structure of fossil teeth, when I was speaking of Acrolepis, and I here give it *in extenso*. "The enamel or ganoine tip is composed of a clear, perfectly transparent homogeneous tissue, in which ramify numerous tubules which are continuations of the tubules that have arisen from the pulp cavity and pursued their course through the dentine that intervenes between that cavity and the tip. The course of the tubules when they have entered the enamel tip tends to be parallel to the long axis of the tooth, those in the centre being quite parallel. As the tubules proceed into the enamel they become finer and finer, and ultimately disappear, very few of them reaching the periphery apparently; they do not, however, terminate in a boundary as they do in the dentine. Here again, I do not doubt that the tubules do reach the external surface, but it is impossible to trace them on account of their minuteness and the clearness of the tissue in which they ramify. Those tubules that are visible are rendered strikingly so by the dark carbonaceous matter contained in their interior contrasting with the clear tissue in which they are imbedded. In fig. LXVII the minute structure of the tip is well portrayed; its form, however, has been somewhat destroyed in making the section, the extreme tip having been rubbed away; it should be acutely pointed. I have added dotted lines to show the extent to which the enamel is wanting."

Discussion.

Mr. MacDonnell asked if the paper was written upon a fish which the writer had not seen.

Professor Liversidge said Mr. Barkas had not seen the particular specimen referred to; but he had devoted a considerable amount of attention to the subject of fossil fishes, and from the descriptions given of it, Mr. Barkas was inclined to think that it had been put in the wrong class. Mr. Barkas's views were, of course, open to discussion, and the discussion of systems of classification did good.

[Mr. MacDonnell has evidently quite mistaken the drift of this paper. In writing it my object was to point out that the majority of the genera in the family Lepidosteidæ, the teeth of which were known, had the teeth tipped in a peculiar manner with enamel, which fact consequently led me to the inference that all the other supposed genera and species of that family that had not tipped teeth probably pertained to some other family than the Lepidosteidæ. I referred to no particular fish, but took Mr. Clarke's specimens—being Australian—as a groundwork upon which to found my paper. Of course, if these Australian specimens have *not* tipped teeth, I, as Professor Liversidge said, would certainly doubt their classification; for every example of Palæoniscus, Pygopterus, and Acrolepis that I have examined, and the number of them is large, *had* teeth tipped with enamel. I have never seen the New South Wales specimens referred to, as Mr. Clarke informed me that none of them showed any teeth. Their classification is, therefore, uncertain, and future discoveries may enable us to decide as to the nature of their teeth.]

Notice of a New Fossil Extinct Species of Kangaroo, *Sthenurus minor* (Owen).

[Supplemental to the notice of the new fossil bird, *Dromornis Australis* (Owen). By the Rev. W. B. CLARKE, M.A., F.R.S., &c.]

[*Read before the Royal Society of N.S.W.*, 5 *December*, 1877.]

AT the close of the paper on *Dromornis*, I mentioned that I had received from Mr. Lowe, of Goree, a portion of a skull of an extinct marsupial, which I was informed came from a lead in the neighbourhood of the "pelvis" of the new fossil bird.

I sent them in the same box to Professor Owen, who has reported on the skull, in the Proceedings of the Zoological Society of London, of April 17, 1877.

As that report may not fall in the way of some members of this Society, it may be useful to make the existence of the new Marsupial known to them by quotations from Professor Owen's remarks, in order to assist in extending information on the Marsupials of Australia.

The report is headed, "On a new species of *Sthenurus*, with remarks on the relation of the genus to *Dorcopsis*, Müller. By Professor Owen, C.B., F.R.S., F.Z.S., &c." (Plates XXXVII and XXXVIII.)

The author says:—"The present species of extinct kangaroo is founded on a fossil fragment of a skull, including the molar series of both sides of the upper jaw, with the intervening bony plate.

"The reference to the genus *Sthenurus*, in Professor Garrod's excellent memoir on *Dorcopsis luctuosus* (Proceedings Zoological Society, 1876), encourages me to think the following notes may not be unacceptable to the Society, which has occasionally admitted illustrations of extinct animals into its publications. The fossil was found in a 'rocky alluvial deposit,' in the shaft of a gold-lead in the County of Phillip,* New South Wales, Australia, and was transmitted to me by the Rev. W. B. Clarke, M.A., F.R.S., the veteran geologist of New South Wales. The fossil is in a massive petrified condition.

"The smallest species of the extinct genus, known at the date of my eighth paper on the "Fossil Mammals of Australia," (P. T., 1874), was the type of one (*Sthenurus atlas*), in which the

* I have recently (November 21, 1877) been informed by Mr. Lowe that the skull came from the Talbragar country. In that district other marsupial relics have been found. I have left the statement in the text with this correction, as the only way of explaining in this note the change of *habitat*, and in justice to Professor Owen, who received the first statement through me.

fore and aft extent of the crown of the upper premolar is nine lines, that of the entire permanent series of upper molars being 2 inches 11 lines. A second species of *Sthenurus (S. brehus)* has the upper premolar 10 lines in fore and aft extent; that of the permanent series of upper molars is three inches four lines. In *Osphranter rufus* this series is two inches three lines, reduced by loss of the premolar to two inches (as in Trans. Zool. Soc., vol. IX., pl. 74), and these dimensions are not exceeded in *Macropus major*. The extinct kangaroo represented by the subject of pl. XXXVII somewhat exceeded the above largest known existing species. The fragment of skull is a little larger than the corresponding part of a full grown *Macropus major*, with the last molar in place and use and the premolar shed; it consists of both maxillaries with their respective (right and left) molar series, the intervening bony plate and a portion of the right orbit, and zygoma with the descending masseteric process. The dentition is in an instructive phase.

"In 1874, M. d'Albertis described and figured a small existing kind of Kangaroo, under the name of *Halmaturus luctuosus*, obtained in the south-east of New Guinea, with a pre-molar more trenchant than in *Sthenurus*, and with the proportions of the tooth differing in the opposite extremes of fore and aft extent, and in greater degree than in *Halmaturus*, from those in the premolar of *Sthenurus*.

"This rare Kangaroo was deposited in the Zoological Gardens, and on its death, in November, 1874, was anatomised by the accomplished pro-sector, A. H. Garrod, B.A., by whom the skull and teeth are well described and figured. Professor Garrod refers the specimen to the same genus as the *Dorcopsis muelleri* of Schlegel."

Besides some other differences, "in *Sthenurus* the transverse thickness of the pre-molar decreases as the crown extends forward; in *Dorcopsis* the transverse thickness is uniform, or is maintained to very near both ends of the crown.

"I have not found an upper canine in a *Sthenurus* of any age.

"In all these characters" (some here omitted) "*Sthenurus* deviates from the Halmaturine, Dorcopsine, and Hysiprymnine types, and approaches that of the great Kangaroos represented by Macropus proper, Osphranter, and Borigale. (P.T. 1874, pl. xx.)

"What evidence, it may be asked, does the skeleton afford of the affinities of the huge Kangaroos of the genus *Sthenurus?* I am able only to adduce those yielded by the skull. The time may come when, in some Australian cavern, a greater proportion of the enduring framework may be recovered in connection with the skull and dentition of one and the same individual. Fortunately the cranial characters at present known are instructive ones, are well shown in the portion of the skull of the smaller species under description, and the more welcome as repeating those previously given by a corresponding portion of a skull of *Sthenurus brehus.* (P. T. 1874, vol. xxviii.) The first of these characters is the integrity of the bony plate. In *Dorcopsis* (P.Z.S. 1875, pl. vii.), as in the *Hypsoprymninæ*, and as in most of the smaller Kangaroos which have been grouped under the less definite genera *Halmaturus*, *Petrogale*, *Lagorchestes* the bony palate *shows two or more large vacuities.* In *Dendrolagus* the palate is entire, as in *Macropus* and *Sthenurus.* The masseteric process is short in *Dorcopsis*, as in the Hipsiprymnines; it is long in *Sthenurus*, as in *Macropus.*"

* * * * * * *

After noticing a mistake of F. Cuvier, as to the generic character of *Macropus*, the author continues :—

"Later investigations of the fossil marsupials of Australia have led to the interesting result, that the developmental condition which F. Cuvier believed to differentiate the larger Kangaroos of the genus *Macropus* from the smaller kinds referred to *Halmaturus* and *Hypsiprymnus* does actually differentiate the huge extinct herbivorous marsupials of the genera *Nototherium* and *Diprotodon* from the *Macropodidæ*, which we know to have been represented by species much exceeding in size the existing Kangaroos. Moreover, the large extinct Kangaroos, even in the partial degree in which we have already come to know them, manifest much better grounds for generic or subgeneric distribution than do any of the existing forms. And such extinct genera, represented as they are by species larger than the existing kinds, manifest in a highly interesting and instructive way an approximation to the Notothere and Diprotodons.

"*Macropus*, *Sthenurus*, *Procoptodon* exemplify stages of transition to the exclusively vegetarian character of the molar series exemplified by *Diprotodon.* The genera *Halmaturus*, *Dorcopsis*, *Dendrolagus*, *Hypsiprymnus* exemplify so many stages in the modification of the teeth for a mixed diet, which, in the Diprotodont series of Marsupialia, culminated carnivorously in *Thylacoleo.* Here the upper anterior incisors acquired their largest proportional size, with the change of the trenchant for the piercing or laniary type. The single lower pair of incisors underwent the same modifications. The conversion of the premolar, in size and shape, to a carnassial tooth, and the reduction of the molars in numbers and size to the tubercular condition of the feline molar, are exemplified in *Thylacoleo*, with corresponding figures of our Cave-Lion and Cave-Hyæna, in plate VI of my 'Researches on the Fossil Mammals of Australia.' In this work a preliminary chapter is devoted to the extinct Marsupials of England, in which it is shown that at the oolitic period our Marsupials had also diverged, by the modifications of the fundamental type, into species exemplifying the 'polyprotodont' and the 'diprotodont' sub-orders—and that, in the formal or adaptive characters of the teeth, species diverged from the common carnivorous or insectivorous types in *Stylodon* and *Thylacotherium*, to the vegetarian type in *Bolodon* and *Stereognathus* in one direction, and to the carnivorous type exemplified by *Triconodon* and *Plagiaulax* in the opposite route."

In reproducing the valuable matter contained in the foregoing extracts, much of the minute critical comparison of the teeth of the various species has been omitted, the chief material quoted being of a more popular character than the details, and yet sufficiently instructive towards the encouragement of Australian explorers in the discovery of the extinct creatures whose remains have not yet reached their full investigation.

May I be pardoned for suggesting that, however necessary it may be to the progress of the present occupants of the prairie lands of Australia to keep within bounds the increase of Marsupials, which once were the support of a race nearly extinct, yet in the extermination that has now received the sanction of law in some of our Colonies, and which will be carried out without compunction when the interest of the squatter requires it, it is not improbable that some species still undistinguished by the scientific and unscientific alike will be included in the slaughter, and ere long Kangaroos may be creatures of the past, as well as the human tribes who are fast dying out.

It is possible, therefore, that Palæontology itself may be a sufferer in the long run. Thirty years since, Professor Owen lamented the want of skeletons of existing Marsupials, in order to study effectually the species that are extinct. Such may still be a source of difficulty in the researches of comparative anatomists, and as new extinct species will probably be discovered, it would be well if those who are making a full end of the *Macropidæ* would save at least some of the hitherto unnoticed species for investigation. But whether or not this consideration has influence, there is a great probability that if the gold-diggers and other persons referred to in the paper on *Dromornis* would make it a conscientious act to carefully preserve all relics of extinct creatures found in the course of their excavations, many new species, as well as those of *Dromornis* and *Sthenurus*, may be obtained for the service of Palæontologists, and towards the progress of general knowledge in the community.

Notes on some recent Barometric Disturbances.

By H. C. Russell, B.A., F.R.A.S., Government Astronomer.

[*Read before the Royal Society of N.S.W.*, 5 *December*, 1877.]

Some of the recent Barometric Disturbances, recorded by the self-registering barograph in the Observatory, are so remarkable that I think a few notes about them should be placed on record for reference; at the same time they will doubtless be interesting to the members present this evening.

The remarkable changes in atmospheric pressure during hurricanes are well known. Fitz Roy stated that a fall in Europe of one-tenth of an inch per hour presaged a storm. In the tropics, where the usual oscillations of the barometer are much *smaller* than in Europe, a similar fall would of course indicate a correspondingly greater disturbance. I have, therefore, for the sake of comparison, taken out from various records the average results for twenty hurricanes.

From these the average hourly fall as the hurricane comes on is 0·147 in.; the average period over which the fall extends is 10 hours, but of course the times of falling barometer vary very much—from 3 to 18 hours. The average total fall in a hurricane is 1·488 in., and the greatest and most rapid fall which I find recorded is that in the hurricane of May 21st, 1833, when the ship "Duke of York" was carried a great distance inland at the river Hoogley and wrecked. The river rose 12 feet perpendicularly, and 50,000 people were drowned. At 8 a.m. on that day the barometer read 29·09 in., and by 11·30 a.m. it read 26·50 in., or a fall of 2·59 in. in 2½ hours.

The first of the Sydney self-registering barograph records which I would like to bring under your notice is that for 16th November, 1877. The afternoon of that day was very cloudy, and so dark that the gas had to be lit in the office at 4 p.m., where, had the day been fine, it would not have been required until 7 p.m. Thunder and lightning were observed in several directions, but no defined storm took place. The barometer, however, began to rise rapidly at 4 p.m., and rose 0·080 in. in 20 minutes, when a sudden fall set in, in the most remarkable manner it has ever been my lot to witness, and in 24 minutes the barometer fell 0·175 in. —the latter half of the fall being much more rapid than the first, in fact quite as rapid as the rise which immediately set in at the rate of 0·130 in. in 8 minutes; now the fall is at the rate of 0·437 in. per hour, and the rise at the rate of 1·350 in. per hour. During the time these changes were being recorded, the anemometer recorded a change in the direction of wind right round the compass, but there was nothing else except the darkness remarkable. From this time (5 p.m.) the barometer was unsteady, but not remarkably so until 7·20 p.m., when another remarkable change is recorded—the barometer fell 0·115 in. in 6 minutes, and rose 0·075 in. in the following 5 minutes; this fall is at the rate of 1·150 in. per hour, and the rise at the rate of 0·750 in. per hour. Again, there was a sudden change in the direction of the wind from S.S.E. to E.S.E. but nothing else to remark; the clouds being still very dark, but apparently passing away.

From 4 to 7·30 p.m. of the 21st November we have another remarkable curve during the passage of a heavy thunderstorm, and it illustrates very well one peculiarity of these storms to which I wished to draw your attention. It is that the curve *rises*, showing an *increase* of pressure as the storm approaches, and falls as the storm passes. Now, we are in the habit of speaking of *heavy clouds*, because they look massive and heavy; but we well know that as masses of vapour they are lighter than the air, and even when in such a condensed form that they are heavier, and therefore *falling*, the pressure must of course be distributed, because the falling motion is comparatively slow, and cannot act locally. It is well known also, from actual experience, that passing rain-clouds are lighter than the surrounding air. How then can we account for the increase of pressure which is so clearly shown here, and is a constant phenomenon of our thunderstorms? I think, in this way: The thunder-cloud is a storm mass, travelling by its own velocity (which is very considerable) *through* the air; and, in so moving, the air in front of it must get compressed as it gives way—and the effect is too rapid to be entirely dissipated by distribution—and it acts locally; but, if this is so, such a moving mass must cause a partial vacuum, or loss of pressure, in its rear; and such we find to be in fact the case, as the fall after the passage of these impulses is greater than the rise which they produce. These phenomena are quite familiar in the passage of a vessel through the water; but I am not aware that they have been before made evident in the passage of a storm through the air.

The next barometer curve which I have to bring under your notice is however in several respects the most remarkable I have ever seen. You have probably read in the daily papers accounts of a fearful storm in the Western Districts on the 27th November, 1877. At Grenfell the damage done to the houses in the town was very great, but I will not detain you with an account of this. I only wish to say that the morning was very sultry, and soon after noon heavy electrical clouds began to gather in the N.W., and at 5 p.m. the tempest broke upon the town with a deluge of rain and hail. On the same afternoon a terrific storm passed over Cowra, but unfortunately the time is not given. We next hear of the storm at Carcoar after a fierce hot wind which had been blowing all the morning; but again the writer has omitted to give the time at which the storm began, and the account for scientific purposes is of very little value. It is next reported at Bathurst, and five cows were killed in the open field—(no time is given). During the afternoon at Sydney several storms passed; at 3 p.m., one passed north of the city, probably down the valley of the Hawkesbury; but the air did not clear, and clouds began to get very heavy to south-west, and the storm gradually approached, with almost incessant lightning, which was for the great part down-strokes; at 7·30 p.m. the storm was passing over Sydney, and then the down-strokes were very few, but the discharges between the clouds very frequent. Struck with the long interval between the flash and the reports, I took out a stop-watch and found that one flash nearly overhead, and so bright that it appeared to be on the under surface of the clouds, was 8^s before the report; several were 10^s, others 12^s, 15^s, and upwards, as their direction became more oblique: the nearest vertical flash therefore indicated an altitude of 9,000 feet for the under side of the cloud. At sunset (6·50 p.m.) a streak of sky was visible in the west; this indicated the margin of the storm cloud, and at 8·50 p.m. it passed over Sydney. Therefore, as the clouds were at least 9,000 feet high, we have a probable velocity of storm translation of fully 50 miles per honr. Again, taking the time it reached Grenfell, 5 p.m., and Sydney at 7·30 p.m., we have an interval of $2\frac{1}{2}$ hours for 170 miles; or at the rate of 68 miles per hour, which is a very close agreement with that deduced from the observations on the clouds themselves; and it is a velocity quite sufficient to account for the remarkable increase in pressure shown by the barograph. which at 6·20 p.m. amounts to fully 0·250 in. above the probable height which the barometer, if there had been no storm, would have shown at that time. The facts which I have already stated indicate that this storm-cloud was of very large dimensions, fully 200 miles in diameter; and, if we examine the barograph curve, we find a sudden rise or increase of pressure at 5·10 p.m., and the sudden fall in the wake of the storm begins at 9·20 p.m.—that is 4 hs. 10 min.; and taking a mean of the two determinations of the velocity, 50 and 68 miles per hour, we get 59 miles for the rate of progress, or 246 miles from the wane of pressure in front to the partial vacuum in the rear. I much regret that the other observers on the line of this storm did not give particulars about the times; but the facts, so far as they go, are so accordant that I think there can be but little doubt that this storm was of the dimensions given, and travelled with a velocity of fully 50 miles per hour. There are several interesting circumstances which I have been obliged to omit, for I have already far exceeded the space allotted to these notes.

Discussion.

Mr. Conder said he was taking observations in connection with the trigonometrical survey party near Carcoar when this storm occurred. They were on the outside edge of the storm. From half-past 5 till 6 o'clock he was trying to see the station at Carcoar, but could not see it; the storm-cloud was then passing over Carcoar. He was a little to the east of the station.

Mr. Scott: What was the greatest velocity of the wind registered at the Observatory?

Mr. Russell: 153 miles an hour.

Mr. Scott: Then the rate at which the storm appeared to travel was not improbable. The increased atmospheric pressure could hardly be produced by the thunder-cloud; the action of the cloud could not be compared to that of a ship passing through the water, as the cloud was carried by the wind, and did not drive the wind before it. Probably the rapid changes in pressure were caused by eddies in the air resembling a cyclone on a small scale. When such a whirlwind passed over a spot the barometer would rise, then fall as the centre passed over, then rise again.

Mr. Russell said he forgot to mention that masters of vessels passing along the coast on the afternoon of the storm could not depend on the wind for 5 minutes. The wind appeared to be going round the compass all the afternoon. The velocity of wind at the Observatory was very small indeed—from 8 to 20 miles per hour. It appeared from the wind register to have been a double storm.

Professor Smith said that these observations were extremely interesting, but at the same time puzzling. No doubt the vortex theory might account for some of the barometrical changes; but about the thunder-cloud, they could not imagine it to be like a ship going through the water. How was a thunder-cloud formed? It must certainly be by the meeting and mixing of two winds. Take the thunder-storms that rose here from the south-west: we saw peculiar rolling clouds coming from the south-west, evidently formed by the meeting of a cold south-westerly wind with the warm moist north-easterly; from the mixing of the two winds it was easy to see how they produced a deposition of moisture and the thunder-cloud was formed. It was formed by the invisible moisture becoming visible, and its electricity being now restricted to a smaller surface the intensity increased so as to form lightning. The velocity of the upper wind determines the velocity of the cloud. The upper, cold wind probably, came on in a series of waves, like the tide-bore in the Hoogley, and so caused a successive rising and falling of the barometer.

The Chairman asked if dry seasons had any influence in the formation of these frequent thunder-storms. His experience was that in dry seasons thunder-storms were frequent. In moist seasons we had never had thunder-storms at all.

Mr. Russell said: The cause of thunder-storms is the meeting of the tropical and polar winds. The tropical is in summer a hot, dry wind, charged with electricity, and when a cold wind meets this the vapour gets condensed, and, as Professor Smith has explained, the electricity becomes distributed over fewer and larger water particles, which cannot take the whole charge, and the excess appears as disruptive discharges. Now, this meeting-ground of the two winds varies with the trades. In a hot summer the trade comes farther south, and we are in the latitude of the margin, and therefore in the latitude of thunder-storms; while in an ordinary year the meeting-ground of the two winds is north of us, and we have few storms. That the immediate cause is this meeting, I think, is proved by an investigation I went into last year, when I found, on examining 195 thunder-storms, that the two currents (tropical and polar) could be traced in 178. The fact that during the past two warm years we have had few storms seems to be opposed to the opinion here stated; but I think it could be explained in accordance with this view, only it would take me too long at this late hour. With regard to the vortex theory which Mr. Scott has suggested, I think we can hardly accept it as an explanation, for in all these cases the barometer shows a rise with the storm, whereas in hurricanes and smaller revolving storms the barometer always falls as the storm comes on, and rises as it goes off. Now, in America a theory has been ably put forward to account for the storms which are so frequent there. It has not been generally accepted, but it is in accordance with very many observed facts. According to this theory, when the tropical and polar currents meet, one passes above the other, and the actual plane of meeting is inclined to the surface of the ground, and the two surfaces are just in that condition when, in accordance with well-known laws, a vortex motion may originate from a small disturbing cause, such as an abrupt hill, and having once started, it travels with great velocity in the plane of the meeting. And I think it is not at all difficult to conceive that a vortex so originated by winds having the velocity of 70 or 80 miles per hour, as I have shown ("Climate of New South Wales") our upper currents to possess, may travel forward as an independent mass, with a velocity such as I have shown this storm of November 27 to have had. We see that such vortices do sometimes form, by the havoc they make in passing through our forests, but whether such a vortex mass passing through the air and not reaching the ground would cause the increase of pressure recorded by the barograph or not; I am not sure. I think it would, and that in its wake there would be a corresponding vacuum. Of course, pressure exerted on a fluid is distributed all over it, but when large spaces are concerned this takes time, and we know from many experiments that when a gale of wind blows against a high wall, the barometer shows a greater pressure to windward than to leeward, but theoretically it should not do so. And another fact which all who have watched the barometer here will remember, as soon as I mention it is, that when a southerly gale comes on, the barometer rises rapidly, and this is owing to the pressure exerted by the incoming wind forcing up the local wind, as may be seen in the peculiar rolling clouds, and in the fact that such a wind with a velocity of from 60 to 70 miles per hour will take from one and a half to two hours to travel from here to Newcastle, a distance of 60 miles. I confess I have some difficulty in accepting some of the conclusions which an investigation of this storm have led me to. But whether we accept its velocity and size or not, there can be no question that thunder-storms do affect the barometer as I have stated—that is, by a sudden rise as they come in, and an equally sudden fall after they are past.

PROCEEDINGS.

PROCEEDINGS

OF THE

ROYAL SOCIETY OF NEW SOUTH WALES.

WEDNESDAY, 2 MAY, 1877.

ANNUAL General Meeting of the Royal Society of New South Wales, held in the Society's Rooms, Elizabeth-street.

Mr. H. C. RUSSELL, F.R.A.S., V.-P., in the Chair.

The Annual Report of the Council was then read :—

"The Council begs to bring before the members a statement of the position of the Society and its progress during the last year.

"This progress, both in the number of members and general activity, is very encouraging, and justifies the hope that the Society is steadily advancing to that position of usefulness which our venerable Vice-President, the Rev. W. B. Clarke, had in view when alluding to its future, in his anniversary address of 1875.

"At the end of 1875 there were 176 members on the roll. 132 new members were elected in 1876, making 308 members, of whom three died during 1876-77, and seven withdrew, leaving 298 members at the beginning of this session of 1877.

"The financial position of the Society will best be seen by a glance at the balance sheet of the Honorary Treasurer, which shows that the receipts for the year were £413 12s.—the expenditure, £389 5s. 2d.—leaving, together with the balance brought over from the previous year, a Bank balance of £123 3s. 2d. to the credit of the Society.

"The most potent agency for bringing about a greater activity and a large increase in the number of members consisted in the establishment of Sections, which were formed during last year; and though a new experiment it may fairly be considered as a very successful one. These Sections were originally formed under nine heads, viz.—Astronomy, Chemistry and Mineralogy, Geology, Biology, Microscopy, Geography, Literature and Fine Arts, Medical, Sanitary and Social Science.

"Geology was temporarily amalgamated with Chemistry and Mineralogy, while the Section for Biology lapsed for the time being. As the preliminary meetings of each Section were not held till towards end of June, the actual work did not begin till July.

"In accordance with the By-laws, reports on the working of each Section were received by the Council from the Chairmen of the respective Sections. From these reports it appears that while several Sections were well attended and actively supported by the members, others may still be considered as only in their preliminary stage, and the Council hopes that the session now commencing will bring each Section into full and vigorous activity.

"The general meetings of the Society held during 1876 were, in addition to the annual Conversazione, which was held at the Masonic Hall on the 3rd of May, eight ordinary meetings and two extra meetings held at the Society's rooms. The meetings of the various Sections were held monthly at the Society's rooms.

"The Council has decided to publish the papers read at these meetings, as well as an Abstract of its Proceedings and those of the Sections, under the (for a small Society) less pretentious name of 'Journal,' instead of 'Transactions' as before.

"The Council much regrets the unavoidable delay in the issue of the Journal for 1876, which they hope, however, will be in the possession of members before long.

"During last year, a very large number of the Society's 'Transactions,' together with many other scientific publications issued by the Government, relating to this Colony, were forwarded by the Council to different Scientific Institutions in England, America, and the Continent of Europe. The Society has thus become one of the most effectual agencies for making this Colony favourably known abroad.

"Already a very numerous and valuable collection of books and pamphlets, received as donations in return for those just referred to, forms the nucleus of a future very valuable scientific library; and to this end the Council have also during last year subscribed, through Messrs. Trübner & Co., in London, for twenty-five different scientific periodicals—English, French, and German.

"The acquisition of these books and scientific periodicals has already filled up most of the available space at the Society's rooms.

"The Council has decided to open the rooms of the Society for three evenings each week during the eight months of the session—viz., on Monday, Wednesday, and Friday, from 7 to 10 o'clock—to enable members to make use of the books and periodicals.

"For the present, the Council has deemed it unadvisable to allow any books or periodicals to be taken away from the Society's rooms by any of the members; but as soon as the books are properly arranged and catalogued such advantage will be readily conceded, under proper restrictions.

"In May last a deputation elected by the members of the Society waited upon the then Minister of Justice and Public Instruction, with a view of urging upon the Government the claim of the Society to a liberal assistance in the shape of an annual endowment, and also a lump sum towards providing a suitable building for the Society.

"This deputation was courteously received by the Minister, who promised to bring the matter before his colleagues.

"The change of Ministry, which has since occurred, prevented this matter being brought to the desired issue. It has, however, quite lately been brought under the favourable consideration of the Hon. the Colonial Secretary, and the Council feel confident that both the Government and Parliament will take a liberal view of the position of this Society and its requirements.

"In such a case its usefulness will be largely increased, while at present the want of adequate funds prevents the Council from carrying out some of the most essential means for effecting such results".

At the conclusion of the Report, Dr. Leibius informed the members of the Society that Mr. Catlett, who had been Assistant Secretary for over twenty years, had, in consequence of the increased duties entailed by the enlarged sphere of the Society, been compelled to tender his resignation, which the Council accepted with much regret.

Mr. W. H. Webb had since been appointed as Assistant Secretary.

The following Financial Statement for the year ending 30th April, 1877, was read by the Rev. W. Scott, M.A., Honorary Treasurer:—

Receipts.

	£	s.	d.
To Balance in the Union Bank on the 30th April, 1876	98	16	4
,, Subscriptions and entrance fees	413	12	0
	512	8	4

Disbursements.

	£	s.	d.
By Rent of Rooms from 1st Feb., 1876, to 30th April, 1877	62	10	0
,, Office-keeper (Mrs. Casey) to 9th April, 1877	8	11	6
,, Hire of Masonic Hall for Conversazione	5	5	0
,, Refreshments do. do.	15	0	0
,, Sundry expenses do. do.	16	5	7
,, Refreshments for Monthly Meetings	19	16	0
,, Office furniture and effects	57	16	8
,, Stationery and Printing Account	82	11	11
,, Advertisements	19	0	1
,, Postage and Petty Cash Account	37	6	2
,, H. W. Ingram (Collector) Commission	8	16	3
,, Rev. W. Ridley, Reporting	6	6	0
,, Assistant Secretary's salary, from 1st January 1876, to 31st March, 1877	50	0	0
,, Balance in the Union Bank on 30th April, 1877	123	3	2
	£512	8	4

ASSETS.

	£	s.	d.
To Balance in the Union Bank	123	3	2
,, Subscriptions and entrance fees due	36	15	0
,, Furniture, books, and pictures, as insured	250	0	0
	£409	18	2

LIABILITIES.

	£	s.	d.
By Frederick White, printing account	21	7	6
,, S. T. Leigh & Co., do. do.	45	0	0
,, Assistant Secretary	23	6	8
,, Periodicals ordered	30	0	0
,, Balance of Assets over Liabilities	290	4	0
	£409	18	2

The statement was adopted.

A ballot was then taken, and the following gentlemen were duly elected officers and members of Council for the current year :—

PRESIDENT
(*ex-officio*) :
HIS EXCELLENCY SIR HERCULES ROBINSON, G.C.M.G.,
&c., &c., &c.

VICE-PRESIDENTS:
REV. W. B. CLARKE, M.A., F.R.S., F.G.S.
CHRISTOPHER ROLLESTON.

HONORARY TREASURER:
REV. W. SCOTT, M.A.

HONORARY SECRETARIES:
PROFESSOR LIVERSIDGE. DR. ADOLPH LEIBIUS.

COUNCIL:

FAIRFAX, JAMES R.
JONES, P. SYDNEY, M.D., M.R.C.S.
MOORE, CHARLES, F.L.S.
RUSSELL, H. C., B.A., F.R.A.S.
SMITH, HON. J., C.M.G., M.D.
WRIGHT, H. G. A., M.R.C.S.

The following gentlemen were balloted for and declared duly elected ordinary members of the Society :—

Arthur Burnell, Survey Office.
Alfred J. Cape, Pitt-st.

The certificates of eight new candidates were read.

The CHAIRMAN announced that arrangements had been made for the Council Room to be opened as a Reading Room three nights a week to the members during the session.

It was stated by the CHAIRMAN that arrangements had been made for the various Sections to hold meetings during the ensuing year, a card of which would when finally settled be printed for distribution amongst the members.

A list showing provisional arrangements had already been issued as follows:—

SECTIONS.

At 8 o'clock p.m.

	May.	June.	July.	Aug.	Sept.	Oct.	Nov.
A—Astronomy, &c., Wednesday	9	13	11	8	12	10	14
B—Chemistry, C—Geology } Friday	18	15	20	17	21	19	16
D—Natural History & Botany, Monday	7	4	2	6	3	1	5
E—Microscopy, Wednesday	23	27	25	22	26	24	28
F—Geography, Monday	14	11	9	13	10	8	12
G—Literature and Art, Friday	25	22	27	24	28	26	23
H—Medical, Friday	11	8	13	10	14	12	9
I—Sanitary, Monday	21	18	16	20	17	15	19

Upwards of two hundred donations were laid upon the table.

Letters were read from the following gentlemen acknowledging their election as honorary members of the Society, viz.:—

Sir James Cockle, M.A., F.R.S., Chief Justice of Queensland.
Professor L. G. De Koninck, M.D., University of Liege.

The Rev. W. SCOTT, M.A., moved—

"That in future no motion be made of which notice had not been given at a previous meeting, excepting motions of adjournment or others of a formal character."

The Hon. J. SMITH, C.M.G., M.D., LL.D., seconded the resolution, which was duly carried.

Mr. H. C. RUSSELL, B.A., F.R.A.S., Vice-President, then read his address, and referred to some of the more important scientific discoveries and improvements of the past year.

WEDNESDAY, 16 *MAY*, 1877.

The annual Conversazione given by the Society was held in the Masonic Hall, York-street, at 8 p.m. on the evening of May 16th, 1877; the gathering was very large, and the evening passed off most pleasantly and successfully.

Members on this, as on former similar occasions, were allowed to introduce the ladies of their families.

The total number of guests (including members, their ladies, and other friends who had received cards of invitation from members of the Council) present was between five and six hundred. In this respect the Conversazione surpassed the one given last year, when four hundred guests were present in response to the invitations issued on that occasion.

The Vice-Presidents and Council received the visitors at the western entrance to the large hall, in which room the principal objects of interest were exhibited.

The entrance hall in York-street, the supper-room in which refreshments were served during the evening, and the large hall were handsomely decorated by Mr. Charles Moore, F.L.S., Director of the Botanic Gardens, with green foliage, ferns, palms, and rare and choice plants from New Guinea.

The Band of the New South Wales Artillery played a selection of music during the evening.

The dark room was occupied by Mr. H. C. Russell's large Ruhmkorff coil and electrical apparatus, with which he repeated series of experiments from time to time during the evening.

A very large number of most interesting objects and pieces of apparatus were exhibited, the necessary references to which were made in the printed catalogue.

The Conversazione Committee consisted of the following members of the Council:—

Mr. H. C. Russell B.A., F.R.A.S.
Mr. Chas. Moore, F.L.S.
Professor Liversidge.
Dr. A. Leibius.

WEDNESDAY, 6 *JUNE*, 1877.

Ordinary monthly meeting of the Royal Society of New South Wales, held in the Society's rooms, Elizabeth-street.

The Rev. W. B. Clarke, M.A., F.R.S., V.P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society, viz.:—

Griffith Evan Russell Jones, B.A., 382, Crown-street, Surry Hills.
Norman Selfe, C.E., Balmain.
H. C. L. Anderson, M.A., Sydney Grammar School.
G. Kopsch, 8, Bridge-street.
W. Moore White, LL.D., Elizabeth-street.
Rev. Jacob Olley, Hunter's Hill.
Josiah Mullens, Hunter-street.
Percival R. Pedley, 1, Carlton Terrace, Wynyard Square.

The certificates of twenty-six new candidates were read.

Professor Liversidge stated that the different Sections of the Society had held their preliminary meetings and elected their officers for the current year.

One hundred and thirty-four pamphlets and nineteen volumes were laid upon the table.

A paper on the "Sphenoid, Cranial Bones, Operculum, and supposed Ear Bones of *Ctenodus*," and on the "Scapula, Coracoid, Ribs and Scales of *Ctenodus*," by Mr. W. J. Barkas, M.R.C.S., was read.

The Rev. W. B. Clarke then read a paper entitled "Notice of a new fossil gigantic Bird of Australia, now named *Dromornis Australis*" (Owen).

Mr. Alfred Roberts then read a paper on "The Liernur System of Sewage, its application to Hospitals and Towns." The paper was illustrated by several diagrams.

Mr. H. C. Russell exhibited an improved form of bichromate battery, by which the current of electricity generated is kept quite constant so long as it may be required. This is accomplished by allowing the bichromate solution to drop in slowly, and flow out at the same rate through a pipe which commences at the bottom of the cell and passes through the side, at three-quarters of an inch from the top. When the supply tap is turned, the solution collects in the cell until it rises to the level of the pipe, and it then begins to pass out as fast as it comes in.

As the bichromate solution passes down the cell its active properties are made use of, and when it reaches the bottom it is waste, and passes out as described. In use it is found that both the zinc and the salt solution are more economically used than in the ordinary bichromate cell.

WEDNESDAY, 4 JULY, 1877.

The Rev. W. B. Clarke, V.P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society :—

Dr. Tucker, Superintendent, Bay View Asylum, Cook's River.
Thomas Bladen, Pyrmont.
J. K. Hume, Cooma, Yass.
W. E. Jennings, B.A., Mining Department, Sydney.
Lawrence Hindson, Careening Cove, North Shore.
John Kinloch, M.A., Sydney.
Edward Knox, jun., Fiona, Double Bay.
Alfred Joseph Watt, Ashfield, Parramatta Road.
A. C. Fraser, North Shore.
Algernon H. Belfield, Eversleigh, Armidale.
Julius Anivitti, Artist, Academy of Art.
Francis A. Adams, Sydney.
F. M. Darley, M.A., Sydney.
W. C. Bundock, Wyangarie, Casino.
Thomas Kingsmill Abbott, P.M., Gunnedah.
— Abbott, Gunnedah.

John Bennett, Sydney.
Fredk. Evans Sloper, 96, Oxford-street, Sydney.
Samuel MacDonnell, 326, George-street, Sydney.
John Keep Broughton, Petersham.
Lawrence Hargrave, Supreme Court.
John Mann, Neutral Bay.
Thomas Slattery, Manly Beach.
William Morris, L.F.P., S.G., Wynyard-square, Sydney.
George Pile, Margaret-street, Sydney.
J. P. Garvan, 130, Elizabeth-street, Sydney.

The certificates of nine new candidates were read.

Professor LIVERSIDGE announced the following names of the Committee-men of the different Sections of the Society, viz.:—

Section A—*Astronomical and Physical Science.*—Chairman: H. C. Russell, B.A., F.R.A.S. Secretary: W. J. MacDonnell. Committee: Rev. G. Martin, H. G. A. Wright, M.R.C.S., G. D. Hirst, H. A. Lenehan.

Section B *and* C—*Chemistry and Geology.*—Chairman: Professor Liversidge. Secretary: W. A. Dixon. Committee: S. L. Bensusan, J. S. Sleep, G. A. Morrell, C.E., J. W. M'Cutcheon.

Section D—*Natural History and Botany.*—Chairman: R. D. Fitzgerald, F.L.S. Secretary: Arthur S. Stopps. Committee: James Norton, E. Daintrey. Curator of Herbarium: W. D. Armstrong.

Section E—*Microscopy.*—Chairman: A. Roberts, M.R.C.S., Secretary: G. D. Hirst. Committee: Rev. G. Martin, Hugh Paterson, J. Milford, M.D., M.R.C.S., W. MacDonnell.

Section F—*Geography.*—Chairman: E. Du Faur, F.R.G.S. Secretary: W. Forde. Committee: Hon. L. F. DeSalis, E. L. Montefiore, James Manning, H. A. Gilliat.

Section H—*Medical Science.*—Chairman: Dr. Neild. Secretaries: Dr. Sydney Jones, Dr. M'Laurin. Committee: H. G. A. Wright, M.R.C.S., Dr. Milford, Dr. Schuette, Dr. O'Reilly.

Section I—*Sanitary and Social Science.*—Chairman: Alfred Roberts, M.R.C.S. Secretary: Harrie Wood. Committee: H. W. Jackson, L.R.C.S., &c., W. J. G. Bedford, M.R.C.S., Dr. Belgrave, W. G. Murray.

Twenty-two volumes and fifty-eight pamphlets were laid upon the table.

The CHAIRMAN mentioned that Mr. James Norton had presented to the Society bound files of the *Sydney Morning Herald* from 1862 to 1872, and the sequent numbers up to the present date unbound.

Mr. H. C. Russell, B.A., F.R.A.S., gave notice that at the next meeting he should move the following resolution, viz.:—"That a Committee be appointed for the purpose of collecting money towards building or purchasing a home for this Society, and securing the money voted by Parliament towards this object."

The Rev. J. E. Tenison-Woods, F.G.S., F.R.G.S., hon. member, having been introduced by the Chairman, then read his paper "On Australian Tertiary Geology, and some new species of Polyzoa."

Professor Liversidge then read a paper "On the occurrence of Chalk in the Pacific Islands," and exhibited the specimens on which the paper was founded.

WEDNESDAY, 1 AUGUST, 1877.

Mr. Christopher Rolleston, V.-P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society:—

James Henry, 754, George-street.
Andrew Cunningham, Queanbeyan.
W. J. Weston, Union Club.
Edward R. Fairfax, 177, Macquarie-street.
Henry A. Perkins, Ocean-street, Woollahra.
T. T. Gurney, M.A., Professor of Mathematics, University of Sydney.
William Clarke, E. S. & A. C. Bank, Pitt-street.
James A. Paterson, Union Bank, Pitt-street.
George Lee Lord, Woolloomooloo.

The certificates of six new candidates were read.

Professor Liversidge announced that the Journal for 1876 had been received from the Government Printer, and would be distributed to the members of the Society without delay.

Seventy-seven donations were laid upon the table.

Mr. H. C. Russell, B.A., F.R.A.S., moved the following resolution:—"That a Committee be appointed for the purpose of suggesting how the sum of £500, voted by Parliament to aid in the erection of a permanent home for this Society, shall be obtained," and proposed that the Committee consist of the following gentlemen:—

Mr. Josiah Mullens.
Mr. A. S. Webster.
Rev. W. Scott, M.A.
Professor Liversidge.
Dr. Leibius.
Mr. H. C. Russell, B.A., F.R.A.S.

The resolution was duly carried.

Mr. W. A. Dixon, F.C.S., then read his paper "On a new method of extracting Gold, Silver, and other metals from Pyrites."

Mr. H. C. Russell, Government Astronomer, exhibited a new form of Crooke's Radiometer, and briefly explained its mode of action.

Professor Liversidge, at the request of Mr. P. N. Trebeck, drew attention to two large specimens of columnar sandstone from the head of Lane Cove, and briefly explained that the columnar structure had probably been set up in the sandstone at that place by the "baking action" of a dyke or overflow of basalt similar to the well-known instance at Bondi. He further stated that the same thing was often observed in the hearths of blast furnaces, where the sandstone floor, after exposure to the intense heat of the molten iron for some time, gradually became partially vitrified and split up into columnar masses, showing like the specimens exhibited a more or less regular polygonal form. Mr. Trebeck he understood wished to present the specimens on the table to the Society.

WEDNESDAY, 5 SEPTEMBER, 1877.

Mr. Christopher Rolleston, V.P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society :—

Neville Griffiths, the Domain, Sydney.
A. W. Anderson, Union Club, Sydney.
Thos. James Thompson, Pitt-street, Sydney.
Edward Lloyd Jones, 345, George-street, Sydney.
Richard Read, M.D., Singleton.
Charles James Fache, Cleveland House, Redfern.

The certificates of four new candidates were read.

The following report from the Finance Committee was brought up :—

"The Committee appointed for the purpose of suggesting how the sum of £500 voted by Parliament to aid in the erection of a permanent home for this Society shall be obtained, recommend that an appeal be made by the Council to the members of the Society and others for subscriptions in aid of the Building Fund.

The motion was put and passed, there being only two dissentients.

Ten donations were laid upon the table.

A statement of exchanges and presentations made by the Royal Society of New South Wales was distributed amongst the members, and the following list of publications received for distribution was read :—

"From the Hon. the Colonial Secretary, *per* Mr. Charles Potter, Acting Government Printer, 200 copies Essay on New South Wales; 100 copies Climate of New South Wales; 20 copies Kamilaroi. From the Under Secretary for Mines, 200 copies Mining Report for 1876. From the Commissioner for Railways, 100 copies Report of Railways, New South Wales. From the Government Astronomer, 100 copies Climate of New South Wales. From the President of the Council of Education 50 copies of the Report of the Council of Education for 1876."

The following letter from the Colonial Secretary was read:—

The Principal Under Secretary to Professor Liversidge.

Colonial Secretary's Office,
Sir, Sydney, 7 September, 1877.

In acknowledging the receipt of your letter of the 30th of last month, enclosing a printed paper setting forth the manner in which the publications supplied by the Government to the Royal Society of New South Wales have been distributed, I am directed by the Colonial Secretary to express to you his approval of what has been done and the satisfaction with which he has received this account of the distribution of those publications.

I have, &c.,
HENRY HALLORAN.

Professor LIVERSIDGE announced that the Journal of the Society for 1876 had been distributed to all members entitled to it for the current year.

The Rev. J. E. TENISON-WOODS, F.G.S., F.R.G.S., then read his paper on "The Palæontological Evidence of Australian Tertiary Formations."

A paper entitled "A Synopsis of Australian Tertiary Fossils," by Mr. R. ETHERIDGE, junr., F.G.S., was read.

WEDNESDAY, 3 *OCTOBER*, 1877.

Ordinary monthly meeting of the Royal Society of New South Wales, held in the Society's Rooms, Elizabeth-street.

CHRISTOPHER ROLLESTON, V.-P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society:—

William Edward Warren, M.D., M.R.C.S., 26, College-street, Sydney.

Rev. C. F. Garnsey, St. James's Parsonage, Sydney.

Joseph Palmer Abbott, Murrurundi.

The certificates of five new candidates were read.

Seventeen donations were laid upon the table.

A paper on "Ctenacanthus, a Spine of Hybodus," by Mr. W. J. BARKAS, M.R.C.S., was taken as read.

The Hon. J. SMITH, C.M.G., M.D., &c., then read his paper on "A System of Notation adapted to explaining to Students certain Electrical Operations."

The following papers on "Guano and other Phosphatic Deposits, Maldon Island," and "Notes on the Meteorology, Natural History, &c., of a Guano Island," were then read by Mr. W. A. DIXON, F.C.S.

WEDNESDAY, 7 NOVEMBER, 1877.

Ordinary monthly meeting of the Royal Society of New South Wales, held in the Society's Rooms, Elizabeth-street.

CHRISTOPHER ROLLESTON, V.-P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society:—

George Bennett, Toowoomba, Queensland.
T. A. Tenison-Woods, Phillip-street, Sydney.
James Merriman, Mayor of Sydney.
The Hon. E. A. Baker, M.P., Minister for Mines, Sydney.
Sir J. G. L. Innes, Knt., Darlinghurst.

The certificates of three new candidates were read.

One hundred and six donations were laid upon the table.

A paper on "Tertiary Corals," by the Rev. J. E. TENISON-WOODS, F.G.S., F.R.G.S., was then read by Professor Liversidge.

Mr. H. C. RUSSELL, B.A., F.R.A.S., read "Some Notes on the recent Opposition of the planet Mars," illustrated by a number of photographs of the planet, taken in Sydney, and reduced.

Professor LIVERSIDGE exhibited some interesting specimens of carbonate of lime deposited upon bundles of yarn brought from the Thames Gold Fields, New Zealand, by Mr. Fitzwilliam Wentworth, as showing the rapidity with which these deposits are made under favourable circumstances.

WEDNESDAY, 5 DECEMBER, 1877.

Ordinary monthly meeting of the Royal Society of New South Wales, held in the Society's Rooms, Elizabeth-street.

C. ROLLESTON, V.-P., in the Chair.

The minutes of the last meeting were read and confirmed.

The following gentlemen were duly elected ordinary members of the Society:—

L. M. Harrison, Moira, Burwood.
John Field Deck, M.D., 251, Macquarie-street.
H. S. Hawkins, M.A., Balmain.

The certificates of two new candidates were read.

Twenty-three donations were laid upon the table.

The following papers were read:—

1. On a new and remarkable Variable Star in the Constellation Ara, by John Tebbutt, F.R.A.S., &c.

2. On a Dental peculiarity of the Lepidosteidæ, by W. J. Barkas, L.R.C.P.L., &c.

3. Notice of a New Fossil Extinct Species of Kangaroo, *Sthenurus minor*, by Rev. W. B. Clarke, M.A., F.R.S., &c.

4. Notes on some recent Barometric Disturbances, by H. C. Russell, B.A., F.R.A.S.

The Rev. W. SCOTT, M.A., Hon. Treasurer, announced that in response to two circulars the sum of £399 3s. had been promised as subscriptions from sixty members towards the Building Fund; this fell short of the amount required (£1,000) to entitle them to the Parliamentary vote, but it was reasonably hoped that they would yet receive the requisite amount.

The CHAIRMAN remarked that as the vote held good for next year, they need not despair about the amount being made up in time.

The following is a copy of the circular and enclosures forwarded to the members of the Society:—

[*Circular.*]

THE ROYAL SOCIETY OF NEW SOUTH WALES.

The Society's Rooms,
Sydney, 13 September, 1877.

Dear Sir,

We have the honor to inform you that, in response to the representations made by the Society, the Government has been pleased to vote the sum of £500 towards the amount requisite to provide the Society with a permanent home, but on the condition that the Society raises the sum of £1,000.

Further, that at the General Monthly Meeting of the members of the Society, held on September 5th, it was resolved that, in order to raise the above amount, an appeal be made for subscriptions.

The Council considers it highly desirable that an earnest endeavour should now be made to obtain a house for the Society, not only to enable the Society to extend its sphere of scientific usefulness, as set forth in the memorandum at foot; but it is also of opinion that it is in the highest degree necessary to do so, inasmuch as the Society holds even its present inadequate accommodation merely as a yearly tenant, and it may at any time have to seek shelter elsewhere.

It is thought that should the Society secure the full amount of £1,500, it will be in a position to obtain a house (one which, with slight alterations, will be suitable for the Society's purposes), when, by judicious management, the Society's annual expenses need not be materially greater than at present; and, moreover, there is every probability that, by sub-letting, the annual expenses could be reduced to even a smaller amount than the rent now paid, viz., £60.

We are also directed to inform you that, to secure the valuable books and other property belonging to it, and to place the Society upon a permanent basis, the necessary legal instruments are now being drawn up to incorporate the Society by charter.

We have the pleasure to inform you that, in addition to the £500 towards a house for the Society, the late Government also voted £200 in aid of current expenses, which will make the income for the present year about £600.

Trusting that you may be favourably disposed towards this object, and willing to contribute to the same,—

We have, &c.,
A. LIVERSIDGE, } Hon.
A. LEIBIUS, } Secretaries.

MEMORANDUM

In re DEPUTATION TO THE GOVERNMENT FROM THE ROYAL SOCIETY OF NEW SOUTH WALES.

Reasons for the application for assistance.

1. *Popular Scientific Lectures.*—To enable the Society to institute courses of popular scientific lectures.
2. *Working Sections.*—To permit the establishment of working Sections of the Society for the promotion of special branches of science.
3. *Scientific Library.*—To enable the Society to form a Library of standard scientific works.
4. *To collect and distribute publications.*—To found a central institution in New South Wales for the exchange of scientific publications between the institutions of this Colony and those of other Countries. Recent experience has shown that the Transactions of this Society will be received as an equivalent for the publications of most of the leading Societies of Europe and America.
5. *Scientific investigations.*—In England similar scientific Societies afford valuable information to the Government on many subjects. The Royal Society of Sydney has done something in the past, and is anxious to do more in the future.
6. *Insufficient funds.*—The money at its disposal will not permit the Society to maintain even its present relations with the public and other Societies, and it is totally inadequate to carry out the contemplated extended scheme of usefulness.
7. *Other Societies receive aid.*—They feel that they are justified in making this request, because other Societies established here to educate and instruct the public receive grants of money and assistance.
8. *Societies in other Colonies.*—The corresponding Societies in Victoria, New Zealand, and Tasmania, are liberally supported and provided with suitable buildings by their respective Governments.
9. £5,000 *subscribed.—Assistance sought*—Since its commencement the Society has subscribed upwards of £5,000 for the

promotion of science and higher education in the Colony; and the undersigned now respectfully ask, in the name of the Society, for assistance from the Government, in order that they may make their past labours and present capabilities of more use to the public. The principal English scientific Societies are provided with suitable accommodation,—Burlington House having been recently rebuilt at great cost expressly for this purpose; and the Royal Society of London has large sums of money annually placed at its disposal by the Government.

W. B. CLARKE, Vice-President.
H. C. RUSSELL, Vice-President.
FRANCIS LORD.
J. S. FARNELL.
A. LANG, D.D.
C. MOORE.
A. LEIBIUS, Honorary Secretary.
A. LIVERSIDGE, Honorary Secretary.

[*Enclosure No.* 1.]

I HEREBY promise to contribute to the Building Fund of the Royal Society of N.S.W. the sum of £ on condition that the full amount of £1,000 be obtained necessary to secure the Government grant of £500.

(Signed)
(Address)

(Date)

[*Enclosure No.* 2.]

PRELIMINARY LIST OF SUBSCRIPTIONS promised towards the Building Fund of the ROYAL SOCIETY OF NEW SOUTH WALES, November 12th, 1877:—

	£	s.	d.
Brodribb, W. A., F.R.G.S., Double Bay	10	10	0
Clarke, Rev. W. B., M.A., F.R.S., North Shore	5	5	0
Fairfax, Edward, 177, Macquarie-street	10	10	0
Fairfax, James R., Double Bay	20	0	0
Hay, Hon. John, M.A., Rose Bay	20	0	0
Hume, Frank, Gunning	5	5	0
Josephson, J. F., F.G.S., Judge	20	0	0
Jones, P. Sydney, M.D., College-street	10	0	0
Liversidge, Professor, The University	10	0	0
Leibius, Dr. Adolph, The Royal Mint	5	0	0
Murray, W. G., 52, Pitt-street	5	0	0
Morehead, R. A. A., 30, O'Connell-street	10	0	0
Mullens, Josiah, 34, Hunter-street	10	0	0
Russell, H. C., B.A., F.R.A.S., Government Astronomer ...	10	0	0
Rolleston, Christopher, Auditor General	10	0	0
Scott, Rev. W., M.A., St. Paul's College	5	0	0
Smith, Hon. J., C.M.G., M.D., &c., The University	5	0	0
Tucker, G. A., Superintendent, Bay View Asylum	10	10	0
Ward, W., Oxford-street	5	0	0
Webster, A. S., Union Club	10	0	0
Wright, H. G. A., M.R.C.S.	5	0	0

ADDITIONS

TO THE

LIBRARY OF THE ROYAL SOCIETY OF NEW SOUTH WALES.

DONATIONS—1877.

The names of the Donors are in *Italics.*

REPORTS, OBSERVATIONS, &c.

ADELAIDE:—South Australian Institute, Library Catalogue Supplement.
Do. do. Reports from 1861–2 to 1875–6.
Do. do. Annual Report 1876-7. (Two copies.)
The Institute.

Meteorological Observations made at the Adelaide Observatory during the months of January, February, March, April, May, June, July, August, September, October, November, 1876.
Chas. Todd, C.M.G., F.R.A.S.

Report of the Progress and Condition of the Botanic Gardens and Government Plantations during the year 1876. *Dr. Schomberg.*

The Opening Ceremony of the Palm House in the Botanic Gardens, Adelaide. (Two copies.)

AUCKLAND:—Report of the Auckland Institute, 1875–76, 1876–77.
The Institute.

BOSTON:—First Annual Report of the Board of Health of the City of Boston, 1873.
Do., do., do., 1875.

Annual Report of the Boston Board of Trade, 1859, 1860, 1861, 1863, 1864, 1865, 1866, 1867, 1868, 1869, 1870, 1871, 1872, 1873, 1874, 1875, 1876.

Report of the School Committee, Boston, 1873, 1874.

Statistics of the Public Schools of the City of Boston, 1874-75.

Expenditure for the Public Schools. Report of the Committee on Accounts.
The Smithsonian Institution.

The Geographical Distribution of Animals and Plants. Part II. Plants in their Wild State. *Dr. Chas. Pickering.*

BRISBANE:—Report of the Acclimatisation Society of Queensland. 1876.
Lewis A. Bernays, F.L.S.

The Annual Report of the Queensland Philosophical Society. 1877. (Two copies.) *The Society.*

(Seven) Photographs of the Brisbane Reservoir (framed and glazed).
The National Agricultural and Industrial Association of Queensland.

DRESDEN:—Correspondenzblatt der Afrikanischen Gesellschaft. No. 21.
The Society.

FRANKFURT A/M.—Bericht über die Senckenbergische Naturforschende Gesellschaft. 1875–1876.

Abhandlungen herausgegeben von der Senckenbergischen Naturforschenden Gesellschaft. Elfter Band. Erstes Heft (with nine plates).
The Society.

GLASGOW :—The Glasgow University Calendar, 1877-78. *The University.*
GÖTTINGEN :—Nachrichten von der K. Gesellschaft der Wissenchaften und der Georg-August. Universität, 1876.
K. Gesellschaft der Wissenchaften Göttingen.
HEIDELBERG :—Verhandlungen des Naturhistorisch-Medicinischen Vereins zu Heidelberg. *The Society.*
IOWA :—Proceedings of the Davenport Academy of Natural Sciences. Vol. I., 1867–76. *The Academy.*
JENA :—Report from the Society of Natural History of Jena—

VIII.	Bd. N.F. 1.	Bd. I.
VIII.	Bd. N.F. 1.	Bd. II.
VIII.	Bd. N.F. 1.	Bd. III.
VIII.	Bd. N.F. 1.	Bd. IV.
IX.	Bd. N.F. 2.	Bd. I.
IX.	Bd. N.F. 2.	Bd. II.
X.	Bd. N.F. 3.	Bd. I.
X.	Bd. N.F. 3.	Bd. Supplement.
X.	Bd. N.F. 3.	Bd. II.
X.	Bd. N.F. 3.	Bd. IV.

Morgenbladet :—21, 22, 23, 24—October.
The Society.
KÖNIGSBERG :—Schriften der Physikalisch-ökonomischen Gesellschaft.

Vols. 1 and 2.	1875.	(Two copies.)		
	1867.	Parts	1 and 2.	
	1868.	Do.	1 and 2.	
	1869.	Do.	1 and 2.	
	1870.	Do.	1 and 2.	
	1871.	Do.	1 and 2.	(Two copies)
	1872.	Do.	1 and 2.	(Do)
	1873.	Do.	1 and 2.	(Do.)
	1874.	Do.	1 and 2.	(Do.)

LONDON :—Proceedings of the Royal Colonial Institute. Vol. VI, VII, and VIII.
Report of the Council of the Royal Colonial Institute.
Imperial Federation. By F. Young, Esq.
The Institute.
Proceedings of the Royal Society. Vol. XXV, Nos 172, 173, 174, 175, 176, 177, 178.
The Society.
Journal of the Linnean Society.
Botany—Nos. 82, 83, 84, 85, 86, 87, 91.
Zoölogy—Nos. 65, 66, 70.

First Report of the Local Government Board,			1871–72.
Second Annual Report		do.	1872–73.
Third	do.	do.	1873–74.
Fourth	do.	do.	1874–75.
Fifth	do.	do.	1875–76.

Report of a Committee on Modes of Treating Sewage; with Plans.
Reports of Poor Laws in Foreign Countries.
The Local Government Board.
List of the Linnean Society of London, 1876.
The Society.
Quarterly Journal of the Meteorological Society. Vol. III, No. 21.
The Society.
Royal Historical Society's Transactions. Vols. I, II, III, IV, V.
List of the Royal Historical Society.
Genealogical Memoirs of Scott and the Haliburtons.
The Society.

MANCHESTER :—Transactions of the Manchester Geological Society. Vol. XIV. Parts 6, 7, 8, 9, 10, 11, 12, 13. *The Society.*

MASSACHUSETTS :—

Massachusetts Fire and Marine Insurance Report, 1869–70–71–72–73–74–75.

Massachusetts Life Insurance Report, 1869–70–71–72–73–74–75.

Thirty-fifth Annual Report of the Board of Education, Massachusetts.

Thirty-sixth	do.	do.
Thirty-seventh	do.	do.
Thirty-eighth	do.	do.

State Board of Health of Massachusetts' Report, 1870–71–72–73–74–75.

Railroad Returns in Massachusetts, 1860–62–63–64–65–66–67–69–70–72–73–74–75.

Report on the Statistics of Labour, Massachusetts, 1870–71–74–75.

Registration Reports, Massachusetts, 1858–59–61–62–63–64–65–66–67–68–69–70–71–72–73.

Report of the Auditor of Accounts of the Commonwealth of Massachusetts, 1872–73–74.

Annual Reports of the Bank Commissioners, 1864–65.

Annual Report of the Commissioner of Savings' Banks, 1867–68–69–70–72–73–74.

Report of the Treasurer and Receiver-General of the Commonwealth of Massachusetts, 1872–73–74.

The Smithsonian Institution.

Memoirs of the American Association for the Advancement of Science. I.

Proceedings of the American Association for the Advancement of Science. (Twenty-fourth meeting.)

The Association.

Twelfth Annual Report of the Board of State Charities of Massachusetts, 1874–75. *The Director of the Board.*

Bulletin of Museum of Comparative Zoölogy. Vol. III. Nos. 1, 5, 6, 9, 10, 11, 14, 15, 16.

Memoirs of Museum of Comparative Zoölogy, No. 10.

Annual Report of do. 1874, 1875.

The Museum, Harvard College.

Essex Institute Historical Collection—
Vol. XI. Parts 1, 2, 3, 4.
Vol. XII. Parts 1, 2, 3, 4.
Vol. XIII. Parts 1, 2.

Bulletin of the Essex Institute—
Vol. V, 1873. Vol. VI, 1874. Vol. VII, 1875.

The Institute.

MELBOURNE :—The Victorian Year Book for 1875.

Statistical Register of the Colony of Victoria for the year 1875. Part VIII—Vital Statistics. Part IX—Religious, Moral, and Intellectual Progress.

Statistical Register of the Colony of Victoria, 1876. Part I—Blue Book. Part II—Population. Part III—Finance. Part IV. Part V. Part VI.

Agricultural Statistics, 1876-7—Supplementary Return.
Do. year ending 31 March, 1877.

Reports of the Mining Surveyors and Registrars (Victoria), quarter ending 31 December, 1876.

The Victorian Year Book, 1876-7.

The Government Statist.

Select Plants readily eligible for industrial culture or naturalization in Victoria.

MELBOURNE—*continued.*

Descriptive Notes on Papuan Plants—V.

The Government Botanist.

Report of the Mining Surveyors and Registrars of Victoria, quarters ending 30th September, 1876. *The Registrar General.*

Sixteenth Report of the Central Board of Health, Victoria.

Seventeenth do. do. do.

The Central Board of Health, Melbourne.

Reports of the Mining Surveyors and Registrars of Victoria, quarters ending 31st March, 1877, and 30th June, 1877.

Report of the Chief Inspector of Mines for 1876.

Mineral Statistics of Victoria for 1876.

Geological Survey of Victoria—Report of Progress. No. IV.

The Hon. the Minister for Mines, on behalf of the Government of Victoria.

Melbourne Medical Record.

Do. Vol. VII, No. 3.

The Publishers.

Transactions and Proceedings of the Royal Society of Victoria. Vol. XII. *The Society.*

Results of Observations taken at the Melbourne Observatory. Vol. IV. 1875. *The Government Astronomer.*

Prodromus of the Palæontology of Victoria. Nos. 1, 2, 3, and 4.

The Vice Chancellor of the University, Melbourne.

MIDDLESBOROUGH:—The Journal of the Iron and Steel Institute. Nos. 1 and 2, 1876, and No. 1, 1877. *The Institute.*

MISSOURI:—The Transactions of the Academy of Science of St. Louis. Vol. III., Nos. 1, 2, 3. *The Academy.*

PHILADELPHIA:—Report of the Twenty-seventh Exhibition of American Manufacturers, held in the City of Philadelphia, 1874.

Franklin Institute, A.D., 1824–74.

Charter and By-laws of the Franklin Institute.

Theory of the Moon's Motion, by Jno. N. Stockwell, M.A.

The Journal of the Franklin Institute, No. 613, 614, 615, 616, 617, 618, 619, 620, 621, and 622.

The Franklin Institute.

Proceedings of the Academy of Natural Sciences of Philadelphia. Parts I, II, III, 1875.

Do. do. do. Parts I, II, III, 1876.

The Academy.

Philadelphia Centennial Exhibition Commission:—Catalogues, Navy Department Exhibits. (Two copies.)

Seventh Annual Report of the State Board of Health of Massachusetts, January, 1876. (Two copies.)

Thirty-ninth Annual Report of the Board of Education, Massachusetts. (Two copies.)

Fifth Annual Report of the Railroad and Warehouse Commission of the State of Illinois, November 30, 1875. (Five copies.)

Eighteenth Annual Report of the Trade and Commerce of Chicago, for year ending December 31, 1875. (Five copies.)

Thirty-third Report of the Registry and Return of Births, Marriages, and Deaths, in the Commonwealth of Massachusetts.

One hundred and ninety-two Pamphlets.

The Philadelphia Exhibition Commission.

Proceedings of the American Philosophical Society. Vol. XV., No. 96. "The Rhynchophora of America." *The Society.*

PISA :—Atti della Societa Toscana di Scienze Naturali. Vol. I, fasc 3; and Vol. II, fas. 2. *The Society.*

STUTTGART :—Württembergische Jahrbücher für Statistik und Landeskunde herausgegeben von dem K. Statistisch-Topographischen Bureau.
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In the following List the numbers refer to the below-mentioned Publications :—

No. 1.—Journal of the Royal Society of New South Wales, 1876.
„ 2.—Progress and Resources of New South Wales.
„ 3.—Report of the Mining Department, 1876.
„ 4.—Climate of New South Wales.
„ 5.—Report of the Commissioner for Railways, 1876.
„ 6.—Report of the Council of Education, 1876.
„ 7.—Kamilaroi, and other Australian Languages.
„ 8.—L'Empire du Brasil.
„ 9.—Report of the Massachusetts Institution of Technology.
„ 10.—Mineral Map and General Statistics of New South Wales.

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„ Naturforschende Gesellschaft zu Freiberg. Nos. 1, 2, 3, 4, 5, 6.

Gottingen.—Königliche Gesellschaft der Wissenschaften in Göttingen. Nos. 1, 2, 3, 4, 5, 6, 7.

Gorlitz.—Naturforschende Gesellschaft in Görlitz. Nos. 1, 2, 3, 4, 5, 6, 9.
Also, Catalogue of Chilian Exhibition.

Hamburg.—Die Geographische Gesellschaft in Hamburg. Nos. 1, 2, 3, 4. 5, 6, 7, 8.—Also :
Catalogue of Chilian Exhibition.
Dominion of Canada (Province of Ontario).
Geological and Topographical Atlas of New Zealand.
Resources of West Virginia.

„ Verein für Naturwissenschaftliche Unterhaltung in Hamburg. Nos. 1, 2, 3. 4.

Heidelberg.—Naturhistorisch Medicinische Gesellschaft zu Heidelberg. Nos. 1, 2, 3, 4, 5, 6, 7.

Jena.—Medicinish Naturwissenschaftliche Gesellschaft. Nos. 1, 2, 3, 4, 8.
And the Increase of Human Life.

Konigsberg.—Die Physikalisch-ökonomische Gesellschaft. Nos. 1, 2, 3, 4, 5, 6, 9.
And the Catalogue of the Chilian exhibits.

Leipzig (Saxony).—University Library. Nos. 1, 2, 3, 4, 5, 6, 7, 9, 10.

Marburg.—The University. Nos. 1, 2, 3, 4, 5, 6, 7, 8.

Muhlhausen.—Industrial Society. Nos. 1, 2. 3, 4, 5.

Munchen.—Königliche Akademie der Wissenschaften in Munchen. Nos. 1, 2, 3, 4, 5, 6, 7, 9, 10.

Stuttgart.—Königliche Statistich Topographische Bureau zu Stuttgart. Nos. 1, 2, 3, 4, 5, 6.

Wurtemberg.—Der Verein für Vaterländische Naturkunde in Wurtemberg. Nos. 1, 2, 3, 4, 5, 6.

India.

Calcutta.—The Asiatic Society. Nos. 1, 2, 3, 4, 5.
„ The Geological Museum. Nos. 1, 2, 3, 4, 5.
„ The Geological Survey of India. Nos. 1, 2, 3, 4, 5.

Ireland.

Dublin.—Geological Society. Nos. 1, 2, 3, 4.
„ Royal Irish Academy. Nos. 1, 2, 3, 4, 5.

Italy.

Bologna.—Accademia delle Scienze dell'Istituto. Nos. 1, 2, 3, 4, 10.

Genoa.—Musio Civico di Storia Naturale. Nos. 1, 2, 3, 4.

Milan.—Reale Istituto Lombardo di Scienze Lettere ed Arti. Nos. 1, 2, 3, 4, 6, 10.
„ Società Italiana di Scienze Naturali. Nos. 1, 2, 3, 4.

Naples.—Società Reale Accademia delle Scienze. Nos. 1, 2, 3, 4, 10.
„ Zoological Station (Dr. Dohrn). Nos. 1, 2, 3, 4.

Palermo.—Accademia Palermitana di Scienze Lettere ed Arti. Nos. 1, 2, 4.
„ Reale Istituto Technico. Nos. 1, 2, 3, 4, 5.

Pisa.—Società Toscana di Scienza Naturale. Nos. 1, 2, 3, 4.

Rome.—Accademia Pontificia de' Nuovi Lincei. Nos. 1, 2, 3, 4.
„ Circolo Geographico d'Italia. Nos. 1, 2, 3, 4, 10.
„ Osservatorio del Collegio Romano. Nos. 1, 2.
„ R. Accademia die Lincei. Nos. 1, 2.
„ R. Comitato Geologico Italiano. Nos. 1, 2, 3, 10.

Siena.—R. Accademia de Fisiocritici. Nos. 1, 2, 3, 4.

Trieste.—Società Adriatica di Scienze Naturale. Nos. 1, 2, 3, 4.

Turin.—Reale Accademia delle Scienza. Nos. 1, 2, 3, 4.
,, Regio Osservatorio della Regio Universita. Nos. 1, 2, 4.
Venice.—Reale Istituto Veneto di Scienze Lettere ed Arti. Nos. 1, 2, 3, 4, 6.

NETHERLANDS.

Amsterdam.—Académie Royale des Sciences. Nos. 1, 2, 3, 4, 5, 8, 10.
Also, Mines and Mineral Statistics of New South Wales. 1875.
Haarlem.—Société Hollandaise des Sciences. Nos. 1, 2, 3, 4, 5, 8, 10.

NORWAY.

Christiana.—Kongelige Norske Fredericks Universitet. Nos. 1, 2, 3, 4, 5.

RUSSIA.

Moscow.—La Société Impériale des Naturalistes. Nos. 1, 2, 3, 4.
St. Petersburg.—L'Académie Impériale des Sciences. Nos. 1, 2, 3, 4, 7.

SCOTLAND.

Edinburgh.—Geological Society. Nos. 1, 2, 3, 4.
,, Royal Physical Society. Nos. 1, 2, 3, 4.
,, The Royal Society. Nos. 1, 2, 3, 4, 5.
Glasgow.—Geological Society. Nos. 1, 2, 3, 4.
,, The University. Nos. 1, 2, 4, 6.

SPAIN.

Madrid.—Instituto Geografico y Estadistico. Nos. 1, 2, 3, 4, 10.

SWEDEN.

Stockholm.—Kongliga Svenska Ventenskapo-Akademie. Nos. 1, 2, 3, 4, 5.

SWITZERLAND.

Geneva.—Institute National Genevoie. Nos. 1, 2, 3, 4, 5.
Lausanne.—De la Société Vaudoise des Sciences Naturelles. Nos. 1, 2, 3, 4, 5.
Neuchatel.—Société des Sciences Naturelles. Nos. 1, 2, 3, 4.

Number of Publications sent to	Great Britain	306
,, ,, ,,	The Colonies	70
,, ,, ,,	America	153
,, ,, ,,	Europe	517
,, ,, ,,	Editors of Periodicals ...	20
	Total ...	1,066

A. LIVERSIDGE, } Hon. Secretaries.
A. LEIBIUS, }

The Society's Rooms, Sydney, 19 August, 1877.

REPORTS FROM THE SECTIONS
(IN ABSTRACT).

REPORTS FROM THE SECTIONS.

(IN ABSTRACT).

SECTION A.—ASTRONOMY AND PHYSICS.

PRELIMINARY MEETING—9 MAY, 1877.

Mr. H. C. Russell, F.R.A.S., in the Chair.

The preliminary meeting of this Section was held on 9th May, 1877, and the following members were appointed as office-bearers for the Session of 1877:—Chairman: Mr. H. C. Russell, B.A., F.R.A.S., F.M.S., &c., Government Astronomer. Committee: Mr. G. D. Hirst, Mr. H. A. Lenehan, Rev. Geo. Martin, and Mr. H. G. A. Wright, M.R.C.S. Hon. Secretary: Mr. W. J. MacDonnell, F.R.A.S.

The Chairman drew attention to the importance of correctly mapping that portion of the Milky Way near the constellation of Crux Australis, as considerable discordances existed between previous representations and the actual appearance of the Galaxy. After discussion the Section adopted the Chairman's proposal, and it was decided that drawings should be prepared for the next meeting.

Mr. Russell exhibited some beautiful drawings of Lissajous's Sound Curves. The patterns were very interesting and intricate, and were drawn by an instrument made from Mr. Russell's instructions by Mr. Lenehan.

FRIDAY, 1 *JUNE*, 1877.

Mr. H. C. Russell, F.R.A.S., &c., in the Chair.

The Rev. Geo. Martin read a paper on "The appearance of that portion of the Milky Way traversing the constellations "Centaurus" and "Crux Australis," accompanied with a drawing illustrating his remarks. The writer stated that he noticed considerable discrepancies in representations of the Galaxy, particularly instancing the part in the vicinity of the two bright stars Alpha and Beta Centauri, which actually seem to lie in the dark opening between the two streams, whereas in most star maps they are represented as being involved in the main stream.

Discussion ensued.

Mr. Russell read some notes on the ever memorable and disastrous storm of 10th Sept., 1876 (the "Dandenong" gale). He traced the course of the gale in its progress through the Colony. The high velocity of the wind (153 miles per hour) registered by the Observatory instruments was confirmed beyond a doubt. Mr. Russell exhibited some maps and drawings in illustration of his paper.

FRIDAY, 6 JULY, 1877.

Mr. H. C. Russell, F.R.A.S., &c., in the Chair.

The Chairman exhibited a series of drawings of the "Milky Way" in the neighbourhood of the "Southern Cross." Some of the drawings had been prepared at his request in the early part of 1873, by Messrs. Hirst, Lenehan, Savage, and others; the rest were drawn by himself quite recently. Mr. G. D. Hirst also submitted a drawing of the same part of the Galaxy made during the past month. All these drawings exhibited variations which were more or less attributable to the differenceof eyesight, and the fineness, or otherwise, of the night, but were fairly in accordance with each other. On comparison with the representations made by Dunlop in 1827, and Sir John Herschel in 1837, considerable differences were shown to exist, particularly in the portions surrounding Alpha and Beta Centauri and the "Coalsack" in the Cross.

Mr. Hirst then presented a drawing in crayon of Jupiter, taken from a Browning, with equatorially mounted reflector of 10¼ inches aperture;—accompanied with a few notes on the present appearance of the planet. He had noticed considerable alteration in the equatorial belt, the central portion of which was now white, in place of being yellow as observed at the opposition of 1876. The green colour of the north polar markings was also much less perceptible this year than formerly.

Mr. Russell stated that, observing the transit of one of the satellites across the disc of the planet, he had been very much struck with the resemblance the satellite in transit bore to one of the white spots occasionally seen in the equatorial belt. Any casual observer might easily have mistaken the satellite for one of the white spots in question. Mr. Russell also gave some particulars about the well-known binary Alpha Centauri. The components are rapidly approaching, and peri-astron will probably occur in 1878. Accurate measures of distance and position are now especially valuable, as considerable discrepancies have been noticed between the predicted and observed places of the two members of this celebrated double star. Mr. Russell had been taking observations with the large refractor by Schroder of $11\frac{3}{5}$-inch aperture, power used 450 diameters; on 5th July, 1877, he found the distance 2″597, angle of position 72°520.

Mr. W. J. MacDonnell exhibited a fine copy in excellent preservation of Scheiner's "Rosa Ursina" folio, Bracciano, 1630. This scarce book, the work of the Jesuit astronomer Scheiner, a contemporary of Galileo, contains one of the earliest published accounts of the spots on the sun's disc, and is profusely illustrated with beautiful steel engravings; it is also interesting from the description of the many difficulties that the first telescopic observers had to conquer in their pursuit of science. Mr. MacDonnell also showed a new form of star-spectroscope made by Browning from designs by Mr. MacClean; the speciality in this instrument consists in the necessity for having a slit being obviated, and in its adaptability to telescopes of 3-inch apertures and upwards.

A discussion on all the points brought before the Section ensued.

FRIDAY, 3 *AUGUST*, 1877.

Mr. H. C. Russell, F.R.A.S., &c., in the Chair.

The Chairman stated that he had been in correspondence with Mr. H. J. Beatson, late Master R.N., and resident in Levuka, Fiji, relative to the transit of some dark body across the sun's disc on 17th March, 1877. Mr. Beatson had in the first place communicated his observation to the Sydney Observatory, in a letter dated 10th May, 1877, and in reply to a request from Mr. Russell for fuller details he supplied the following account of his observation:—

Levuka, Isle of Ovaulau,
Fiji, 12 July, 1877.

H. J. Beatson, Esq., to H. C. Russell, Esq.

Dear Sir,

Your favour of 28th June is to hand, and in reply thereto I beg to subjoin the following account of my observation on the 17th March last, and much regret I had not been more fully prepared for such an advent, so that a more minute description could have been given.

1st. On 15th and 16th March I observed, though indistinctly, one of the usual spots on the sun's disc, but not larger than usual.

2nd. On 17th March I was using my sextant as usual with a moderately powerful inverting tube, when I observed the first shadow as before described; it was then distinctly clear of the S.E. limb of the sun, the tail or shadow tending downwards to the north.

3rd. The point or head was dark, nearly black, and gradually lighting towards the tail; the tail or shadow was quite transparent graduated into mist.

4th. I have estimated the diameter of head both by calculation and comparison with the same instrument to be $\frac{2}{5}$ the size of Jupiter. Of course

I could not well define its exact shape on account of the mist which surrounded it, but the upper portion clear of the mist was sufficiently defined to determine its spheroid form.

5th. Its greatest alt. at 9 h. 6 min. 12 sec. was fully ⅓ of the sun's disc off the l. l., the shadow nearly reaching to the l. l., but inclining still to the north.

As the shadow passed to the northward, the whole body partook of the elliptical form, as shown in the sketch, the centre rising about 15°–16° from the points of ingress and egress. The shadow was entirely lost as it passed off the sun to the N.E., and the last I saw of it after attentively watching was a mere dark speck, nor was there anything to be observed near the northern l. of the sun afterwards.

March 17th.—This morning was beautifully clear with light S.E. wind, nothing to interrupt the sight, and for that reason I had selected the time to determine the error and rate of chronometer.

Position of point observation, Lat. S....	17 deg.	42 min.	43 sec.
Time E....	11 h.	55 min.	16 sec.
1. Time when shadow was first observed	8 h.	55 min.	15 sec.
,, centre..................................	9 h.	6 min.	46 sec.
,, last contact	9 h.	22 min.	57 sec.
Mean altitude corrected......................	41 deg.	38 min.	30 sec.
Worked by lat.	17 deg.	43 min.	
Bearing S. 76 deg. E.			

I will be glad at any time to give any further information on this subject in my power, and beg to remain,

Dear Sir,

Yours very faithfully,

HUME J. BEATSON.

Mr. RUSSELL stated that he had forwarded the original letters to M. Leverrier, Astronomer for France, Paris.

Rev. G. MARTIN read a paper on the appearance of the planet Mars, as viewed in his 5-inch Cooke equatorial; the great south polar snow-cap was prominently visible. Mr. Martin noticed the border of the snow-cap is that of an arc, and seems to cut the disc of the planet like the intersection of a circle—whereas in Warren De La Rue's drawing of Mars at his opposition of 1856 the cap terminates in a bluff point. The other details on the planet's surface were not distinctly made out,—a circumstance probably due to the fact that the intense brilliancy of Mars in Mr. Martin's telescope had blotted them out.

Mr. J. U. C. COLYER exhibited a working model of an observatory he is erecting for his 10¼-inch silvered glass equatorial.

A set of seven eye-pieces for the fine refractor at the Sydney Observatory, made by Schroeder of Hamburgh, were shown by the Chairman. These eye-pieces ranged in power from 130 to 1,500, and constructed after designs by Mr. Russell. A special feature in their construction was the ease with which the lenses could be removed, and consequent lessening of risk of injury when cleaning them.

Mr. RUSSELL further read a paper by Howard Grubb, F.R.A.S. of Dublin, on "The Telescopes of the future," in which the author entered minutely into the difficulties to be contended with in the construction of large instruments; and after balancing the comparative advantages and disadvantages between reflectors and refractors, finally inclined to the opinion that the Cassegraineau form of reflector would offer least difficulty in any increase of dimension over those now in use. The meeting then terminated.

FRIDAY, 7 SEPTEMBER, 1877.

Mr. H. C. Russell, F.R.A.S., &c., in the Chair.

Both the Chairman and Mr. G. D. Hirst brought several fine drawings of Mars. A comparison between these and the work of observers at former oppositions brought out many points of agreement; sufficient material was not ready to afford a complete collation with the results of previous workers in this field of Astronomy. The great snow-cap surrounding Mars' southern pole had of late decreased considerably in size, owing doubtless to the rapid approach of midsummer to the planet's southern hemisphere. From a mean of several measures Mr. Russell found a polar compression of $\frac{1}{40}$th closely in accordance with Main's results, who makes it $\frac{1}{39}$th; it is to be noted, however, that other observers have given widely different values to this compression, the ellipticity not being distinguishable by the eye like that of Jupiter.

FRIDAY, 5 OCTOBER, 1877.

Mr. H. C. Russell, F.R.A.S., &c., in the Chair.

Mr. Russell submitted a series of drawings of Mars made by himself, Mr. A. Fairfax, and Mr. G. D. Hirst. These were arranged so as to form a consecutive series of views showing a whole revolution of the planet. Several features were identified on comparison with the drawings of Dawes, but the markings as a whole showed little resemblance to any previous delineation of the planet. Mr. Russell stated that a telegram had been received from Sir G. Airy, the Astronomer Royal, informing him that two satellites to Mars had been discovered at Washington, and requesting a search for the new satellites. Mr. Russell said he had kept a careful watch on Mars with $11\frac{3}{8}$-inch refractor, but had not succeeded in seeing them. A discussion took place on some curious facts connected with the thunderstorm of 23rd September, 1877, and the meeting closed.

FRIDAY, 2 NOVEMBER, 1877.

This meeting lapsed, owing to the absence of several of the members from town.

SECTION B.—CHEMISTRY, MINERALOGY, and by amalgamation with Section C, GEOLOGY and PALÆONTOLOGY.

FRIDAY, 18 MAY, 1877.

PROFESSOR LIVERSIDGE in the Chair.

THE principal business before the meeting was to elect a new Committee, and to make arrangements for the ensuing year. The following members were elected a Committee, viz.,—PROFESSOR LIVERSIDGE, Chairman; Mr. DIXON, F.C.S., Secretary; and Messrs. SLEEP, MORELL, M'CUTCHEON, and BENSUSAN. It was resolved to make application to the Council for a sum of money for the purchase of a cabinet for the preservation of geological and other specimens collected by the Section and presented to the Society, and for the purchase of standard works of reference upon branches of science embraced by this and the closely allied Sections. A discussion ensued as to the future work of the Section, and Professor Liversidge suggested that excursion parties should be made to visit certain interesting geological sections in the neighbourhood of Sydney. He also proposed that certain members should make a detailed study of the outcrops of the various basaltic dykes (as the one at Bondi) which exist in the vicinity, and should prepare a map of the same; while others should make it their business to plot out the areas of, and the faults in, the Wianamatta shales of the county of Cumberland. Another most interesting object for the investigation of such excursion parties would be to ascertain the extent and general characters of such river drift deposits as that on Lapstone Hill.

Mr. M'CUTCHEON called the attention of the Section to the variable nature of the alloys of Australian gold with silver, and thought that an investigation into the question would be interesting, especially as the quality of certain samples of native gold seems to indicate that deposits have yet to be found in this Colony.

Mr. BENSUSAN exhibited samples of the solid core of hard sandstone and quartzite brought up by the new diamond rock-boring apparatus. He also offered some explanatory remarks upon a series of photographs showing the apparatus at work and the different parts of the same. The meeting then adjourned.

FRIDAY, 15 JUNE, 1877.

PROFESSOR LIVERSIDGE in the Chair.

Mr. M'CUTCHEON brought under the notice of the Section a process for the analytic separation of nickel and cobalt, founded on the solubility of sulphide of nickel in cyanide of potassium and the insolubility of sulphide of cobalt.

Mr. SLEEP exhibited specimens of crystallized quartz penetrated by acicular crystals, probably hornblende and crystallized cuprous oxide (cuprite), from Cloncurry mine, encrusted with the *blue* carbonate or chessylite.

Mr. BENSUSAN mentioned having found associated with some specimens of noumeite a considerable quantity of carbonate of bismuth.

FRIDAY, 20 *JULY*, 1877.

PROFESSOR LIVERSIDGE in the Chair.

The CHAIRMAN announced that a sum not exceeding £20 had been placed at the disposal of the Section, for the purchase of a suitable cabinet.

A conversational discussion took place upon chemical and geological subjects, especially relating to work which the Section might undertake.

FRIDAY, 17 *AUGUST*, 1877.

PROFESSOR LIVERSIDGE in the Chair.

PROFESSOR LIVERSIDGE announced that the Hon. F. Lord had invited the members of the Section to examine the Devonian measures near Mount Lambie; and that Mr. P. N. Trebeck had invited them to visit the columnar sandstone at the head of Lane Cove, on days to be subsequently fixed.

Mr. BENSUSAN exhibited a series of interesting silver and copper ores from America, also specimens of cinnabar and other minerals; together with a reputed rhodium ore from Monroe, Orange Co., U.S.

FRIDAY, 21 *SEPTEMBER*, 1877.

PROFESSOR LIVERSIDGE in the Chair.

The CHAIRMAN exhibited a series of specimens of characteristic American minerals, lately received by him from Dr. Forbes, of New York. The collection included examples of many rare and beautiful minerals peculiar to the American continent.

FRIDAY, 19 *OCTOBER*, 1877.

PROFESSOR LIVERSIDGE in the Chair.

The CHAIRMAN showed a specimen of native moss gold, on the artificial formation of which he had read a paper to the Society last session. This specimen occurred on a piece of mispickel from the Uncle Tom claim, Lucknow. He also exhibited a piece of lignite from the Rewa River, Fiji, with the following note attached:—During the time that Mr. Layard, C.M.G., was

Consul in the Fijis, I received from him a small specimen of lignite which he had obtained from the Rewa River. Description: black in colour, the weathered surfaces more or less grey; brittle, breaking with a sub-conchoidal fracture; the fresh surfaces possess a resinous lustre; yields readily to the knife, and furnishes a black powder, and shining streak; it burns readily, but like charcoal almost without flame; no coke is formed, but a voluminous brown-coloured ash is left. Sp. gr. 1·30. Small particles of pyrites are present.

Approximate analysis—

Moisture	16·82
Combustible matter... ...	75·16
Ash...	8·02
	100·00

A second piece yielded only 7·2 per cent. of ash. The portion entered under head of combustible matter includes the sulphur, nitrogen, oxygen, and hydrogen present, which it was not thought necessary to determine until further information was received as to the extent and thickness of the deposit. It is not dissimilar to many lignites used for fuel in Europe.

SATURDAY, 28 *OCTOBER*, 1877.

The members of the Section, on the invitation of Mr. P. N. Trebeck, went to the head of Lane Cove to examine the columnar sandstone which he had brought before the notice of the Society at one of the early meetings of this session.

The columnar structure, in which the individual pieces are of an irregular polygonal form in section, occurs on the top of a hill. It has been formed from the ordinary sandstone, probably by an outflow of basalt or other igneous rock since removed by denudation; the subsequent contraction in cooling causing the mass to form fissures in the lines of least resistance.

FRIDAY, 16 *NOVEMBER*, 1877.

PROFESSOR LIVERSIDGE in the Chair.

PROFESSOR LIVERSIDGE exhibited some interesting specimens of the siliceous and other deposits from some of the hot springs in New Zealand. He stated that he was not prepared with any paper descriptive of them, or of the geology of the localities whence they were obtained, for such would take up much more time than he could at present devote to the matter; and moreover, such a paper would perhaps be more or less superfluous, after the many able descriptions of these springs which had been already published by various observers. He would only trouble them with a few remarks upon certain of the specimens, and would invite their attention to the series of photographs placed on the table, in lieu of any description of the place. Amongst the specimens were some samples of siliceous sinter, from a spring opposite the hotel at Ohaiawai, on the road between the Bay of Islands and Hokianga on the west coast; also of cinnabar, from the mercurial springs near to the same place. Professor Liversidge mentioned that he was much struck by the general similarity between the "volcanic" phenomena at Ohaiawai and those presented by the burning coal seam at Mount Wingen, the so-called "burning mountain," near to Scone—the chief differences being that the phenomena at the latter place are confined to a more limited area, and that water is absent; hence there are no hot springs or pools of warm water at Mount Wingen, as there would be if the jets of steam and heated vapour had to make their upward passage through water. The escaping gases at both places possess very much the same general character, and deposit similar sublimates of sulphur and certain volatile salts around the vents. At the hot mercurial springs near Ohaiawai the mercury occurs both in the native state and in the form of cinnabar; some of the cinnabar is apparently of recent deposition, since it was observed in one place to uniformly and completely fill certain small cracks and crevices existing in the shaly rock, but the greater part of it is evidently mechanically brought to the spot by the small stream which runs down to the lake. The presence of an extensive deposit of coal, shale, or pyrites undergoing a smothered combustion would be quite sufficient to account for the phenomena observed at Ohaiawai and other hot springs in New Zealand—even for the celebrated ones at Ohinemutu and at the Pink and White Terraces on the Lake Rotomahana. Respecting the beautiful bright blue colour of the water in the basins on the Pink and White Terraces at Rotomahana, a blue so extraordinarily beautiful that many travellers are unable to find words to express their admiration for it, Professor Liversidge explained that the blue colour was due to the reflection of the light from the innumerable minute particles of silica suspended in the water—just as the pale sky-blue colour of a mixture of milk and water is caused by the reflection of the light from the minute fat globules suspended in it. He was also inclined to attribute the equally beautiful blue colour of the lower layers of steam floating over the surface of the boiling waters to a similar cause, for he had but little doubt that the escaping steam bears minute particles of silica with it in its upward course. The colour of the steam does not appear to be due to a reflection of the colour of the water below it, any more than the colour of the water in the basin is due to a reflection of the sky. The beautiful opalescent blue of the water in the basin is very different in appearance from the clear but equally magnificent purple blue of one of *ngwahas* or boiling springs, near Ohinemutu. This latter blue water is remarkably transparent, and one can see down through it to very great depths, but the Terrace water is rendered too turbid by the silica in suspension for the eye to penetrate far down into it. Part of the silica brought up by the water is thrown down as a soft pulverulent deposit at the bottom of the basins, while another portion is more slowly precipitated as a hard and smooth stony material, known as siliceous sinter or geysirite, and it is of this that the terraces and basins are built up. So rapidly is this deposited that leaves and twigs become quickly invested, and it is stated that even dead birds become coated with it before the animal matter has time to decay and fall to pieces. The pink colour of the pink terrace is apparently due to the entanglement by the asperities on the stalactitic faces of the terraces of small quantities of red clay brought down by the water. A specimen of recently formed iron pyrites, which had been taken from a mass now forming upon some dead twigs in one of the hot springs (Jack Loffley's, the Taupo guide) at Lake Taupo, was also shown. On examination, this mass of mixed newly formed iron pyrites and dead vegetable matter was found to contain traces of gold.

SECTION D.—BOTANY.

Four meetings of the Botanic Section have been held this session, at which numerous specimens of indigenous plants have been contributed, identified, named, and placed in the Herbarium which has been established.

A proposition that members of the Section should each make especial study of a separate Order has been adopted, and the following Orders have been undertaken by four of the members :—

Compositæ.	Labeliaceæ.
Epacridaceæ.	Proteaceæ.

SECTION E.—MICROSCOPICAL SCIENCE.

WEDNESDAY, 23 *MAY*, 1877.

The first meeting of the session was held on the above date.

In the absence of the Chairman, Mr. H. C. Russell, B.A., F.R.C.S., took the Chair.

The following gentlemen were elected as members of the Committee for the current year:—Mr. A. Roberts, M.R.C.S. (Chairman), Mr. G. D. Hirst (Secretary), Rev. Geo. Martin, Mr. Hugh Paterson, Dr. Milford, and Mr. Wm. MacDonnell.

It was resolved that the future meetings of the Section should be held on the second Monday in each month.

The Secretary, on behalf of Mr. H. Sharp, of Adelong, presented to the Society's cabinet a series of twelve slides, consisting chiefly of animal parasites, neatly mounted in glycerine, with tin cells.

A vote of thanks was unanimously accorded to Mr. Sharp.

Mr. G. D. Hirst exhibited Swift's new patent achromatic condenser. He described its construction, and read a few notes on the use of achromatic condensers generally.

Mr. W. MacDonnell exhibited a metal gauge for measuring thin glass covers to the $\frac{1}{1000}$ inch.

The Rev. Geo. Martin exhibited Crouch's No. 1 A binocular microscope, a particularly substantial instrument, with concentric rotating stage, sub-stage, and apparatus.

Dr. Milford exhibited a large binocular by Collins, with sub-stage and achromatic condenser added by Gaunt, of Melbourne.

Mr. G. D. Hirst exhibited a prize medal binocular by Swift.

MONDAY, 11 *JUNE,* 1877.

Mr. H. G. A. Wright, M.R.C.S., in the Chair.

The minutes of the preceding meeting were read and confirmed.

Mr. Wm. MacDonnell introduced the subject of the microscopical analysis of drinking water; and a discussion ensued as to the best means of obtaining and preserving sediments for examination.

It was resolved that the matter should be brought before the next meeting.

Mr. G. D. Hirst exhibited Bramhall's illuminator, consisting of a plain mirror introduced beneath the slide on the stage of the microscope. The light being thrown down on the mirror by means of the bull's-eye condenser, is reflected obliquely up through the slide, illuminating the object in its passage; the advantage claimed for this simple piece of apparatus being a resolving power on close-lined tests nearly equal to a large-angled achromatic condenser. In illustration of its power, Mr. Hirst showed a valve of the *N. rhomboides* with the transverse lines, 80,000 to the inch, perfectly resolved under a $\frac{1}{16}$ inch immersion lens.

Mr. Wm. MacDonnell exhibited a Crouch's No. 2a binocular microscope, with a quantity of apparatus. The instrument was furnished with an adaptation, by which perfect centricity of the stage with the optic axis of the tube was easily secured.

Mr. H. Paterson showed some diatoms he had obtained from the fresh water supplied in the city mains.

MONDAY, 9 JULY, 1877.

Mr. Alfred Roberts, M.R.C.S., in the Chair.

A discussion ensued in reference to diatoms obtainable in the vicinity of Sydney, both marine and fresh water species; and the Chairman suggested that members should endeavour to procure and mount specimens for the next meeting, and in doing so should keep notes of the locality and surroundings of each variety, with a view to the ultimate construction of a complete collection of the diatoms of the harbour and its neighbourhood.

Mr. J. U. C. Colyer exhibited specimens of *Drosera peltata*, *Drosera glanduligera*, and *Drosera pygmæa*, insectivorous plants found in the neighbourhood of Sydney. He made some remarks upon the leading characteristics of these species, and promised to pursue the matter further and place the results before the Section in the form of a paper.

Mr. G. D. Hirst showed a drawing of a new species of *Branchionus*—a rotifer apparently common at the present time in ponds on the Sydney water reserve. A specimen was exhibited under the microscope.

Mr. H. G. A. Wright exhibited a patent $\frac{1}{2}$-inch objective by Ross, and as a sample of its resolving powers he showed a valve of the *P. angulatum*, which with the D. eyepiece and illuminated by Ross's $\frac{4}{10}$th inch achromatic condenser was finely resolved into dots. The objective was also tested for penetration on the trachæ of a caterpillar, and was found also to be thoroughly satisfactory in this respect.

The Rev. Geo. Martin exhibited some slides of his own preparing, among which were *Foraminifera* from Port Jackson, mounted in damar, and showing well their internal structure; also *Polypide* of *Hydroid zoophyte* from Newcastle, and the parasite *Cimex lectularia;* this latter was prepared in acetic acid, and showed the structure of the thorax and abdominal segments.

Mr. Wm. MacDonnell exhibited a collection of anatomical slides, including blood discs from mammalia, birds, and reptiles, and showing the different size of the corpuscle in each species.

MONDAY, 13 *AUGUST*, 1877.

Mr. Alfred Roberts, M.R.C.S., in the Chair.

The minutes of the preceding meeting were read and confirmed.

Mr. Wm. MacDonnell exhibited Swift's popular achromatic condenser. He read a few notes descriptive of this piece of apparatus, which combines in itself all the accessories usually adapted to the sub-stage of first-class instruments.

The Chairman then referring to the proposition made at the last meeting, viz., that members should endeavour to procure and mount specimens of diatoms in the vicinity of Sydney, called upon those who had engaged in this work to report the result.

Mr. H. Paterson said he had obtained numerous specimens from a pond in the Botanic Gardens, and from the water supplied to the city he exhibited several slides of these.

The Rev. Geo. Martin stated that he had examined the mud from anchors of ships in the harbour for marine forms of diatoms, but with poor results; he had, however, obtained specimens of *A. longipes* and *P. angulatum* from scrapings obtained from floating objects. He exhibited a slide showing valves of the *P. angulatum.*

Mr. G. D. Hirst read a paper on "Some local species of *Diatomaceæ*," with an account of the method he recommended to be followed in the preparation of gatherings, and some remarks on the use of diatoms as test objects; he also exhibited numerous slides of the species he had found.

On the motion of Mr. H. G. A. Wright, seconded by Dr. Milford, it was resolved that a Committee should be appointed for the classification of local species of diatoms, and the following gentlemen were appointed:—Rev. Geo. Martin, Dr. Morris, Mr. J. U. C. Colyer, Mr. G. D. Hirst.

Dr. Milford read a paper on the Coccus of the Cape Mulberry, illustrating the same by drawings of the larva of this parasite in its abdominal and dorsal aspects.

Mr. Percival Pedley exhibited some *Foraminifera* from New Guinea.

MONDAY, 10 *SEPTEMBER*, 1877.

Rev. Geo. Martin in the Chair.

The Secretary read a note he had received from the Chairman, Mr. Alfred Roberts, apologising for his absence through professional engagements.

Mr. Wm. MacDonnell exhibited two $\frac{1}{32}$ inch objectives, by Seiberz. These lenses showed the very finest definition, with a capacity for working through covering glass ·007 inch in thickness; their magnification was 1,600 diameters with the A. eyepiece. A valve of the *N. rhomboides* was shown under one of these objectives resolved into beads.

Mr. MacDonnell also exhibited Crouch's new centering nosepiece, by means of which an objective may be brought into perfect centricity with the revolving stage when the latter is not furnished with any arrangement for effecting this.

Mr. Hugh Paterson exhibited several slides containing local diatoms, principally varieties of the *Pleurosigma.*

Dr. Morris exhibited prepared specimens of the male coccus of the orange, an insect somewhat rare and difficult to procure on account of its diminutive size.

The Rev. George Martin exhibited several slides of pathological subjects, prepared by himself, and subjected to Dr. Beale's staining process.

Mr. P. Pedley exhibited some diatoms from Port Jackson.

TUESDAY, 9 OCTOBER, 1877.

Rev. George Martin in the Chair.

Mr. H. Sharp, of Adelong, presented several slides for the cabinet, containing scales of different species of *Podura,* mounted by himself, for which a vote of thanks was accorded.

Mr. H. J. Brown exhibited some specimens of the pink *Synapta*, or Admiralty worm, found by him in Port Jackson. Mr. Brown made a few remarks on the habits of these creatures, the localities in which he had been most successful in finding them, and the method he recommended to be adopted for obtaining and mounting the anchor-shaped spicules. Mr. Brown's remarks were listened to with some interest, as it has not been generally known that the *Synapta* is to be found on this coast.

Mr. H. Sharp read a paper on Zeiss's objectives, with an account of their performance in his hands, by which it appeared from results obtained from some of the most difficult test objects procurable, that these lenses exceeded many of the finest productions of the London makers, in their great resolving power and fine definition. Mr. Sharp, in illustration, showed some difficult diatoms, including the *N. crassinervis,* well resolved with a Zeiss $\frac{1}{25}$-in.

Mr. Wm. MacDonnell read a paper on foreign objectives. He argued that the introduction of high class work, such as these lenses of Zeiss, tended much to remove the prejudice with which many microscopists have hitherto regarded continental objectives, this having arisen from the numerous cheap and inferior glasses which have found their way into the English market. Mr. MacDonnell quoted some extracts showing the haphazard way in which these cheap lenses are made, and contrasted it with an account of the elaborate and careful manner in which such makers as Zeiss and Seiberz construct their work.

Mr. G. D. HIRST read a paper on "Professor Abbe's Theory of Microscopic Vision," illustrated by experiments with his diffraction platte. Mr. Hirst's paper showed the possibility of misinterpretation when close-lined objects are viewed under high powers, and some novel facts bearing closely on the study of the markings on diatoms were proved by experiments with the diffraction platte.

MONDAY, 12 *NOVEMBER*, 1877.

Mr. ALFRED ROBERTS, M.R.C.S., in the Chair.

The SECRETARY reported that he had no papers from the members to be read that evening.

The Rev. GEORGE MARTIN read a letter that he had received from the Rev. Mr. Dallinger, the well-known English microscopist, on the choice of objectives of medium power. The letter entered fully into the debated question of angular aperture, and some important information was furnished as to the capabilities of objectives differing widely from each other in this respect.

Dr. MORRIS exhibited a fine microscope by Browning, on the Stephenson's binocular principle, made specially to his order by this maker. The microscope differed from the ordinary Wenham form in being capable of working as a binocular up to the $\frac{1}{16}$-in. objective with good definition and a well illuminated field. The stage was constructed so as to remain horizontal while the tubes of the microscope incline at a convenient angle for observation. The whole instrument was substantially made, and the finish reflected great credit on the maker.

PROFESSOR LIVERSIDGE exhibited specimens of "diseased" sugar-cane from the Maryborough districts, Queensland. Professor Liversidge stated that Sir Joseph Hooker, K.C.S.I., Director of the Botanic Gardens, Kew, had written to him for some specimens of the affected canes, as he thought that the "disease" might be somewhat the same as that affecting the coffee plant. By the last mail a reply had been received saying that the specimens had been submitted to careful examination by Mr. Berkeley and Mr. Broom, the two ablest English funglogists, and they had pronounced the markings on the leaves to be due to the presence of a minute fungus, a species of *Depazea*, and the little cup-like bodies under the leaf scrolls which Professor Liversidge had suggested as resembling the fructification of *Æcidiacei* they considered to be due to a coccus.

It was resolved that an application should be made to the Council to obtain if possible the use of the room for the Section once a fortnight during the recess.

Remarks on the Coccus of the Cape Mulberry.

By F. Milford, M.D., M.R.C.S., &c.

[*Read before the Microscopical Section*, 13 *August*, 1877.]

A few years ago, in the neighbourhood of Parramatta, I planted a considerable number of mulberry cuttings, three-fourths of which belonged to the Cape variety; the rest were *Morus alba*. These latter have thriven very well, and are now healthy and flourishing. The Cape trees have signally failed, however; they have been stunted in growth, the bark in parts has assumed a black colour, and the foliage has been very scarce. On a casual inspection of the cause I found, some three years since, almost all the Cape trees affected with a parasite having a singular appearance: the tender stalks and young leaves had protuberances on them similar to gall-nuts, raised about from $\frac{1}{30}$ to $\frac{1}{15}$ of an inch above the bark, were dome-shaped, almost circular in circumference, chocolate-colour, and varied from a line to $\frac{1}{4}$ inch in diameter. These dome-shaped bodies occurred in clusters of about nine or ten each on the affected branch. On removing a specimen from its adhesive surface, I found it contained particles of deep orange-coloured dust, and that the parts of the tree to which it adhered was of a white woolly appearance. Wherever these parasites most abounded the trees seemed most sickly, and accordingly I was desirous of ascertaining their history, in order to procure some means for their destruction, as I could not but connect their sickliness with the presence of these creatures. Accordingly I procured some branches of affected trees, removed one of the dome-shaped bodies, and the dust obtained from it I placed under the microscope, which upon inspection I found to consist of eggs and the larvæ of an insect. I applied to the well-known entomologist Mr. Scott, and having shown him a slide with the objects prepared and a branch of the tree, he at once informed me that it was a coccus, and lent me the 2nd volume of the History of Insects, VIIth of the Family Library, in which is an account of some varieties of European coccus, and recommended me to refer to Cuvier. From reference to these works I have been able to glean the following information with regard to the genus. The protuberances visible on the trees are the female cocci. These dying after impregnation, their eggs and recently hatched larvæ are found in their remains. The eggs at maturity being hatched escape from the dead mother by a small opening or porch at the back and soon change from the larva to the perfect state. The males have wings and are very much smaller than the female. The female, who is furnished with a proboscis, immediately takes up a position on the tree and inserts the tube into the bark, through which she extracts the nutrient juices; here she remains stationary. The male when at liberty does not use his wings, but walks up to the female and remains with her. After fecundation the female deposits her eggs between the tree and herself, having exhausted the whole of her substance in generating the ova; she then dies and becomes a covering for the eggs, which in their turn go through the same course of existence. I have here views of the larva in its abdominal and dorsal aspects and the egg magnified 190 diameters, also a branch of the mulberry and a slide showing the larva. These creatures attack some species of fern, but will leave others in immediate juxtaposition in our ferneries.

Various efforts have been made to get rid of this pest from the trees without beneficial results, and I hear that the farmers in the neighbourhood of Baulkham Hills use soft soap and sulphur for the purpose freely applied. I propose trying some experiments for the purpose of destroying them.

Cuvier describes four varieties of these creatures, the third family of the *Homopterus hemiptera* called *Gallinsecta*. He says that they have only a single joint in the tarsis with a single hook at the tip. The male is destitute of a proboscis, has only two wings, which shut horizontally upon the body: the abdomen is terminated by two threads. The female is without wings, and furnished with a proboscis. The antennæ are filiform and often eleven-jointed. The four varieties mentioned by Cuvier, *C. admidem*, *C. cacti*, *C. palmicas*, *C. ghüs*.

These creatures here depicted have a single joint in the tarsi, but they have three hooks at the tip. I have never been able to capture a specimen of the perfect winged male. These differ materially from the species of the coccus which attacks the orange, which I have also examined microscopically.

Notes on some local Species of Diatomaceæ.

By G. D. Hirst.

[Read before the Microscopical Section, 13 August, 1877.]

At the last meeting of this Section it was suggested by our Chairman that, as probably many marine and fresh water species of *Diatomaceæ* existed in the vicinity of this city, on the observation and classifying of which but little had been hitherto done, it would be interesting and also doing good work if such of the members as were able, would devote a little time to obtaining and preparing specimens for our meeting to-night. Pressure of business has prevented me until the last week or ten days from taking the matter up, and this must be my apology for the somewhat hurried character of these notes, which I will ask you to look upon as the merest outline of what might be done by one having more time and talent than I possess to devote to this very interesting branch of microscopical research. There is in almost every department of Natural History on this continent such a vast field for work, so much unexplored territory, such an abundant harvest waiting only to be gathered, that the amateur, conscious of his own feeble powers, feels inclined to despair, from the feeling perhaps of not knowing where to begin. The *Diatomaceæ* are no exception to this rule; little or no work has yet been done to classify the very numerous species which may be found within a mile of Sydney, and I have been much embarrassed sometimes in trying to identify specimens with any drawing or description in the standard works on the subject.

Many well-known European species have their representatives in these waters, but there are many more whose designation one hesitates to fix from the want of some work in which these Australian varieties have been included. Commencing first with marine and brackish water species, my first gathering was from some stranded logs in Darling Harbour that looked promising, that is to say green and muddy, but after careful washing and preparation the result turned out absolutely nil, not a single diatom rewarded my search; however, as the locality looked so very favourable I determined to try again, and a few hundred yards further up the bay I obtained scrapings from some of the logs that had evidently been in the water for a considerable time, being covered on their under surface with a thick brown scum. This on being treated yielded a fair supply of various forms, prominent among which was *Pleurosigma Balticum*, valves rather smaller than the English species, but the cross-lines coarser; I measured them 34,000 to the inch. Prichard in his Infusoria gives 38,000 as the average for English and Continental species. The following were also in tolerable abundance in the same gathering:—*Pleurosigma elongatum*, diagonal lines 57,000 to the inch, being finer than English specimens, which average 48,000. Two or three species of *Stauroneis* were also found, on one of which the markings though coarse were so faint that nothing lower than the $\frac{1}{16}$-in. with careful illumination would show them; also a magnificent *Navicula*, with coarse beading easily resolvable under the 1-in., a really beautiful diatom, and one that I have been unable to identify with any known species; also a species of *Nitzschia*, very like the *Nitzschia Brightwellii* in form and size; but, instead of possessing coarse beading like this diatom, its markings if any were so fine as to defy the resolving power of my $\frac{1}{16}$-in. immersion of large angle. I have no doubt that the lines existed, though I could not see them, as some of these *Nitzschia* are among the most difficult of our test objects. Also *Pleurosigma*, probably *Æsturii;* diagonal lines faint, and in consequence difficult to measure accurately, but about 65,000 to the inch, and a good test for a large-angled $\frac{1}{4}$-inch. A few valves were also found of a curious form of *Pleurosigma*, very broad with obtuse ends, and totally devoid of any markings whatever, as far as I could ascertain with any power to the $\frac{1}{16}$-in. The species most plentiful in these Darling Harbour gatherings appear to be the *Balticum* and two or three kinds of *Stauroneis;* the latter is a very elegant genus, deriving its name from its having the central nodule prolonged into a pellucid band or stauros free from striæ. The different species found of this genus vary much in size, some are as large as 150″, while others are no more than 800″; this last is far however from being the smallest variety known, as Prichard mentions some as small as 1,600″. Doubtless other parts of Darling Harbour will furnish numerous other species of diatoms, but I can only mention this result of one gathering.

The mud near the mouth of Cook's River will, if collected from suitable spots, yield a rich return. From a sample supplied me by Dr. Tucker I have several slides on which are the following:—*Pleurosigma formosum*, diagonal lines 33,000 to the inch. Pritchard gives for English specimens 36,000; *Pleurosigma Balticum*, small valves, but like the Darling Harbour specimens much coarser marked than the old world species, the striæ ranging as low as 28,000 to the inch. *Pleurosigma Æsturii* and several species of *Cymbella* were also numerous. I would strongly recommend this locality to any one collecting diatoms, as I am certain that there would be found a rich harvest of interesting forms both of known and unknown species.

It appears to me however, that it is in fresh water that the greatest variety of our local *Diatomaceæ* are to be found. My first trial for fresh water specimens was in the sediment obtained from the top of a filter supplied with water from the city main. This yielded a large supply of diatoms, and sponge spiculæ, probably from fresh water sponges growing in the dams; amongst the diatoms were an immense multitude of minute diamond-shaped bodies not more than the 2,000th of an inch in extreme length; some with two holes pierced in them near the centre, others without. I have been unable to find anything resembling them in any work I have access to; they may probably be a species of minute diatom, but whatever be their nature, they are undoubtedly present in vast numbers in the water supplied to the city. Of the known species of diatoms in this gathering, I found *Pinnularia* both *major* and *nobilis*, *Stauroneis*, *Cymbella*, and several kinds of *Pleurosigma*. The sponge spicules mentioned were present in great abundance; under the microscope they look most unpleasantly indigestible, having sharply pointed ends and jagged edges. One could not but after seeing them register a mental vow never to drink anything but filtered water.

At the head of Fletcher's bay, a small rocky bight south of Bondi, there is a stream in which I obtained a plentiful supply of *Synedra fulgens*, a long spindle-shaped diatom with coarse transverse ribbing; the gathering was very pure and free from extraneous matter, but the most plentiful haul I have had was from a fresh-water pool on the old tramway track leading to Bondi beach. I find the limit of this paper will not allow me to enter into a full account of the extraordinary number of species and different genus contained in this gathering; besides, the time at my disposal has not afforded me an opportunity of identifying half of them. I will merely mention *Pinnularia major* and *nobilis*, besides several other species of this genus, *Cymbella*, several forms of *Naviculæ* in abundance, and *Stauroneis* of all kinds, to give you an idea of the variety to be met with on a single slide. That you may the more easily judge for yourselves of the abundance in which so many different species are present, I have prepared a few slides for presentation to any gentleman who may wish to have one. One thing I notice in this gathering, that amid the multiplicity of other forms the *Pleurosigma* are conspicuous by their absence; at least, in a hasty search through several slides I have not been able to find any.

A peculiarity that seems connected with the *Diatomaceæ* in the vicinity of Sydney, so far as my limited experience goes, is the variety of genera met with in a single gathering; in England and on the Continent, gatherings taken from different places yield each a characteristic genus or even a single species. *Pleurosigma angulatum*, *P. Balticum*, *Pinnularia*, are found with scarcely the intervention of a valve of another species; here we seem to have a sort of happy family, which, though gratifying to those who seek variety on their slides, is rather puzzling to the collector who wishes perhaps to adapt his slides and style of mounting to suit the conditions required for the perfect display of any given diatom.

It may not be out of place here if I mention the process I adopt for cleaning the diatom valves, and freeing them from the extraneous matter, which even in the purest gatherings is sure to be present, and which I have found out of several methods tried to be the most simple and efficacious. Of course the process of cleaning will in some instances have to be modified by the peculiar nature of the matter in which the diatoms are contained, but the following will answer very well for any of the ordinary fresh or salt water gatherings obtainable in this vicinity. The apparatus required will be a couple of Florence flasks, a spirit lamp, a small quantity of chlorate of potash, and some nitric and sulphuric acid. Place the gathering in one of the Florence flasks, half-fill with water, and shake well for a couple of minutes; this will detatch the diatoms from the vegetable and flocculent matter to which they adhere; after shaking, hold the flask upright for eight or ten seconds, when the particles of sand will subside to the bottom, now before the diatoms have time to settle also, decant the liquid into the other flask; this process might be repeated with advantage once or twice, when one troublesome element, that is the sand, will have been pretty well got rid of.

After the final decanting let the liquid stand for half-an-hour, giving everything plenty of time to settle, carefully pour off the water without disturbing the sediment, and add nitric acid until the flask is about one-third full; this must now be boiled over the spirit lamp for ten minutes or so, then allowing the deposit to settle as before, pour off the acid and add fresh, boil again, and again pour off the liquid after giving the deposit full time to settle. If there is any lime in the gathering this must be got rid of by the addition of hydrochloric acid; a little of this acid added will immediately show its presence by effervescing; if there is no lime, sulphuric acid can now be added in about the same quantity as the nitric; this must be boiled until it fails to turn any darker; if there is much carbonaceous matter in the gathering the mixture will turn quite black. While the acid is on the boiling point add cautiously in very small portions at a time, to prevent any chance of explosion, some powdered chlorate of potass; the liquid will gradually turn lighter and eventually quite clear, the diatoms being suspended in it in the form of white cloudy flocculent matter. When the acid is cool add cautiously water until the flask is three parts full, allow the diatoms ample time to settle, as the acid on account of its high specific gravity keeps them suspended for a longer time than water alone; when they have at last settled pour off and add more water, repeating the process until the diatoms are washed clean from the acid, which will be when the liquid poured off gives no acid taste when applied to the tongue.

The diatoms may now be transferred to a convenient receptacle and preserved in distilled water until required; a drop or two of methylated spirit added will prevent the chance of any confervoid growths. The above process may sound somewhat formidable to those not experienced, but it practically is not troublesome, and will be sure to give good results if carefully carried out. I have here two bottles, in one of which is the *raw material* if I may so term it, and the other contains the pure diatoms obtained from a similar quantity of stuff. You will see there is a large reduction in bulk, showing the amount of foreign matter got rid of.

In mounting the diatoms, some are better shown in balsam or damar, others display their markings best when dry. The general rule appears to be as far as my experience goes, that all those species with coarse lines or beadings show to the best advantage when mounted in balsam; those with very fine lines, such as in all the difficult test objects, are better mounted dry.

In conclusion I would say a word in reply to questions I have heard put sometimes, when after the expenditure of much time, trouble, and patience, adjusting of light and mirror, the lines on some difficult test diatom have at last been fairly displayed, well what good have you accomplished? In what respect is microscopic science benefited by the fact that such a diatom has so many lines to the inch? There are I know many microscopists who affect to despise those whom they call "Diatomaniacs" and count the time and trouble expended in the resolution of markings as simply wasted. Now without for a moment arguing that the only or chief work for the microscope is counting the striæ on diatoms, I would hold that the time spent in successfully resolving a difficult test is by no means wasted. The tyro sitting down before his newly acquired instrument places an object on the stage, turns on the full glare of light from his mirror and condenser and fancies he sees everything to perfection. Let him try the same method of proceeding on some delicate diatom valve; and where in the hand of the skilful manipulator a moment before, lines or beading were beautifully displayed, he sees a blank. He may spend long hours in trying every trick of illumination, moderating his light, varying its obliquity by altering the angle of his mirror, focussing and re-focussing the condenser, altering the adjustment of his objective, and at last when his patience is well nigh exhausted the desired result is obtained, the delicate markings start suddenly into view, and he possesses the consciousness that under his hands mirror, condenser, and objective are now doing their best. Has this time been wasted? I think not; he will carry the knowledge obtained in the struggle and apply it in the broad field of real work that lies before him on every side. Should he turn his attention to the development of minute life, organs are seen in living transparent bodies where before he saw nothing; should he be a pathologist, tissues appear full of structure which before in his inexperienced hands seemed homogeneous, minute nerve fibres become visible where before they were unsuspected. I do not think I am exaggerating in saying what I have; I have felt the benefit conveyed in an education of this kind, and I could recommend nothing better for a beginner than a year's constant study of all the species of *Diatomaceæ* at his command. When he is fully convinced that he sees all in them that his optical means will allow, he is far better fitted to commence real work than he ever could have been without this preliminary training. Only let us not mistake: our work, though commencing on diatoms, should not end there; let their delicate lines be the means of familiarizing ourselves with the optical capabilities of the noble instruments at our disposal, and the questions I have quoted will be duly answered—the time spent will not be in vain.

SECTION F.—GEOGRAPHY AND ETHNOLOGY.

THIS being the first meeting of the Section for the present year, the office-bearers were elected to serve on the Committee: The Hon. LEOPOLD FANE DE SALIS, M.L.C., Messrs. E. DU FAUR, F.R.G.S., WILLIAM FORDE, H. A. GILLIAT, JAMES MANNING, and E. L. MONTEFIORE, out of which number Mr. DU FAUR was elected Chairman, and Mr. W. FORDE Hon. Secretary. The CHAIRMAN reported the general objects of the Section and the progress made during the past session, and Mr. Forde read some remarks which he had prepared on various geographical subjects, to which the attention of members was specially directed. With a view of keeping a record of what may appear from time to time in local or other papers relating to geographical exploration in all parts of the world, members were invited to assist the Committee in making such a collection as complete as possible; and clippings from European and foreign papers on this subject will be gladly received. Attention of members was called to an interesting private expedition to New Britain and New Guinea which recently left Sydney. It was suggested that much information might be collected from surveyors who have been more recently extending their work into that portion of the north-western district of this Colony, of which at present little is known.

SECTION G.—LITERATURE AND THE FINE ARTS.

[No report of meetings of this Section has been sent in.]

SECTION H.—MEDICAL SCIENCE.

During the session of 1877 there have been held eight meetings of the Section—one special general meeting for the election of office-bearers, and seven general meetings.

The following gentlemen were elected members of the Committee for the current year.

J. C. Neild, Chairman.
F. N. Milford,
H. G. A. Wright,
R. Schuette,
W. J. O'Reilly, } members of Committee.
P. S. Jones,
H. N. MacLaurin, } Secretaries.

At the meetings many papers of considerable interest were read by members of the Society, and most of the meetings of the Section were well attended.

The papers read being of an exclusively professional character, the Committee do not recommend that any of them should be published in the Journal of the Royal Society.

P. SYDNEY JONES.
Nov. 27th, 1877. H. N. MACLAURIN.

SECTION I.—SANITARY SCIENCE.

Report of the Social and Sanitary Science Section of Royal Society for the session of 1877.

Sydney, 4 December, 1877.

To the President of the Royal Society of New South Wales.

Sir,

I have the honor to submit the following report:—

The Section held its first meeting on the 21st day of March last, when the gentlemen were elected to the offices named.

Mr. Alfred Roberts, Chairman.
Messrs. Jackson, Bedford, Belgrave, and Murray, members of Committee.
Mr. Harrie Wood, Honorary Secretary.

On the subject of the Vital Statistics of the Colony further information was obtained from the Registrar General.

Steps were taken to procure the Report of the Royal College of Physicians on the "Improvement of Health of Towns, 1849 to 1869," Report on "Cellar Dwellings and Common Lodging-houses," Report on Model Lodging-houses. Rumeig (H. W.), "Public Health, the right use of records founded on local facts."

The Chairman was asked to read the paper which he had prepared on the Leirneur system of Sewage, before the Society, on account of its public importance.

On the 16th July last, Mr. Jackson read an able paper on Small-pox in its hygienic aspect.

Some of the recent meetings of the Section lapsed for want of a quorum, owing to the inability of members to attend.

I have, &c.,

ALFRED ROBERTS,

Chairman.

APPENDIX.

ABSTRACT OF THE METEOROLOGICAL OBSERVATIONS TAKEN AT THE SYDNEY OBSERVATORY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

JANUARY, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·066 inches	on the 28th, at 9·30 a.m.
	Lowest Reading	29·357 ,,	on the 11th, at 12 noon.
	Mean Height	29·717	

(Being 0·051 inch less than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure	8·4 lbs. on the 29th.
	Mean Pressure	0·6 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	S.

(Prevailing direction during the same month for the preceding 18 years N.E.)

Temperature	Highest in the Shade ...	93·8	On the 6th.
	Lowest in the Shade ...	57·8	On the 14th.
	Greatest Range	23·9	On the 6th.
	Highest in the Sun ...	149·2	On the 6th.
	Highest in Black Box with Glass Top	203·1	On the 10th.
	Lowest on the Grass ...	55·3	On the 29th.
	Mean Diurnal Range ...	12·6	
	Mean in the Shade... ...	72·0	

(Being 0·8 greater than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount	96·0	On the 8th.
	Least	41·0	On the 6th.
	Mean	71·7	

(Being 1·1 less than that of the same month on an average of the preceding 18 years.)

Rain ...	Number of Days	10	
	Greatest Fall	0·840 inch.	On the 12th.
	Total Fall	1·104 inch.	65 feet above ground.
		1·550 inch.	15 in. above ground.

(Being 2·352 inches less than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	6·811 inches.
Ozone ...	Mean Amount	6·4

(Being 1·8 greater than that in the same month on an average of the preceding 17 years.)

Electricity...	Number of Days Lightning	3
Cloudy Sky...	Mean Amount	7·0
	Number of Clear Days ...	1
Meteors ...	Number Observed	1

Remarks.

The severe drought still continues in the western and south-western districts, but along the coast and in New England some rain has fallen. In Sydney the temperature has been high, and the rainfall 2·352 inches below the average, and rain is very much wanted.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

FEBRUARY, 1877.—GENERAL ABSTRACT.

Barometer ...	Highest Reading	30·139 inches on the 3rd, at 8·10 p.m	
At 32° Faht.	Lowest Reading	39·567 „ on the 22nd, at 6 p.m	
	Mean Height	29·850	

(Being 0·052 inch greater than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure	11·5 lbs. on the 23rd.	
	Mean Pressure	0·7 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	S.	

(Prevailing direction during the same month for the preceding 18 years S.)

Temperature	Highest in the Shade ...	90·0	On the 1st.
	Lowest in the Shade ...	58·2	On the 3rd.
	Greatest Range	19·4	On the 16th.
	Highest in the Sun ...	151·9	On the 1st.
	Highest in Black Box with Glass Top	200·1	On the 1st.
	Lowest on the Grass ...	52·7	On the 9th.
	Mean Diurnal Range ...	12·8	
	Mean in the Shade ...	72·3	

(Being 1·6 greater than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount	99·0	On the 24th.
	Least	42·0	On the 9th.
	Mean	71·7	

(Being 3·2 less than that of the same month on an average of the preceding 18 years.)

Rain ...	Number of Days	10 rain and 5 dew.	
	Greatest Fall	0·609 inch.	On the 24th.
	Total Fall	0·853 inch.	65 feet above ground.
		1·600 inch.	15 in. above ground.

(Being 4·922 inches less than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	5·848 inches.	
Ozone ...	Mean Amount	6·3	

(Being 1·6 greater than that in the same month on an average of the preceding 17 years.)

Electricity...	Number of Days Lightning	6	
Cloudy Sky...	Mean Amount	6·8	
	Number of Clear Days ...	1	
Meteors ...	Number Observed	2	

Remarks.

Another hot and very dry month; at thirty-two of the stations the rainfall was less than one inch. At Sydney the temperature was 1·6 greater than the average, and the rainfall 4·922 inches below the average of the last 18 years. Inland the continued drought is severely felt, and great numbers of sheep and cattle are dying.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″ ; LONGITUDE 10h 4m 46s ; MAGNETIC VARIATION 9° 32′ 45″ East.

MARCH, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·187 inches on the 31st, at 8 a.m.
	Lowest Reading	29·579 „ on the 2nd, at 5 p.m.
	Mean Height	29·961 „

(Being 0·061 inch greater than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure... ...	11·5 lbs. on the 2nd.
	Mean Pressure	0·6 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	N.E.

(Prevailing direction during the same month for the preceding 18 years N.E.)

Temperature	Highest in the Shade ...	90·9	... On the 1st.
	Lowest in the Shade ...	59·5	... On the 8th.
	Greatest Range	17·7	... On the 15th.
	Highest in the Sun ...	150·3	... On the 1st.
	Highest in Black Box with Glass Top	188·3	... On the 1st.
	Lowest on the Grass ...	53·5	... On the 4th.
	Mean Diurnal Range ...	11·2	
	Mean in the Shade ...	69·9	

(Being 0·7 greater than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount ...	99·0	... On the 17th.
	Least	49·0	... On the 4th.
	Mean	79·3	

(Being 3·0 greater than that of the same month on an average of the preceding 18 years.)

Rain	Number of Days	17 rain and 3 dew.	
	Greatest Fall	2·495 inches.	On the 31st.
	Total Fall	5·617 inches.	65 ft. above ground.
		6·343 inches.	15 in. above ground.

(Being 0·903 inch greater than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	4·228 inches.
Ozone ...	Mean Amount	5·7

(Being 0·7 greater than that in the same month on an average of the preceding 17 years.)

Electricity...	Number of Days Lightning	11
Cloudy Sky...	Mean Amount	6·4
	Number of Clear Days ...	1
Meteors ...	Number Observed ...	2

Remarks.

Valuable rains have fallen along the coast and mountain districts; but in the districts about Mudgee, Dubbo, and thence westward, the drought still continues. At Sydney, the rainfall, the temperature, and the barometer have all been above the average.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10^h 4^m 46^s; MAGNETIC VARIATION 9° 32′ 45″ East.

APRIL, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·293 inches on the 15th, at 10 a.m.	
	Lowest Reading	29·515 ,, on the 26th, at 1 p.m.	
	Mean Height	29·948	

(Being 0·024 inch greater than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure	14·6 lbs. on the 26th.	
	Mean Pressure	0·6 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	W.	

(Prevailing direction during the same month for the preceding 18 years W.)

Temperature	Highest in the Shade ...	83·7	On the 10th.
	Lowest in the Shade ...	48·6	On the 24th.
	Greatest Range	21·1	On the 10th.
	Highest in the Sun ...	144·1	On the 10th.
	Highest in Black Box with Glass Top	186·5	On the 10th.
	Lowest on the Grass ...	44·6	On the 27th.
	Mean Diurnal Range ...	13·7	
	Mean in the Shade... ...	64·7	

(Being 0·3 less than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount	100·0	On the 29th.
	Least	38·0	On the 27th.
	Mean	72·2	

(Being 5·6 less than that of the same month on an average of the preceding 18 years.)

Rain ...	Number of Days	6 rain and 8 dew.	
	Greatest Fall	3·752 inches.	On the 30th.
	Total Fall	5·550 inches.	65 feet above ground.
		6·572 inches.	15 in. above ground.

(Being 0·665 inch less than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	3·855 inches.	
Ozone ...	Mean Amount	6·7	

(Being 1·6 greater than that in the same month on an average of the preceding 17 years.)

Electricity ..	Number of Days Lightning	7	
Cloudy Sky	Mean Amount	4·1	
	Number of Clear Days ...	0	
Meteors ...	Number Observed	2	

Remarks.

Temperature this month is rather below the average at Sydney. Along the coast, between Bodalla and Newcastle, and extending inland to the mountains, fine rains have again fallen; but in other parts of the Colony the fall has been very small, and the rivers Darling and Murray are very low and still falling.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″ ; LONGITUDE 10h 4m 46s ; MAGNETIC VARIATION 9° 32′ 45″ East.

MAY, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·308	inches on the 31st, at 10 a.m.
	Lowest Reading	29·201	,, on the 23rd, at 5 p.m.
	Mean Height	29·724	

(Being 0·207 inch less than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure... ...	162·0	lbs. on the 23rd.
	Mean Pressure	1·1	lb.
	Number of Days Calm ...	0	
	Prevailing Direction ...	W.	

(Prevailing direction during the same month for the preceding 18 years W.)

Temperature	Highest in the Shade ...	72·3	... On the 22nd and 23rd.
	Lowest in the Shade ...	46·7	... On the 21st and 28th.
	Greatest Range	21·5	... On the 22nd.
	Highest in the Sun ...	127·1	... On the 6th.
	Highest in Black Box with Glass Top	142·2	... On the 24th.
	Lowest on the Grass ...	41·3	... On the 27th.
	Mean Diurnal Range ...	11·7	
	Mean in the Shade ...	59·4	

(Being 0·9 greater than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount... ...	100·0	... On the 1st, 14th, and 15th.
	Least	36·0	... On the 24th.
	Mean	74·6	

(Being 1·6 less than that of the same month on an average of the preceding 18 years.)

Rain... ...	Number of Days	16	
	Greatest Fall	3·483 inches.	On the 2nd.
	Total Fall	6·749 inches.	65 ft. above ground.
		9·945 inches.	15 in. above ground.

(Being 4·830 inches greater than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	2·776 inches.
Ozone ...	Mean Amount	6·7

(Being 1·9 greater than that in the same month on an average of the preceding 17 years.)

Electricity...	Number of Days Lightning	9
Cloudy Sky	Mean Amount	5·7
	Number of Clear Days ...	0
Meteors ...	Number Observed ...	0

Remarks.

The barometer this month is considerably below the average, and the temperature is above it. Abundant rains have fallen on all the coast and mountain districts. The amount at Liverpool was over eleven inches, and at several stations over ten inches; but little or none has fallen in the west, and the rivers Darling and Murray are very low and falling. Tidal waves reached Sydney at 5h. 20m. a.m. of the 11th May, and continued all day; the height of the greatest was 3 ft. 6 in. They were observed at other points along our coast, and were much larger in New Zealand.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 32′ 45″ East.

JUNE, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading ...	... 30·473 inches on the 19th, at 10 a.m.
	Lowest Reading ...	... 29·780 „ on the 12th, at 5 a.m.
	Mean Height ...	... 30·117

(Being 0·196 inch greater than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure ...	... 14·6 lbs. on the 27th.
	Mean Pressure ...	... 0·5 lb.
	Number of Days Calm	... 0
	Prevailing Direction	... W.

(Prevailing direction during the same month for the preceding 18 years W.)

Temperature	Highest in the Shade	... 68·9 on the 8th.
	Lowest in the Shade	... 41·6 on the 29th.
	Greatest Range ...	... 22·6 on the 20th.
	Highest in the Sun	...121·0 on the 5th.
	Highest in Black Box with Glass Top ...	...138·3 on the 6th.
	Lowest on the Grass	... 37·3 on the 29th.
	Mean Diurnal Range	... 14·0
	Mean in the Shade...	... 54·9

(Being 0·1 greater than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount ...	...100·0 on the 4th, 5th, 25th, and 26th.
	Least	... 42·0 on the 20th.
	Mean	... 77·9

(Being 0·8 greater than that of the same month on an average of the preceding 18 years.)

Rain... ...	Number of Days ...	... 5 rain and 13 dew.
	Greatest Fall ..	... 0·288 inch. On the 12th.
	Total Fall	... { 0·670* inch. 65 feet above ground. 0·541 inch. 15 inches above ground.

(Being 5·254 inches less than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount ...	... 1·959 inch.
Ozone ...	Mean Amount ...	... 4·1 „

(Being 1·4 less than that in the same month on an average of the preceding 18 years.)

Electricity...	Number of Days Lightning	3
Cloudy Sky...	Mean Amount ...	... 3·6
	Number of Clear Days	... 3
Meteors ...	Number Observed ...	... 0

* To midnight, June 30th.

Remarks.

Mean Barometer is this month 0·196 greater than the average, and the temperature very close to the average. Generally the month has been very dry, except the district about the head of the Murray River, where fine rains have fallen, and at the end of the month the Murray at Wentworth was 9 ft. 9 in. above summer level and rising, while the Darling is still below summer level.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″ ; LONGITUDE 10h 4m 46s ; MAGNETIC VARIATION 9° 32′ 45″ East.

JULY, 1877.—GENERAL ABSTRACT.

Barometer .. At 32° Faht.	Highest Reading ...	30·508 inches	on the 3rd, at 9 a.m.
	Lowest Reading	29·510 ,,	on the 18th, at 3 p.m.
	Mean Height	30·075	

(Being 0·137 inch greater than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure ...	19·8 lbs.	on the 15th.
	Mean Pressure	0·6 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	W.	

(Prevailing direction during the same month for the preceding 18 years W.N.W.)

Temperature	Highest in the Shade ...	66·1	... On the 9th.
	Lowest in the Shade ...	45·6	... On the 23rd.
	Greatest Range	16·2	... On the 31st.
	Highest in the Sun ...	124·7	... On the 19th.
	Highest in Black Box with Glass Top	135·2	... On the 31st.
	Lowest on the Grass ...	39·8	... On the 27th.
	Mean Diurnal Range ...	11·3	
	Mean in the Shade ...	54·9	

(Being 2·6 greater than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount ...	100·0	...On the 1st, 2nd, 11th, 12th, 13th, 14th, 15th, 16th, and 31st.
	Least	50·0	...On the 28th.
	Mean	85·2	

(Being 11·0 greater than that of the same month on an average of the preceding 18 years.)

Rain	Number of Days ...	17 rain and 4 dew.	
	Greatest Fall	3·109 inches.	On the 15th.
	Total Fall	7·053 inches.	65 ft. above ground.
		11·410 inches.	15 in. above ground.

(Being 7·126 inches greater than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	1·752 inch.
Ozone ...	Mean Amount	5·9

(Being 0·6 greater than that in the same month on an average of the preceding 16 years.)

Electricity ...	Number of Days Lightning	5
Cloudy Sky	Mean Amount	5·9
	Number of Clear Days ...	1
Meteors ...	Number Observed ...	2

Remarks.

The Barometer has been much above the average, and the weather unusually mild for the season ; the temperature being 2·6 above the average. Very heavy rains fell along the coast only, from Bodalla to Clarence River ; the fall was heaviest on the coast near Sydney, the greatest amount recorded being 12·180 inches at Gosford. At the Heads of the Murray River the rains extended a little over the main range of mountains, and at Wentworth the river was 11 feet above summer level ; at the same time and place the river Darling was very low.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 25′ 2″ East.

AUGUST, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·350 inches on the 7th, at 8 a.m.
	Lowest Reading	29·611 „ on the 25th, at 2 p.m.
	Mean Height	30·009

(Being 0·065 inch greater than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure	18·6 lbs. on the 10th.
	Mean Pressure	0·5 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	W.

(Prevailing direction during the same month for the preceding 18 years W.)

Temperature	Highest in the Shade ...	74·3	On the 15th.
	Lowest in the Shade ...	44·9	On the 3rd.
	Greatest Range	26·0	On the 14th.
	Highest in the Sun ...	130·0	On the 27th.
	Highest in Black Box with Glass Top	153·4	On the 24th.
	Lowest on the Grass ...	37·9	On the 23rd.
	Mean Diurnal Range ...	16·3	
	Mean in the Shade ...	56·3	

(Being 1·8 greater than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount	99·0	On the 1st.
	Least	35·0	On the 15th.
	Mean	71·3	

(Being 0·7 greater than that of the same month on an average of the preceding 18 years.)

Rain	Number of Days	9 rain and 7 dew.	
	Greatest Fall	2·087 inches.	On the 30th.
	Total Fall	2·306 inches.	65 feet above ground.
		2·927 inches.	15 in. above ground.

(Being 0·172 inch greater than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	3·275 inches.
Ozone ...	Mean Amount	5·7

(Being 0·6 greater than that in the same month on an average of the preceding 16 years.)

Electricity ...	Number of Days Lightning	5
Cloudy Sky	Mean Amount	3·3
	Number of Clear Days ...	10
Meteors ...	Number Observed	8

Remarks.

Excepting just along the coast, from Sydney northwards, the month has been a very dry one throughout the Colony, and at 38 out of 49 recording stations the fall has been less than one inch of rain, and at many places little or none has fallen; water is running short in many places, and the large rivers falling fast; the Murray is 2 feet 8 inches lower than it was last month at Wentworth. The month has been very mild, and at Sydney the temperature 1·8 above the average. On the 10th, at Sydney, a hot W.N.W. wind came on after 10 p.m.; and on the 15th there was a hot wind from noon until after sunset.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 25′ 2″ East.

SEPTEMBER, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·265 inches on the 14th, at 9·40 a.m.	
	Lowest Reading	29·609 ,, on the 20th, at 3 p.m.	
	Mean Height	29·963	

(Being 0·077 inch greater than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure	25·2 lbs. on the 23rd.	
	Mean Pressure	0·4 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	W.	

(Prevailing direction during the same month for the preceding 18 years W.)

Temperature	Highest in the Shade ...	76·1	On the 9th.
	Lowest in the Shade ...	43·3	On the 15th.
	Greatest Range	26·2	On the 6th.
	Highest in the Sun ...	136·7	On the 19th.
	Highest in Black Box with Glass Top	183·1	On the 19th.
	Lowest on the Grass ...	37·7	On the 1st.
	Mean Diurnal Range ...	14·4	
	Mean in the Shade ...	58·4	

(Being 0·1 less than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount	100·0	On the 11th and 26th.
	Least	43·0	On the 6th.
	Mean	79·3	

(Being 10·4 greater than that of the same month on an average of the preceding 18 years.)

Rain	Number of Days	15 rain and 2 dew.	
	Greatest Fall	1·740 inch.	On the 11th.
	Total Fall	4·845 inches.	65 feet above ground.
		6·274 inches.	15 in. above ground.

(Being 3·977 inches greater than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	3·317 inches.
Ozone ...	Mean Amount	6·0

(Being 0·7 greater than that in the same month on an average of the preceding 16 years.)

Electricity ...	Number of Days Lightning	9
Cloudy Sky	Mean Amount	5·5
	Number of Clear Days ...	2
Meteors ...	Number Observed	2

Remarks.

The pressure, temperature, and wind this month are very near the average. Moderate rains have fallen at all reporting stations; it was heaviest on the coast south of Sydney, reaching 9·690 inches at Bodalla; along the coast and mountains the quantity ranged from 3 to 9 inches, and inland from 1½ to 3 inches. The rains do not seem to have affected the level of the Darling at Wentworth, and the Murray at the same place has fallen 11 inches since last month. Thunderstorms have been very frequent. Snow was reported from Lake George, Winderradeen Station, on the 14th.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 25′ 2″ East.

OCTOBER, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·359 inches on the 23rd, at 9 a.m.
	Lowest Reading	29·426 „ on the 19th, at 3 p.m.
	Mean Height	29·891

(Being 0·056 inch greater than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure	19·8 lbs. on the 29th.
	Mean Pressure	0·9 lb.
	Number of Days Calm ...	3
	Prevailing Direction ...	S.S.W.

(Prevailing direction during the same month for the preceding 18 years N.E.)

Temperature	Highest in the Shade ...	90·8	On the 27th.
	Lowest in the Shade ...	48·2	On the 22nd.
	Greatest Range	31·5	On the 27th.
	Highest in the Sun ...	147·0	On the 27th.
	Highest in Black Box with Glass Top	198·5	On the 25th.
	Lowest on the Grass ...	41·8	On the 15th.
	Mean Diurnal Range ...	14·9	
	Mean in the Shade... ...	62·4	

(Being 1·2 less than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount	100·0	On the 4th and 12th.
	Least	25·0	On the 27th.
	Mean	72·1	

(Being 3·6 greater than that of the same month on an average of the preceding 18 years.)

Rain... ...	Number of Days	14 rain and 3 dew.	
	Greatest Fall	4·890 inches.	On the 5th.
	Total Fall	6·895 inches.	65 feet above ground.
		8·312 inches.	15 in. above ground.

(Being 5·769 inches greater than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	5·966 inches.
Ozone ...	Mean Amount	6·2

(Being 0·9 greater than that in the same month on an average of the preceding 17 years.)

Electricity...	Number of Days Lightning	9
Cloudy Sky	Mean Amount	5·7
	Number of Clear Days ...	1
Meteors ...	Number Observed... ...	2

Remarks.

Another month of severe drought inland, but along the coast abundant rains have fallen; and at Sydney the amount is 5·769 above the average, greater part of which fell during a storm on the 5th.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 25′ 2″ East.

NOVEMBER, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·081 inches on the 19th, at 10 a.m.	
	Lowest Reading	29·440 „ on the 2nd, at 2 a.m.	
	Mean Height	29·764	

(Being 0·046 inch less than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure	25·2 lbs. on the 1st.	
	Mean Pressure	0·9 lb.	
	Number of Days Calm ...	0	
	Prevailing Direction ...	S.	

(Prevailing direction during the same month for the preceding 18 years S.)

Temperature	Highest in the Shade ...	90·6	On the 1st.
	Lowest in the Shade ...	56·3	On the 5th.
	Greatest Range	27·7	On the 1st.
	Highest in the Sun ...	144·2	On the 2nd.
	Highest in Black Box with Glass Top	196·1	On the 4th and 6th.
	Lowest on the Grass ...	42·2	On the 5th.
	Mean Diurnal Range ...	14·1	
	Mean in the Shade ...	68·2	

(Being 2·2 greater than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount	100·0	On the 9th and 10th.
	Least	27·0	On the 1st.
	Mean	70·9	

(Being 1·6 greater than that of the same month on an average of the preceding 18 years.)

Rain... ...	Number of Days	12 rain and 2 dew.	
	Greatest Fall	1·088 inch. On the 19th.	
	Total Fall	1·604 inch. 65 feet above ground.	
		2·725 inches. 15 in. above ground.	

(Being 0·845 inch less than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	7·339 inches.	
Ozone ...	Mean Amount	5·6	

(Being 0·5 greater than that in the same month on an average of the preceding 17 years.)

Electricity...	Number of Days Lightning	10	
Cloudy Sky...	Mean Amount	5·9	
	Number of Clear Days ...	1	
Meteors ..	Number Observed	2	

Remarks.

The barometer this month has been below the average, but the temperature has been 2·2 greater, and the maximum reached 90·6° on the first of the month, which is very unusual; inland the temperature in many instances has been upwards of 110°. The rainfall on the coast has been moderate, but inland there has been little or none, and the drought is very severe.

GOVERNMENT OBSERVATORY, SYDNEY.

LATITUDE 33° 51′ 41″; LONGITUDE 10h 4m 46s; MAGNETIC VARIATION 9° 25′ 2″ East.

DECEMBER, 1877.—GENERAL ABSTRACT.

Barometer ... At 32° Faht.	Highest Reading	30·114 inches on the 11th, at 10 a.m.
	Lowest Reading	29·204 ,, on the 18th, at 6 p.m.
	Mean Height	29·732

(Being 0·020 inch less than that in the same month on an average of the preceding 18 years.)

Wind ...	Greatest Pressure	20·5 lbs. on the 28th.
	Mean Pressure	1·1 lb.
	Number of Days Calm ...	0
	Prevailing Direction ...	E.N.E.

(Prevailing direction during the same month for the preceding 18 years E.N.E.)

Temperature	Highest in the Shade ...	97·4	On the 23rd.
	Lowest in the Shade ...	55·8	On the 7th.
	Greatest Range	29·6	On the 23rd.
	Highest in the Sun... ...	153·0	On the 23rd.
	Highest in Black Box with Glass Top	213·3	On the 14th.
	Lowest on the Grass ...	50·2	On the 26th.
	Mean Diurnal Range ...	16·5	
	Mean in the Shade... ...	71·6	

(Being 2·1 greater than that of the same month on an average of the preceding 18 years.)

Humidity ...	Greatest Amount	97·7	On the 10th.
	Least	41·0	On the 27th.
	Mean	68·7	

(Being 1·1 greater than that of the same month on an average of the preceding 18 years.)

Rain ...	Number of Days	16 rain and 0 dew.	
	Greatest Fall	0·310 inch.	On the 10th.
	Total Fall	0·701 inch.	65 feet above ground.
		1·461 inch.	15 in. above ground.

(Being 0·746 inch less than that of the same month on an average of the preceding 18 years.)

Evaporation	Total Amount	8·423 inches.
Ozone ...	Mean Amount	5·2

(Being 0·8 greater than that in the same month on an average of the preceding 17 years.)

Electricity...	Number of Days Lightning	10
Cloudy Sky...	Mean Amount	6·6
	Number of Clear Days ...	1
Meteors ...	Number Observed	4

Remarks.

The mean temperature in shade is again 2·1 above the average in Sydney, and generally the heat has been very great. On the coast the rainfall has been considerably below the average, but inland drought still holds sway, and the losses in stock have been very great.

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JOURNAL OF THE ROYAL SOCIETY OF NEW SOUTH WALES, 1877.

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(Edited by Professor Liversidge.)

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Sydney: Thomas Richards, Government Printer.—1878.

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